A Descriptive Catalogue of Indian Astronomical Instruments



Sreeramula Rajeswara Sarma

A Descriptive Catalogue of Indian Astronomical Instruments

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for

Rena and Ananda

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PREFACE

In AD 628, Brahmagupta completed his monumental *Brāhmasphuṭa-siddhānta* which, as David Pingree observes, 'was enormously influential on later Indian astronomy as well as on Islamic and Western European' astronomies.[i] The twenty-second chapter of this work describes the construction and use of several astronomical instruments, from the simple quadrant to mercury-driven perpetual motion machines. While studying this chapter,[ii] I wondered whether any specimens of these instruments are preserved today in museums. Such specimens, I thought, would help in understanding better the rather brief descriptions in Sanskrit texts. Therefore, a survey of Sanskrit astronomical instruments in various museums in India would a worthwhile task, I reflected. But gradually I came to realise that many Sanskrit instruments are closely related to Islamic astronomical instruments, that several Islamic astronomical instruments were also produced in India as well and that large numbers of specimens of Sanskrit as well as Islamic astronomical instruments are preserved in museums abroad, especially in UK.

It was about this time that I came across a catalogue of the exhibition on 'Science in India' which was mounted by the Science Museum of London in connection with the Festival of India in 1982. The exhibition gave an admirable account of scientific activity in India from the earliest times up to the present day, by means of manuscripts and artefacts. The catalogue, compiled by Dr R. G. W. Anderson, who later became the Director of the British Museum, made me aware of the actual specimens of Indian astronomical instruments which are still extant in various museums in India and abroad. Encouraged by this catalogue and later by personal conversations with Dr Anderson and other scholars, I began studying Indian astronomical instruments in museums and private collections within India and outside.

Thus began my exploration of pre-modern Indian astronomical instruments in 1991 which lasted a quarter century and spanned three continents.[iii] A descriptive catalogue of the extant instruments which I identified during the course my explorations in about a hundred museums and private collections is presented in the following pages. The majority of the surviving instruments are astrolabes. These are not simple measuring tools. Their fabrication from sheets of brass demands sophisticated workmanship. Engraving the various kinds of lines and circles on the plates and on the back requires high precision. Fashioning the *kursī* and the rete involves fine artistic sense. Furthermore, large quantities of astronomical, astrological and geographical data

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[i] Pingree 1981, p. 21.

[ii] Sarma 1986-87a

[iii] I tried to cover all the known collections in India, Europe and USA; in India, the Asiatic Society, Kolkata, Indian Museum, Kolkata, and L. D. Institute, Ahmedabad, are known to own astronomical instruments, but they did not respond to my repeated requests for permission to study the instruments in their collections. New museums are coming up in Kuwait and in the United Arab Emirates, some of which are reported to possess Indo-Persian astrolabes and celestial globes, but I have not been able to contact these museums.

are engraved on them. Therefore, astrolabes have been carefully preserved by owners and eagerly collected by cognoscenti throughout the centuries in all the regions.

In this catalogue, astrolabes are described in five sections A, B, C, D and E. Then follow celestial globes in three sections F, G and H. These are also products of excellent metal craft and artistic beauty. Thereafter are treated diverse kinds of instruments which exist in smaller numbers.

I have personally examined and photographed many of the instruments described in this catalogue. In some cases, where I could not personally study the instruments, detailed information and photos were kindly sent to me by museums, auction houses and private collectors. The third source is archival. At the Museum of the History of Science, Oxford, Francis Maddison collected a large number of photos of astrolabes and of other instruments which were sent to him for evaluation by auction houses. Likewise, Anthony J. Turner, Le Mesnil-le-Roi, has a large collection of photos. Both very generously lent me photos of Indian instruments in their collections. These photos fill important gaps and help in a drawing a more comprehensive picture of instrument production in India.

Astronomical instruments produced in India in the pre-modern period can be classified into two broad groups. In the first group are those with inscriptions and legends in Arabic and Persian. More specifically, the astronomical technical terms are in Arabic, and the inscriptions regarding the manufacture or ownership are often in Persian. These are classified as Indo-Persian instruments, because they were produced in a milieu where Persian was the official or scholarly language. The second group consists of instruments on which the legends are in Sanskrit language and in Devanagari script. These are called Sanskrit instruments. The original prototypes for the Indo-Persian instruments were derived from the Islamic world. Some of the Sanskrit instruments are indigenous to the Indian subcontinent and some others are adapted from Islamic models. There is also a small number of Sanskrit instruments derived from European models.

Excluded from this survey are the modern or post-telescopic astronomical instruments which were directly imported from the west and did not undergo any substantial variation in India, even when they were manufactured here. A further distinction between these two groups of pre-modern and modern instruments lies in the manner and scale of production: the former were produced by traditional artisans and each item was a unique product, whereas the latter were industrial products on a mass scale with identical copies. This difference is somewhat akin to the difference between manuscripts and printed books.

This does not mean that modern instruments like telescopes, sextants, transit circles have no historical value. Just as the copies of the first edition of a book are valuable as collectibles, so are also nineteenth century European instruments of historical interest. Universities and other academic institutions in India still possess many such historically interesting European instruments. These also deserve to be catalogued; in fact, even other kinds of scientific instruments and obsolete measuring

devices like steel-yards which are scattered in museum stores need to be studied; but it is beyond the scope of the present catalogue.[iv]

Had I known the enormity of the project, I probably would not have ventured in the first place. But the interest and encouragement shown by scholars and the enthusiastic cooperation of museum directors gave me the necessary confidence to continue with the project. Therefore, the list of persons to whom I owe deep debt gratitude is rather long.

I am quite conscious of the many shortcomings in this catalogue, caused by my linguistic and technical limitations. But I do hope that this first ever attempt at compiling the information about pre-modern Indian astronomical instruments which are dispersed in many parts of the world will be of some use to the historians of science and to the curators of museums.

Safavid astrolabe makers like Muḥammad Mahdī al-Khādim al-Yazdī (Y008), ᶜAbd al-A'imma (Y009), Muḥammad Amīn (Y010), ᶜAbd al-ᶜAlī (Y011) and others usually engrave on their richly decorated astrolabes a line from the *Gulistān* of the Persian poet Shaykh Saᶜdī, which reads *gharaḍ nakshīst kaz mā bāz mānad* (the intention of this drawing is that it should remain after us), as can be been in this cartouche engraved on the back of the astrolabe by Muḥammad Mahdī al-Khādim al-Yazdī (Figure Y008.6).



This is indeed the hope nurtured by every astrolabe maker and every author, including the compiler of this catalogue.

[iv] National inventories of scientific instruments, both pre-modern and modern, are being compiled elsewhere. In the 1950s, the History of Science Division of the International Union for History and Philosophy of Science set up a commission to promote the compilation of an 'inventaire mondiale des appareils scientifiques historiques'. The first step in this direction was to compile national inventories. Accordingly, several European countries brought out national inventories of scientific instruments: Belgium (1959-1960), Italy (1963), France (1964), USSR (1968), Czechoslovakia (1970; unpublished), Ireland (1990). The last and the most comprehensive in this series is *Science Preserved: A Directory of Scientific Instruments in Collections in the United Kingdom and Eire*, compiled by Mary Holbrook, R. G. W. Anderson & D. J. Bryden, London 1992.

ABBREVIATIONS AND OTHER CONVENTIONS

1. Abbreviations

anon = anonymous

attr = attributable

ca = circa

d = diameter

ed = edited

h = height

L = terrestrial longitude

mm = millimeters

nd = not dated

PC = private collection

PLU = present location unknown

r = reign

s.v. = sub voce

t = thickness

tr = translated

φ = terrestrial latitude

⊙ = instruments which I have personally examined

; = (semi-colon) mark of separation in sexagesimal system between degrees and minutes of arc and between hours and minutes of time

All linear measurements are in millimeters

Material of almost all instruments is brass; in a few cases, it is wood or wood and ivory. Only such cases will be mentioned in the catalogue. Where no material is mentioned, it should be understood as brass.

2. Other Abbreviations and Expressions

CCA = Sharon L. Gibbs, Janice A. Henderson & Derek de Sola Price, *A Computerized Checklist of Astrolabes*, Yale University, New Haven 1973 Astrolabes are identified with the serial numbers given here.

CESS = David Pingree, *Census of Exact Sciences in Sanskrit,* Series A, vols. 1-5, Philadelphia 1970-1994.

DSB = Charles Couston Gillispie*Dictionary of Scientific Biography,* 16 vols, 1970-1980.

ESS = Emilie Savage-Smith, Islamicate Celestial Globes: Their History, Construction and Use, Washington, D.C., 1985. ESS followed by a serial number refers to the globe under this serial number in the catalogue part of the book.

Khalili = Nasser D. Khalili Collection of Islamic Art, London

MHS = Museum of the History of Science, Oxford

NMM = National Maritime Museum, Greenwich

Répertoire = Alain Brieux, Francis Maddison, avec la collaboration de Ludwik Kulus et Yusuf Ragheb, *Répertoire des Facteurs d'Astrolabes, et leurs oeuvres. Islam, plus Byzance, Arménie, Géorgie et Inde Hindoue* (in press). I use the 1993 version. Here the instrument makers are listed alphabetically and under each name the instruments by this maker are listed chronologically with serial numbers. Répertoire, followed by a serial number, refers to an instrument made by the instrument maker concerned.

India, Indian = refer to the Indian subcontinent

Indo-Persian = refers to artefacts produced in India where Persian was the official and/or academic language

Islam, Islamic= refer to the culture of the Islamic world and not to the religion.

3. Chronology

AD = Anno Domini, Christian era

AH/H = Hijrī era (lunar)

Śaka = Śaka era (luni-solar)

VS = Vikrama Saṃvat (luni-solar)

Dates in Hijrī era are converted by the CALH (Calendar conversion program) developed by Benno van Dalen.
http://www.bennovandalen.de/Programs/programs.html
[also http://goo.gl/gFvLXO, last accessed in April 2017]

Dates in Śaka and Vikrama Saṃvat eras are converted by the 'Pancanga' program developed by Michio Yano and Makoto Fushimi
http://www.cc.kyoto-su.ac.jp/~yanom/pancanga/index.html
[also http://goo.gl/MN37FC, last accessed in April 2017]

4. Languages

The language of the engravings on the Indo-Persian instruments is mainly Persian with Arabic technical terms. The transcription of these Arabic terms is somewhat peculiar. Because of the limited space available for engraving, or even otherwise, the Arabic definite article *al-* is often omitted. Epithets in masculine gender are added to nouns even when the latter are feminine. The term *ra's* (head) is generally transcribed as *rās*. In order to retain the peculiarity of the language, the engravings are transliterated exactly, without making any attempt at assimilation or vocalization either according to the usage either in Arabic or in Persian.

As will be explained in the introduction to Sanskrit astrolabes, unlike in the Islamic and in Indo-Persian milieu in India, no professional class of Sanskrit instrument makers developed. Hindu or Jaina astronomers or astrologers, who used Sanskrit as the language of learning, when they wished to have instrument, themselves prepared the technical designs and the text of engravings and asked the willing brass worker, who may be barely literate, to prepare the instrument. Consequently, the Sanskrit engravings of star names and even place names are often incorrect. Therefore, I have added the correct version in most of the cases, for the sake of intelligibility.

5. Transliteration

Arabic/ Persian

ص	ش	س	ز	ر	ذ	د	خ	ح	ج	ث	ت	ب	آ	ا
ṣ	*sh*	*s*	*z*	*r*	*dh*	*d*	*kh*	*ḥ*	*j*	*th*	*t*	*b*	*ā*	*a*
ء	ی	ہ	و	ن	م	ل	ک	ق	ف	غ	ع	ظ	ط	ض
ʻ	*y/ī*	*h*	*w/au*	*n*	*m*	*l*	*k*	*q*	*f*	*gh*	*c*	*ẓ*	*ṭ*	*ḍ*

Transliteration Sanskrit

अ	आ	इ	ई	उ	ऊ	ऋ	ए	ऐ	ओ	औ	ं	ः		
a	*ā*	*i*	*ī*	*u*	*ū*	*ṛ*	*e*	*ai*	*o*	*au*	*ṃ*	*ḥ*		
क	ख	ग	घ	ङ	च	छ	ज	झ	ञ	ट	ठ	ड	ढ	ण
k	*kh*	*g*	*gh*	*ṅ*	*c*	*ch*	*j*	*jh*	*ñ*	*ṭ*	*ṭh*	*ḍ*	*ḍh*	*ṇ*
प	फ	ब	भ	म	य	र	ल	व	श	ष	स	ह		
p	*ph*	*b*	*bh*	*m*	*y*	*r*	*l*	*v*	*ś*	*ṣ*	*s*	*h*		

6. Numerical Notations

Abjad | On Indo-Persian instruments, the numerical quantities are transcribed mostly in the *Abjad* alpha-numeric notation and occasionally with the common Arabic/Persian numerals. Khareghat published a very convenient table of the *Abjad* notation which is reproduced below. [v]

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[v] From Khareghat 1950, pp. x-xii. In the argument astrolabe is misspelt.

Number	Value in Letters	How engraved on the Astralobe	Number	Value in Letters	How engraved on the Astralobe	Number	Value in Letters	How edgraved on the Astralobe
1	ا	ا	21	كا	كا	41	ما	ما
2	ب	ب	22	كب	كب	42	مب	مب
3	ج	ج	23	كج	كج	43	مج	مج
4	د	د	24	كد	كد	44	مد	مد
5	ه	ه	25	كه	كه	45	مه	مه
6	و	و	26	كو	كو	46	مو	مو
7	ز	ز	27	كز	كز	47	مز	مز
8	ح	ح	28	كح	كح	48	مح	مح
9	ط	ط	29	كط	كط	49	مط	مط
10	ى	ى	30	ل	لى	50	ن	نى
11	يا	يا	31	لا	لا	51	نا	نا
12	يب	يب	32	لب	لب	52	نب	نب
13	يج	يج	33	لج	لج	53	نج	نج
14	يد	يد	34	لد	لد	54	ند	ند
15	يه	يه	35	له	له	55	نه	نه
16	يو	يو	36	لو	لو	56	نو	نو
17	يز	يز	37	لز	لز	57	نز	نز
18	يح	يح	38	لح	لح	58	نح	نح
19	يط	يط	39	لط	لط	59	نط	نط
20	ك	ك	40	م	م مه	60	س	سه

Number	Value in Letters	How engraved on the Astralobe	Nnmber	Value in Letters	How engraved on the Astralobe	Number	Value in Letters	How engraved on the Astralobe
61	سا	سا	82	فب	ف	155	قنه	قنه
62	سب	سب	83	فج	فح	160	قس	قسم
63	سج	سح	84	فد	فد	165	قسه	قسه
64	سد	سد	85	فه	فه	170	قع	قع
65	سه	سه	86	فو	فو	175	قعه	قعه
66	سو	سو	87	فز	فر	180	قف	قف
67	سز	سر	88	فح	فح	185	قفه	قفه
68	سح	سح	89	فط	فط	190	قص	قصم
69	سط	سط	90	ص	صم	195	قصه	قصه
70	ع	ع	95	صه	صه	200	ر	ر
71	عا	عا	100	ق	ق	205	ره	ره
72	عب	عب	105	قه	قه	210	رے	رے
73	عج	عج	110	قے قی	قے	215	ريه	ريه
74	عد	عد	115	قيه	قيه	220	ركـ	ركـ
75	عه	عه	120	فک	فک	225	رکه	رکه
76	عو	عو	125	فکه	فکه	230	رل	رل
77	عز	عر	130	قل	قل	235	رله	رله
78	عح	عح	135	قله	قله	240	رمـ	رمـ
79	عط	عط	140	قم	قم	245	رمه	رمه
80	ف	ف	145	قمه	قمه	250	رن	رنـ
81	فا	فا	150	قن	قن	255	رنه	رنه

Number	Value in Letters	How engraved on the Astrolobe	Number	Value in Letters	How engraved on the Astrolobe	Number	Value in Letters
260	رس	رسم	310	شم	شم	360	شس
265	رسه	رسه	315	شبه	شبه	400	ت
270	رع	رعم	320	شک	شک	500	ث
275	رعه	رعـه	325	شکه	شکه	600	خ
280	رف	رف	330	شل	شلم	700	ذ
285	رفه	رفه	335	شله	شله	800	ض
290	رص	رصم	340	شم	شمم	900	ظ
295	رصه	رصه	345	شمه	شمم	1000	غ
300	ش	شم	350	شن	شنم	0	ها
305	شه	شه	355	شنه	شنه		

Common Arabic/ Persian Numerals | used occasionally on Indo-Persian instruments
١ (1), ٢ (2), ٣ (3), ۴ (4), ۵ (5), ۶(6), ٧ (7), ٨ (8), ٩ (9), ٠ (0).

Devanagari Numerals | used generally on Sanskrit instruments
१ (1), २ (2), ३ (3), ४ (4), ५ (5), ६ (6), ७ (7), ८ (8), ९ (9), ० (0).

The Sanskrit alpha-numeric system called ***Kaṭapayādi*** is employed in two Sanskrit instruments (C015 and H003), in imitation of the *Abjad* notation on Indo-Persian instruments.[vi]

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**0**
क *ka*	ख *kha*	ग *ga*	घ *gha*	ङ *ṅa*	च *ca*	छ *cha*	ज *ja*	झ *jha*	ञ *ña*
ट *ṭa*	ठ *ṭha*	ड *ḍa*	ढ *ḍha*	ण *ṇa*	त *ta*	थ *tha*	द *da*	ध *dha*	न *na*
प *pa*	फ *pha*	ब *ba*	भ *bha*	म *ma*					
य *ya*	र *ra*	ल *la*	व *va*	श *śa*	ष *ṣa*	स *sa*	ह *ha*		unattached vowels

Bhūtasaṃkhyā | A more widely employed notation, in Sanskrit texts on astronomy and mathematics, and also in inscriptions, is generally known as the *Bhūtasaṃkhyā* system, or ‘word numerals’, where Sanskrit words denoting the sky stand for zero, words denoting the moon etc., represent one, words denoting objects that occur in pairs, like eyes, ears, hands etc., express ‘two’ and so on.[vii] This notation is used in the inscription on H003.

[vi] Sarma 1999b; Sarma 2012d.

[vii] Bīrūnī 1910; SarmaKV 2003; Sarma 2009b.

ACKNOWLEDGEMENTS

In Indian Academic tradition, it is customary to commence with a homage to one's gurus. From Professor David A. King (University of Frankfurt) I received my first lessons in how to study an astrolabe when I accompanied him to the Salar Jung Museum at Hyderabad and to the Jaipur Observatory in 1991. In his monumental *In Synchrony with the Heavens*, he dedicated a section to me and mentioned there my work with approval. I cannot think of any honour higher than this.

The little knowledge I acquired in these years on the medieval astronomical instruments is due to the writings of the late Professor Willy Hartner (University of Frankfurt), Professor David A. King (University of Frankfurt), the late Francis Maddison (Museum of the History of Science, Oxford), James Morrison (Rehoboth Beach, Delaware, USA), the late Professor David Pingree (Brown University, Providence), Professor Emilie Savage-Smith (University of Oxford) and Anthony J. Turner (Le Mesnil-le-Roi, France). Not only their books, but they themselves helped me in myriad ways through all these years. To these gurus, I address my first acknowledgement of gratitude.

I owe a deep debt of gratitude to Professor Fuat Sezgin, the founder and director of the Institut für die Geschichte der Arabisch-Islamischen Wissenschaften at Frankfurt. I had the privilege of using the rich library and the guest apartment of the Institute several times. Professor Sezgin established a unique museum of history of science and technology in Islam with replicas of instruments and artefacts which were carefully reconstructed from descriptions and diagrams in Arabic manuscripts, and prepared a large comprehensive catalogue of this museum in five volumes. He entrusted my wife and me the task of translating this catalogue from German into English. Through this translation I could widen my knowledge of the Islamic astronomical instruments.

At Aligarh Muslim University, where I spent most of my professional career, my stay was considerably enriched by the occasional conversations with Professor Irfan Habib who always found time to answer my queries on medieval Indian history and has translated several Persian passages for me, for which I am highly obliged.

Special thanks are due to Professor Owen Gingerich (Harvard University), the only university professor I know who owns an Indo-Persian astrolabe, for his encouragement and help at the initial stages of my work.

It is my pleasant duty to thank two friends and colleagues of long standing for their encouragement and constant support. Professor S. M. Razaullah Ansari (formerly Professor of Physics at Aligarh Muslim University and formerly President of the Commission for the History of Ancient and Medieval Astronomy) aroused my interest in astronomical instruments by suggesting that I prepare an edition and translation the *Yantraprakāra* which the astronomer prince Sawai Jai Singh got compiled before he

designed the huge instruments in masonry.[viii] He also has published some of my early studies on instruments in the *Studies in History of Medicine and Science* of which he was the editor. Dr A. K. Bag (History of Science Division, Indian National Science Academy, New Delhi) has been very supportive of my project from the beginning. He published several of my papers in the *Indian Journal of History of Science* and thus gave me the opportunity to present my work to a wider academic community.

Three other friends whose expertise in Sanskrit and Arabic sources on astronomy and mathematics I could always draw on are Professors Michio Yano (Kyoto Sangyo University), Takao Hayashi (Doshisha University, Kyoto) and Takanori Kusuba (Osaka University of Economics). Professor Hayashi read parts of this catalogue and made valuable suggestions for improvement. It is a pleasure to express my thanks to them.

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For this project, I received funding from the following sources, which is gratefully acknowledged. The Scientific Instrument Commission (Dr R. G. W. Anderson, President; Professor G L' E. Turner, Secretary) awarded me a grant for studying Indian astronomical instruments in the museums in UK in summer 1993.

Through the initiative of Professor Nalini Balbir (Sorbonne Nouvelle, University of Paris 3), I was offered Visiting Professorship at her department to study Indian instruments in Paris from mid-September to mid-October 1994.

On the recommendation of Professor David A. King (Institute für Geschichte der Naturwissenschaften, Goethe University, Frankfurt), the Deutsche Akademische Austauschdienst awarded me a scholarship to study the Indian instruments in Germany in the winter 1995-96.

Through the initiative of Dr A. K. Bag, the Indian National Science Academy, New Delhi, awarded me a project to study the instruments in the various museums in India from October 1998- September 2001.

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Now I must record my deep appreciation and grateful thanks to the authorities of all the museums for opening the treasures of their collections for my study.

MUSEUMS IN INDIA

I began my exploration of museums in May 1991 at the **Salar Jung Museum, Hyderabad**, where I had my first glimpse of the astrolabes and globes of the Lahore Family, with the warm-hearted cooperation of the director Dr M. L. Nigam and the keeper of the manuscripts Dr Rahmat Ali Khan. The next director Dr I. K. Sarma invited me to deliver the Salar Jung Memorial Lecture in 1995 and published the lecture under

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[viii] Sarma 1986-87a.

the title *Astronomical Instruments in the Salar Jung Museum*.[ix] During my third visit in 2004, the director Dr A. K. V. S. Reddy treated me as a special guest of the museum.

There are two other places in India which I visited frequently for the project. Sawai Jai Singh, aside from erecting huge astronomical instruments in masonry, collected some splendid masterpieces of Lahore astrolabes. His son Sawai Madho Singh designed some interesting instruments. A veritable treasury of these and several other instruments are preserved at the **Jaipur Observatory**. I went several times to Jaipur to study these instruments. I would like to thank the authorities of the Rajasthan State Department of Archaeology and Museums and, in particular, the Superintendent of the Observatory, Pandit Om Prakash Sharma. Pandit Om Prakash Sharma constructed a special gallery to display these portable instruments.

The **Rampur Raza Library** owns important instruments which I studied with the warm support of the late Dr W. H. Siddiqi, officer on special duty. Akbar Ali Khan Arshizada and Abu Sad Ilahi deciphered and translated Arabic and Persian inscriptions on some of these instruments. Dr Siddiqi desired that I prepare a catalogue of the astronomical instruments in their collection with the photographs by Mirza Jamshed Agha; the catalogue was published quite elegantly by Tanzim Raza Qureshi, Islamic Wonders Bureau, Delhi.

The other museums I visited, or collected information from, in India are listed in alphabetical order of the cities, with the names of the authorities in parentheses.

Aligarh, Aligarh Muslim University, **Ajmal Khan Tibbia College** (principal).

Hyderabad: **Saidiya Library** (Ahmad Athaullah); **State Museum of Archaeology** (S. S. Rangacharylu, assistant director).

Jaipur: **Government Maharaja's Sanskrit College** (Professor Vijay Kumar Sharma); **Maharaja Sawai Man Singh II Museum, City Palace** (Dr Giles H. R. Tillotson, director of research); **Museum of Indology** (Ramachandra Vyakul); **Shri Sanjay Sharma Museum & Research Institute** (Ram Kripalu Sharma and Tilak Raj Sharma).

Lucknow: **Nadwatul Ulama** (M. Haroon Nadwi, librarian of the Shibli Nomani Library),

Mumbai, **Chatrapati Shivaji Sangrahalay** (Dr Kalpana Desai, director; Arvind Fondekar, assistant curator); **K. R. Cama Oriental Institute** (Homai N. Modi, trustee).

New Delhi: **Mumtaj Mahl Museum (Archaeological Museum)**, Red Fort (Director-General of the Archaeological Survey of India); **National Museum** (U. Das, keeper; Anamika Pathak, C.A.).

Patna: **Khuda Bakhsh Oriental Public Library** (Dr A. R. Bedar, director; Md. Atiqur Rehman, assistant librarian; Ata Khurshid, library assistant; Dr Mohammad Zakir Hussain, research scholar).

Srinagar: University of Kashmir**, Central Asian Museum** (Nazir Ahmad Doshab, photographer).

[ix] Sarma 1996a.

Vadodara: MS University of Baroda, **Oriental Institute** (Professor M. L. Wadekar, director; Dr. Sweta Prajapati); **Sanskrit Mahavidylaya** (Professor Yogesh B. Oza, principal).

Varanasi: Banaras Hindu University, **Bharat Kala Bhavan** (Dr R. C. Sharma, director; Yashodhara Agarwal, curator); Sampurnanand Sanskrit University, **Sarasvati Bhavan Library** (Professor Mandan Mishra, vice-chancellor; D. S. Mishra, assistant librarian).

MUSEUMS IN UK

In 1989, I attended the International Congress of History of Science at Hamburg and made a presentation on the 'Astronomical Instruments in Mughal Miniatures.'[x] In the course of my presentation, I spoke about the need of an inventory of the extant astronomical instruments produced in India. The audience included Dr R. G. W. Anderson and Professor G. L' E. Turner, who were then the president and secretary of the Scientific Instrument Commission. They approved of my idea and suggested that I should begin the work in UK where there are large collections. But I could not make it to UK until the summer of 1993.

A large part of my stay was spent at the **Museum of the History of Science at Oxford**, where the director Francis Maddison showed keen interest in my work. He allowed me access to a large collection of photographs of astronomical instruments which various auction houses sent him for his evaluation. He also allowed me to copy the relevant parts of the *Repertoire* he was then compiling. This work was never published, but the 1993 version I have has been very valuable for my work. I am highly indebted to him and also to Dr W. D. Hackmann, assistant director; A. V. Simcock, librarian and L. Norman, photographer. I was again in this museum in 2005 and the new director Dr Jim Bennett very kindly provided me all facilities to study the instruments. The present director, Dr Silke Ackermann, graciously permitted me to include several museum photos in this catalogue.

The other museums I visited in UK are listed in alphabetical order of the cities.

Cambridge: **Whipple Museum of the History of Science** (Dr J. A. Bennett, curator).

Cardiff: **Welsh Industrial and Maritime Museum** (Alex Dawson, documentation officer).

Edinburgh: **Royal Museum of Scotland** (Dr Alison Morrison-Low provided me excellent photos of instruments in the museum).

Lancashire: **Stonyhurst College** (Elizabeth Robinson, Persons Fellow).

London: **British Museum** (Dr R. G. W. Anderson, director; Dr Richard Blurton, Beatriz Waters); **The Clockmakers' Company Collection,** Guildhall (Sir George White, curator); **Horniman Museum** (Ken Teague, assistant keeper); **Nasser D. Khalili Collection of Islamic Art** (Professor Nasser D. Khalili and Nahla Nassar, registrar);

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[x] Sarma 1992a.

National Maritime Museum, Greenwich (Dr Kristin Lippincott, Dr Gloria Clifton, Dr Louise Devoy); **Science Museum** (Kevin Johnson, Alison Boyle, Jeremiah Solak); **Victoria and Albert Museum** (Anthony North, Susan Strange).

Oxford: **Pitt Rivers Museum of Ethnology** (Linda Mowat, assistant curator).

MUSEUMS IN USA

Professor David Pingree offered me visiting associate professorship at his Department of History of Mathematics at Brown University Providence for the year 1992-93. This gave me the opportunity to visit the various museums in the USA with collections of Indian astronomical instruments. More important, I read Mahendra Sūri's *Yantrarāja,* the first Sanskrit manual on the astrolabe, with David Pingree and his students. I also had the opportunity to read the catalogue of Sanskrit and Indo-Persian astrolabes in the Adler Planetarium at Chicago, which Pingree was then preparing and which appeared posthumously in 2009 under the title *Eastern Astrolabes.*

Chicago: **The Adler Planetarium and Astronomy Museum** (Roderick Webster and Marjorie Webster, honorary curators). I am highly thankful to Dr Pedro Raposo, the curator, and Lauren Boegen, digital collections manager, for their kindness in generously sending me more than a hundred digital images of the Indian instruments in their collection.

New Haven, Yale University, **Cushing/Whitney Medical Library** (Dr Melisa Graffe, librarian).

New York: Columbia University, **Butler Library, Rare Book and Manuscript Library** (Rudolph Ellenbogen, assistant librarian).

Rockford: **Time Museum** (Patricia H. Atwood, executive director).

Washington, D. C.: **National Museum of American History** (Dr Peggy Kidwell, (late) Silvio Bedini, Deborah J. Warner, Drew Robarge).

I must offer special thanks to Dr David Coffeen (**Tesseract**, Hastings-on-Hudson, NY) for many photos of instruments in his collection anf for valuable suggestions.

MUSEUMS IN FRANCE

Paris: **Institute du Monde Arabe** (Jeanne Mouliérac); **Observatory of Paris** (Dr Jean-Pierre Verdet, Dr Suzanne Débarbat.

Anthony Turner and Dominique Brieux helped me in studying the instruments in private collections.

MUSEUMS IN GERMANY

With a scholarship from the Deutsche Akademische Austauschdienst, I spent the winter 1995-96 at Professor David King's Institut für die Geschichte der Naturwissenschaften, where I could make use of the rich library of the Institute and

benefit from the expertise of Professor King's students, Dr Francoise Charette, Dr Benno van Dalen, Dr Petra Schmidl and Dr Burkhard Stautz.

At Frankfurt, I could also use the rich library of the Institut für Geschichte der Arabisch-islamische Wissenschaft where Farid Benfeghoul, Dr Carl Ehrig-Eggert, Lutz Kotthof and Dr Gesine Yildiz rendered me various kinds of help.

Berlin: **Museum für Indische Kunst** (Regina Hickemann, Deputy Director).

Bielefeld: **Kunstgewerbesammlung der Stadt Bielefeld.**

Hannover: **Kestner Museum** (Prof. Dr. Rosemarie Drenkhahn, Director).

Stuttgart: **Linden Museum** (Beate Siewart-Meyer, Wissenscaftliche Mitarbeiterin).

BELGIUM

In Belgium, there are several Indian instruments in private collections and it is to the credit of Jan De Greave that I could study and photograph these instruments.

NETHERLANDS

Leiden: **Museum Boerhaave** (Tiemen Cocquyt).

PAKISTAN

I did not have the opportunity to visit the museums in Pakistan. Dr Nasim Naqvi (London) obtained for me some photographs of instruments through his contacts. Now Mubashir Ul-Haq Abbasi (Institute of Space Technology, Islamabad, Pakistan) kindly sent me detailed photos and information of instruments in the **Islamabad Museum**, **Lahore Museum** and **National Museum of Pakistan** at Karachi. He is also preparing a comprehensive catalogue of the astronomical instruments preserved in the museums of Pakistan.

QATAR

Doha: **Museum of Islamic Art** (Marc Pelletreau, Head of Multimedia)

RUSSIA

St. Petersburg, **The State Hermitage Museum (Dr** Olga P. Deshpande, Senior Curator, Oriental Department; Zhanna Etsina, Manager, Rights and Reproductions Office).

SWITZERLAND

Geneva, Musée d'histoire des sciences (Laurence-Isaline Stahl Gretsch; Stéphane Fischer).

TURKEY

I did not have the chance to visit Istanbul. At **Kandilli Observatory and Earthquake Research Institute**, Professor Mustafa Aktar, professor of geophysics and in-charge of the collection of historical instruments, very kindly sent me photos and the exact measurements of the Indian instruments in the collection.

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Besides the museums mentioned above, many private collectors allowed me to study the Indian instruments in their collections; some have provided me with good photos. I am much obliged to them, but it is not appropriate to identify them with their names.

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Outside the museums, I am highly obliged to many scholars for arranging my lectures on instruments, for publishing my papers, for introducing me to the museums and private collectors and for various other favours.

India: Professor Ishrat Alam (Aligarh Muslim University), Dr Vijay V. Bedekar (Chairman, Vidyaprasarak Mandal, Thane, India); Professor Ramkrishna Bhattacharya (Kolkata); Dr Divyabhanusinh Chawda (Jaipur); Professor Ratna Prabha Chivukula (M. S. University of Baroda); Professor Ashok Das (formerly Director, Sawai Mansingh Library and Museum, Jaipur); Dr Devangana Desai (Editor, *Journal of the Asiatic Society of Mumbai*); Dr Sanjay Garg (National Archives of India, New Delhi); (late) S. A. K. Ghori (Aligarh); Dr Sudha Gopalakrishnan (formerly Director, National Manuscript Mission, New Delhi); Professor S. Irfan Habib (National University for Educational Planning and Administration, New Delhi); Professor Amina Kishore (Aligarh Muslim University); Professor M. A. Kishore (Aligarh Muslim University); Professor Rani Majumdar (Aligarh Muslim University); Dr Syed Liyaqat Hussain Moini (Aligarh Muslim University); Professor Shirin Moosvi (Aligarh Muslim University); Ghulam Mujtaba, Aligarh; Professor Jayant Narliker (Inter-University Centre for Astronomy and Astrophysics, Pune); (late) Professor Ahsan Jan Qaisar (Aligarh Muslim University); Professor Zillur Rahman (President, Ibn Sina Academy of Medieval Medicine and Sciences, Aligarh); Professor K. Ramasubramanian (IIT-B, Mumbai); Professor S. Balachandra Rao (Formerly Professor of Mathematics and Principal, National College, Bangalore); Abdul Rashid (Indira Gandhi National Centre for the Arts, New Delhi); Dr Mira Roy (Kolkata); (late) Yaduendra Sahai (Sawai Mansingh Library and Museum, Jaipur); (late) S. N. Sen (Indian Association for the Cultivation of Science, Kolkata); Subhash Sharma (Jaipur); Professor B. V. Subbarayappa (former President, International Union of History and Philosophy of Science, Bangalore); Dr Vijay Shankar Shukla (India Gandhi National Centre for Arts); Dr B. G. Sidharth (Director, B. M. Birla Science Centre, Hyderabad); Professor Romila Thaper (Jawaharlal Nehru University, New Delhi); Professor Radha Vallabh Tripathi

(formerly Vice Chancellor, Rashtriya Sanskrit Sansthan, New Delhi); Dr Lotika Varadarajan (New Delhi); Dr Kapila Vatsyayan (Founder-Director, Indira Gandhi National Centre for the Arts, New Delhi).

Belgium: Ernesto Canobbio and Dr Jean-Michel Delire.

Canada: Professor Ashok Aklujkar (University of British Columbia, Vancouver); Professor Dominik Wujastyk (University of Alberta, Edmonton).

Egypt: Dr Flora Vafea (Cairo); Ayman Aly (Cairo).

France: Professor Jan Houben (École Pratique des Hautes Études, Paris); Dr Jérôme Petit **(**Bibliothèque Nationale de **France); (**late) Dr Arion Roşu (Versailles); Dr Fabrizio Speziale (Université Paris 3 Sorbonne Nouvelle).

Germany: Professor Willem Bollée (Bamberg), Professor Rahul Peter Das (Martin Luther University Halle-Wittenburg), (late) Professor Michael Hahn (Philipps University, Marburg), Professor Jürgen Hanneder (Philipps University, Marburg), Professor Oskar von Hinüber (Albert-Ludwigs University, Freiburg), (late) Dr Anthony R. Michaelis (Heidelberg); Professor Eva Orthmann (University of Bonn); (late) Professor Wilhelm Rau (Philipps University, Marburg); Dr Alexander Walland (Ingelheim); Karl Pohl (Cologne); Dr Jayandra Soni (Philipps University, Marburg); (late) Professor Claus Vogel (University of Bonn); Professor Albrecht Wezler (University of Hamburg).

Iran: Professor Mohammad Bagheri (Institute for the History of Science, University of Tehran).

Italy: Dr Paulo Brenni (President, Scientific Instruments Society); Dr Ileana Chinnici (Palermo Observatory, Palermo, Italy); Professor Mara Miniati (Curator Emeritus, Museo Galileo, Florence).

Japan: Dr Yukio Ohashi (Tokyo); Satoshi Ogura (Kyoto University).

Netherlands: Wilfred de Graaf and Professor Jan P. Hogendijk (University of Utrecht); Dr Saraju Rath (International Institute of Asian Studies, Leiden).

Russia: Sergei Maslikov (Director, Large Novosibirsk Planetarium, Novosibirsk).

Spain: Professor Emilia Calvo, Dr Roser Puig and Professor Julio Samso (University of Barcelona).

Sweden: Dr Martin Gansten (Lund, Sweden).

Switzerland: Dr Johannes Thomann (University of Zurich).

Thailand: Professor Ampha Otrakul (Chulalongkorn University, Bangkok).

UK: Dr Josefina Rodriguez Arribas (Warburg Institute, University of London); Professor Charles Burnett (Warburg Institute, University of London); Jeremy Collins (Christie's, London); Dr Roy Fischel (School of Oriental and African Studies, University of London); Dr Edward Gibbs (Sotheby's, London); Dr Willem Hackmann (Editor, *Bulletin of the Scientific Instruments Society*).

USA: Professor Muzaffar Alam (University of Chicago); Dr Owen T. Cornwall (Columbia University, New York); Dr Sharon Gibbs-Thibodeau (US National Archives, College Park, Maryland); Dr Toke Lindegaard Knudsen (State University of New York,

Oneonta); Professor Phyllis Granoff (Yale University, New Haven); Dr James McHugh (University of Southern California, Los Angeles); Dr Clemency Montelle (Brown University, Providence; now: University of Canterbury, Christchurch, New Zealand); Angur Patel (San Diego, California); Professor Sumathi Ramaswamy (Duke University, Durham, North Carolina); Professor Virendra Nath Sharma (University of Wisconsin); Profesor Michael Witzel (Harvard University).

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I must record my sincere thanks to the following friends whose help I sought frequently during the past two years while drafting this catalogue and who have readily and warm-heartedly responded:

Dr Vijay Bedekar (Thane) and Jan de Graeve (Brussels) sent me, at short notices, rare published material; Dr Jean-Michel Delire (Brussels) very generously provided me detailed photos of instruments in Jaipur; Dr Martin Gansten (Lund) helped me with astrological matters. Mubashir Ul-Haq Abbasi (Islamabad) has been an enthusiastic collaborator during the past three years; the detailed descriptions and photos of the instruments preserved in the various museums of Pakistan are due to him; he also deciphered and translated some Persian inscriptions for me. When I asked Debasish Das (Gurgaon) for a photo of the sundial at the Jama Masjid in Delhi, he promptly sent me detailed photos of that sundial; not only that, he also made explorations throughout India and within a short time located several thitherto unknown sundials and became an expert in this process (see his very comprehensive and eminently readable report on the sundials in mosques in India at Das 2018).

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For their abiding friendship and many acts of help, I owe a special debt of gratitude to Ursula and Oskar Kober (Homberg/Efze, Germany).

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Without the loving support of my wife Renate Sarma and our son Ananda Sarma, I could not have worked for so many years and completed this catalogue. Renate proofread much of the catalogue with great patience. Ananda gave shape to my raw text, with his efficient formatting and nice layout; he is, in fact, the manager, editor and publisher of this catalogue.

PREAMBLE

तनुर्नेत्रैर्न्यूना नृपतिरहिता राजनगरी
सरस्यो निष्पद्मा युवतिरपि कान्तेन रहिता |
निशा निःशीतांशुः सरिदपि यथा चक्ररहिता
तथा ज्योतिर्विद्या भवति विफला यन्त्ररहिता ||

tanur netrair nyūnā nṛpatirahitā rājanagarī
sarasyo niṣpadmā yuvatir api kāntena rahitā |
niśā niḥśītāṃśuḥ sarid api yathā cakrarahitā
tathā jyotirvidyā bhavati viphalā yantrarahitā ||

Like body without eyes, royal capital minus the king,
lakes devoid of lotus flowers, a young woman without a lover,
the night without the moon, a river bereft of *Cakravāka* birds,
even so astronomical science is fruitless without instruments.

— Rāmacandra Vājapeyin, 1428, *Yantra-prakāśa*

In reconstructing the history of science and technology of any civilization, scientific instruments play as valuable a role as literary documents do. This is particularly true of astronomical instruments. As Francis Maddison, long-time curator of the famous Museum of the History of Science at Oxford, remarks:

> It was in astronomy that accurate measurement was first used systematically to obtain quantitative evaluations of observed phenomena. The instruments which were invented and which developed in response to this approach to scientific enquiry are (…) worthy of study as primary sources of the history of scientific thought and of technological achievement.[11]

In the Indian subcontinent, scientific instruments were used throughout history. The large number of weights, the remains of some metal scales and the fragment of a linear scale incised on a shell, which were recovered at the Indus Valley sites of Mahenjo-daro and Harappa, are some of the earliest specimens of Indian scientific instruments.[12] Unfortunately, neither a systematic inventory of these instruments was made, nor were they studied in the context of their historical development. On the other extremity of the chronological scale, even Sawai Jai Singh's observatories, which must be ranked as unique astronomical monuments of the world, are in a sad state of neglect. The large masonry instruments which Jai Singh designed and erected in his observatories are indeed the culmination of a long process of development in astronomical instrumentation. But what sort of instruments were used until the eighteenth century, before the time of Jai Singh?

SANSKRIT TEXTS ON ASTRONOMICAL INSTRUMENTS

Sanskrit astronomical texts describe many instruments (*yantra*) for measuring time, for taking the altitudes of heavenly bodies, for measuring the angular distance between two celestial objects, for visually demonstrating the apparent motion of the heavens, and so on. Kauṭilya's *Artha-śāstra,* which was composed and expanded between the second century BC and the third century AD, speaks of measuring time by

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11 Maddison 1963, p. 17.

12 Bose, Sen & Subbarayappa 1971, pp. 137-138.

means of a water clock or with a gnomon.[13] At the beginning of the sixth century, Āryabhaṭa described several interesting astronomical instruments in his *Āryabhaṭa-siddhānta*. This work is now lost but the descriptions of the instruments survive in Rāmakṛṣṇa Ārādhya's commentary on the *Sūrya-siddhānta*.[14] About the middle of the sixth century, Varāhamihira discussed a few instruments in the fourteenth chapter of his *Pañca-siddhāntikā*.

The first systematic and comprehensive account of astronomical instruments (*kāla-yantras*) is provided by Brahmagupta in his *Brāhmasphuṭa-siddhānta,* which he completed in 628 in western India. Here the twenty-first chapter is devoted to the armillary sphere (*Gola-yantra*) and the twenty-second chapter to the other instruments. The armillary sphere is treated separately because it is primarily a didactic device and not a measuring tool. Moreover, it appears that students of astronomy were encouraged to assemble their own armillary spheres, because by arranging the various imaginary circles in the heavens such as the celestial equator, the ecliptic and others as physical entities in the armillary sphere, they can grasp the purpose and function of these imaginary circles. Therefore, *gola-bandha,* i.e., tying together the different rings to constitute the armillary sphere, seems to be part of the traditional curriculum.

In the twenty-second chapter called *Yantrādhyāya* (chapter on instruments), Brahmagupta describes the construction and use of nine varieties of instruments, *Dhanus, Turyagola, Cakra, Yaṣṭi, Śaṅku, Ghaṭikā, Kapāla, Kartarī* and *Pīṭha*. In addition, he describes eight types of accessories which are required when observations are made with instruments. He also describes some varieties of automata and perpetual motion machines (*Svayaṃvaha-yantra*).[15]

This procedure was adopted nearly in all the major astronomical texts in Sanskrit. In his *Śiṣyadhīvṛddhida-tantra,* Lalla (eighth or ninth century) devotes the fifteenth chapter *Golabandhādhikāra* for the construction of the armillary sphere and the twenty-

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13 Kauṭilya, *Arthaśāstra,* 1.19.6: *nālikābhir ahar aṣṭadhā rātriṃ ca vibhajet, chāyāpramāṇena vā.* '[The king] shall divide the day, and also the night, into eight parts, by means of the water clock or by means of the shadow-lengths [of the gnomon]. This passage will be discussed in detail in sections O (column dials) and R (water clocks).

14 These are retrieved and interpreted by Shukla 1967.

15 Sarma 1986-87a.

first chapter *Yantrādhyāya* for the following instruments: automata, *Gola, Cakra, Dhanus, Kartarī, Kapāla, Pīṭha, Bhagaṇa, Śaṅku, Ghaṭī, Śalākā, Śakaṭa* and *Yaṣṭi.* Of these *Bhagaṇa, Śalākā* and *Śakaṭa* are new; these have not been described by Brahmagupta.

In his *Siddhānta-śekhara* of 1039, Śrīpati discusses the instruments somewhat briefly as compared to Lalla. The construction of the armillary sphere is treated in the fifteenth chapter entitled *Golādhyāya*. The nineteenth chapter entitled *Yantrādhyāya* deals with the following nine instruments: *Svayaṃvaha-gola-yantra, Cakra, Dhanus, Kartarī, Kapāla, Pīṭha, Śaṅku, Ghaṭī* and *Yaṣṭi.*

Closely following these predecessors, Bhāskarācārya devotes, in the *Golādhyāya* of his *Siddhānta-śiromaṇi* (1150), an exclusive chapter entitled *Golabandhādhikāra* to the armillary sphere and a subsequent chapter called *Yantrādhyāya* to ten different types of measuring instruments and three varieties of perpetual motion machines. The instruments discussed by him are *Gola, Nāḍīvalaya, Ghaṭikā, Śaṅku, Cakra, Cāpa, Turya, Phalaka, Yaṣṭi* and *Dhī.* In addition, he discusses *Nalaka-yantra* in the *Tripraśnādhikāra* of the *Grahagaṇita.*

In his *Siddhānta-sundara* (1503), Jñānarāja also follows the same pattern of separate chapters for the armillary sphere and for other instruments; in the latter he describes *Turya, Chakra, Ghaṭī-yantra* and *Kāca-yantra,* and several automata.

CONTACT WITH ISLAMIC ASTRONOMY

Contact with Islamic astronomy led, from about the fourteenth century onwards, to the composition of texts exclusively devoted to instruments. The earliest work of this nature is the *Yantrarāja* composed by the Jaina monk Mahendra Sūri at the court of Fīrūz Shāh Tughluq in Delhi in 1370. In this first Sanskrit manual on the astrolabe, this instrument was called *yantrarāja,* 'king of instruments'. Astronomers also began to emphasise that astronomical studies remain incomplete without proper observational instruments. Thus Mahendra Sūri declares in his *Yantrarāja*:

Though hardened in fierce battles,
The soldier is defeated when deprived of weapons,
Though profound in the whole range of astral science,
The astronomer is disgraced without his instruments.'[16]

Writing about half a century later, in 1428, Rāmacandra Vājapeyin echoes the same idea in his *Yantra-prakāśa,* which is cited at the beginning of this Introduction.[17] In the subsequent centuries also, several Sanskrit works were composed on instruments. The astrolabe was discussed in more than a dozen Sanskrit texts, some of which were exclusively devoted to this instrument. These texts will be discussed in the introduction to section C on Sanskrit astrolabes.

Besides, there are also other texts which dealt with several instruments. Notable among these is Rāmacandra Vajapeyin's voluminous *Yantra-prakāśa* of 1428 in six chapters. Here the first four chapters are devoted to the astrolabe, the fifth chapter deals with the gnomon and staff, while the sixth chapter describes the construction and use of as many as 36 different types of instruments.[18] Viśrāma's *Yantra-śiromaṇi* of 1615 is a modest work which deals with six instruments, viz. *Nara-yantra* (gnomon), *Jala-yantra* (water clock), *Yantrarāja* (astrolabe), *Cāpa-yantra* (semi-circular instrument), *Turya-yantra* (quadrant) and *Nalaka-yantra* (sighting tube). Nandalāla Miśra's *Yantra-sāra* of 1772 discusses eleven instruments with special emphasis on the astrolabe and the quadrant.

There are also exclusive works on other instruments. About 1423 Padmanābha composed an exclusive text on the *Dhruvabhrama-yantra* which he had invented. Probably in the first half of sixteenth century, Cakradhara composed the *Yantra-cintāmaṇi* on the sine quadrant. The work must have been very popular; there exist several manuscript copies. Not so popular, but more comprehensive is Bhūdhara's

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16 Mahendra Sūri, 1.4. Extracts from this text, together with translation, will be added in an appendix.

17 Rāmacandra Vājapeyin, 1.10.

18 Sarma 2008b.

Turya-yantra-prakāśa of 1572 on the sine quadrant, which text is available just in a single complete manuscript.[19]

This overview of Sanskrit texts on astronomical instruments raises the following questions. Were any of these instruments ever constructed and used in observation? Are there any specimens extant in museums in India or outside? If yes, are these extant instruments mentioned or described in literature? [20]

The study of scientific instruments in other culture areas is well developed. In the West, there are excellent museums of history of science and technology, such as the Museum of History of Science at Oxford, the Adler Planetarium at Chicago, and the Deutsches Museum at Munich. Also the literature on medieval European instruments and instrument-makers is truly impressive, beginning with Ernst Zinner's classic study *Deutsche und Niederländische Astronomische Instrumente*.[21] Islamic astronomical instruments like the astrolabe and the celestial globe have been catalogued and studied in several publications, notably in *A Computerized Checklist of Astrolabes* by Derek Price and his associates[22] and in the *Islamicate Celestial Globes, their History, Construction, and Use* by Emilie Savage-Smith.[23] Professor David King embarked on a path-breaking work of cataloguing medieval European and Islamic astronomical instruments,[24] and published a vast corpus of highly valuable work.[25]

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19 SaKHYa 2014. It is beyond the scope of this catalogue to discuss these Sanskrit texts and the instruments mentioned there in greater detail. Some of these texts will be referred to while describing the extant instruments. Extracts from a few texts will also be reproduced with translation in the Appendices. For more information on the instruments described in these Sanskrit texts, see Das 1928, Rai 1985, SarmaKV 1990, and all the papers by Yukio Ôhashi listed in the bibliography.

20 Rai 1985, after giving a lucid account of the instruments described in Sanskrit texts, concludes on p. 336: 'None of the instruments described by Indian astronomers before the time of Maharaja Jai Singh survive today. Perhaps they were made of perishable materials like wood and bamboo. Admittedly they were not very sophisticated. But it must be remembered that mechanical clocks had not been devised up to that time and it was not possible to measure time accurately.' Luckily, several specimens of the instruments described in the Sanskrit texts survive.

21 Zinner 1979.

22 CCA.

23 Savage-Smith 1985.

24 King 1991.

25 See, in particular, his recent publications like King 1999b, King 2004, King 2005.

In India, no comparable work has been done on the existing instruments. While studying Jai Singh's masonry instruments in the early part of the last century, Garrett and Kaye severally paid some attention to the portable instruments at Jaipur.[26] In 1921 Kaye also studied the four instruments acquired by the Archaeological Museum at Delhi.[27] In 1935 Sulaiman Nadvi brought to light a hitherto unknown family of instrument makers of Lahore by listing 8 astrolabes and 4 celestial globes manufactured by the various members of this family.[28] In the 1970s, S. N. Sen undertook a survey of 'Astronomical Instruments of Historical Importance,' and published an interesting study on the astrolabe.[29] Beyond this, nothing more came out of the project.[30]

However, the first steps towards a descriptive catalogue were taken by R. T. Gunther in his pioneering work, *The Astrolabes of the World,* where he published the descriptions of 25 Indo-Persian astrolabes and 9 Sanskrit Astrolabes, together with excellent photos.[31] Likewise, Emilie Savage-Smith's catalogue of *Islamicate Celestial Globes* of 1985 contains descriptions of several Indo-Persian celestial globes.

Following this lead, I began the survey of extant astronomical instruments produced in pre-modern India and now preserved in museums and in private collections in India, Europe and USA, and identified some 555 instruments of diverse types, belonging to the two broad categories of Sanskrit instruments and Indo-Persian instruments.

INDO-PERSIAN ASTRONOMICAL INSTRUMENTS

Muslim astronomers in India cultivated the Middle Eastern tradition of astronomical instrumentation. They avidly studied and copied the Arabic and Persian

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26 Garrett & Guleri 1902, pp. 60-65; Kaye 1918, pp. 16-36.

27 Kaye 1921.

28 Nadvi 1935.

29 Sen 1990.

30 Vijai Govind, Sen's assistant in this project, published two more papers: Govind 1979; Behari & Govind 1980. But there are serious flaws in these two papers in the identification of instruments. For the sake of comprehensiveness, three other papers may be mentioned here: Dvivedi 1923; Dube 1928; Stone 1958.

31 Gunther 1932: Indian astrolabes, nos. 67-91, 74a, pp. 179-220; Hindu astrolabes, nos. 92-98, pp. 221-228.

texts on astronomy, astrology and astronomical instruments composed in the various parts of the Islamic world; this is attested by the rich collections of manuscripts in various libraries in India.[32] They may also have composed original works on astronomical instruments either in Arabic or Persian, but such texts are yet to be surveyed. Immediately relevant for us is the fact that the Muslim astronomers in India produced a substantial number of Islamic, or more precisely Indo-Persian, astronomical instruments, mainly astrolabes and celestial globes, and a small number of other instruments like sine quadrants.

The production of Indo-Persian astrolabes in India may have begun at the court of Fīrūz Shāh Tughluq at Delhi in the second half of the fourteenth century, but the earliest extant dated astrolabe is of 1567. It was made by Allāhdād of Lahore. He and his six descendants dominated the production of astrolabes and celestial globes in the sixteenth and seventeenth centuries. Compared to the instruments made by this family, very few instruments by others outside this family are extant today. The instrument production in the Allāhdād family ceased after 1691. Hardly any Indo-Persian instruments bearing dates in the eighteenth century came to light. But this does not mean that the production of astrolabes or celestial globes ceased completely in the eighteenth century, because there exist quite many instruments fabricated in the nineteenth century. It is possible that some of the extant unsigned and undated astrolabes and celestial globes may have been produced in the eighteenth century. But what seems to be certain is that with gradual decline of the Mughal empire, patronage also declined for astronomical instruments, as a consequence of which not many large and ornate astrolabes and celestial globes with the names of makers and dates may have been made in the eighteenth century.

Although there is a kind of vigorous revival of the production of Indo-Persian astrolabes and celestial globes towards the middle of the nineteenth century, as will be shown below, the geographical extent of their production was limited only to the Panjab-Delhi region.[33]

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[32] Rahman, Alvi, Khan & Murthy 1982; see also a critical review of this by Ansari & Fatima 1984.

[33] For a solitary case of commercial production of astronomical instruments with Urdu legends at Madras ca. 1915, see Q003.

SANSKRIT ASTRONOMICAL INSTRUMENTS

On the other hand, one would expect that Sanskrit astronomical instruments, unlike the Indo-Persian instruments, were manufactured throughout India. But surprisingly, their production, with the exception of the armillary spheres and water clocks, was also largely confined to the region comprising Gujarat, Rajasthan and Panjab, where it continued in the eighteenth and nineteenth centuries as well. I am unable to explain this anomaly. After all, there has been no discernable break in the study of Sanskrit astronomy in the southern and eastern parts of India. This is attested by manuscripts of all of major Sanskrit texts copied in all parts of India and in all regional scripts. In the fifteenth and sixteenth centuries Kerala made great advances in mathematical astronomy. A central figure of these advances, the great Nīlakaṇṭha Somayājin enjoins that only such astronomical treatises should be followed which agree with actual observations.[34] This statement presupposes the existence of instruments for astronomical observation. Yet no astronomical instruments of any consequence were found there.

The earliest dated Sanskrit instrument is an astrolabe (C001) which was completed on Sunday, 25 December 1605, at Ahmedabad. It was commissioned by the astrologer Caṇḍīdāsa for his son Dāmodara. One may wonder why no Sanskrit astronomical instrument made earlier than this date is available. I have shown elsewhere that the custom of engraving the name of the maker and the date of production on metal instruments and other objects was introduced into India along with the astrolabe.[35] Of course, stone epigraphs in India carried often the date and the name of the king who issued the epigraph, the name of the poet who composed the text and the name of the artisan who incised the inscription. The practice was followed later in copper plate epigraphs and in manuscripts as well. But there was no custom of engraving the name of the maker and date on metal artefacts before the introduction of the astrolabe.[36]

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34 Nīlakaṇṭha Somayājin, *Jyotirmīmāṃsā,* p. 6: *yaḥ siddhāntaḥ darśanāvisaṃvādī bhavati so 'nveṣaṇīyaḥ,* quoted in: Subbarayappa & Sarma 1985, p. 7; for similar statements by other astronomers, see ibid, pp. 5-8.

35 Sarma 2010.

36 Interestingly on a Sanskrit astrolabe of 1605 (C001), the style of the inscription followed that of Sanskrit manuscript colophons, even though the custom of engraving the date and the name of the

Another reason for the absence of Sanskrit instruments made before the seventeenth century is that often brass instruments not in use were recycled to produce other objects.

As mentioned above, the earliest extant Sanskrit astrolabe was made in Ahmedabad in Gujarat. Some other early astrolabes also emanate from Gujarat. From there, the production spread to Rajasthan, where it received an impetus at the court of Sawai Jai Singh in the early eighteenth century. It is well known that Sawai Jai Singh (1688-1743) designed huge masonry instruments for accurate observations and with these he set up five observatories at Delhi, Jaipur, Varanasi, Mathura and Ujjain. But he did not neglect portable instruments. He was a great admirer of the astrolabe. He collected some of the best Mughal astrolabes, to some of which he caused Sanskrit legends to be added. He also appears to have established a workshop at Jaipur to produce Sanskrit astrolabes. Here were produced some ornate astrolabes with multiple plates, designed after the Indo-Persian astrolabes of the Lahore family (C021 and C022). But, the main products of this workshop are astrolabes with single plates calibrated to the latitude of Jaipur at 27°. Jai Singh seems to have got a large number of such astrolabes fabricated and distributed them among the astronomers of his court, so that they became proficient in the science of the astrolabe. In the stores of Jai Singh's Observatory at Jaipur, I discovered a number of unfinished astrolabes belonging to this workshop (D077 – D089).

But production of Sanskrit astronomical instruments was not confined to Jaipur in the eighteenth century. Instruments were made and collected also at several other kingdoms in Rajasthan, and also in Gujarat.

In the nineteenth century, western sciences, including astronomy, began to be taught in universities and colleges throughout India and modern observatories were set up at several places with telescopes and related instruments. But these activities did not completely replace the Sanskrit and Islamic traditions of astronomical learning and the production traditional astronomical instruments. At some places, the traditional Sanskrit or Islamic learning flourished side by side with western sciences; at others there is an amalgamation of both the streams in varying proportions. This is true also of scientific

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person who caused to be made was borrowed from Islamic practice. Therefore, Pingree dismissed the astrolabe as late production. For his arguments and for my refutation, see Sarma 2012c.

instrumentation. Sanskrit astronomical instruments continued to be manufactured mainly in Rajasthan. A new centre of production came up at Kuchaman, which is situated some 130 km west of Jaipur, but roughly on the same latitude of 27°. Here were produced Sanskrit astrolabes, the last of which (D037) was completed on Monday, the sixth day of the bright half of Kārtika in the year 1960 of Vikrama Saṃvat (= Monday 26 October 1903).[37]

Indo-Persian astrolabes and celestial globes continued to be made in Panjab, mainly at Lahore, in the nineteenth century. At Aurangabad in Maharashtra (19;53 N, 75;23 E), there flourished an astrolabe maker Muḥammad Mūsa Asṭurlābī in the 18th century. A celestial globe made by his grandson Muḥammad Faḍl Allāh in 1808 (presumably at Aurangabad) survives today. This globe is mounted on a European style stand into which a magnetic compass is incorporated.[38] In the east, at Tikari in Bihar (24;57° N, 85;53° E), Ghulām Ḥussayn Jaunpūrī made a celestial globe in 1816.[39] But these are exceptions and not the rule. The production of Indo-Persian astrolabes and celestial globes was centred primarily at Lahore. Towards the middle of the nineteenth century, there was a sudden upsurge in the manufacture of these traditional astronomical instruments at Lahore under the aegis of a Hindu by name Lālah Bulhomal Lāhorī, who crafted astrolabes and celestial globes with legends either in Arabic-Persian or in Sanskrit. He also crafted Sanskrit instruments like *Dhruvabhrama-yantras* and *Turīya-yantras*, signing his name in pretty Sanskrit verses. He even created some new instruments of his own design. Some forty-five instruments of diverse types at Lahore made by him and by his Hindu and Muslim associates are known. Bulhomal can be regarded as the last representative of both Islamic and Sanskrit traditions of astronomical instrumentation.[40]

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37 In the latter half of the nineteenth century, Sāmanta Candraśekhara designed in Orissa his own astronomical instruments out of bamboo and wood and made systematic observations and composed the *Siddhānta-darpaṇa* in Sanskrit; on his work, see Misra 1996; Naik & Satpathy 1995 Naik & Satpathy 1998; Naik 2000.

38 Preserved at the Salar Jung Museum, Hyderabad; cf. Sarma 1996a, pp. 27-28, pl. 15.

39 Cf. Ansari & Sarma 1999-2000.

40 For a comprehensive study of his oeuvre, see Sarma 2015b.

Although the telescope and the pendulum clock were widely available, it is interesting to note that Indian craftsmen copied European models of naked eye instruments, like ring dials, and engraved on them Persian legends for the sake of Muslim astrologers and Sanskrit legends for the use of Hindu *jyotiṣīs*. A scientific instrument that is still produced today at Muradabad in Uttar Pradesh, quite elegantly and in large numbers, is the perpetual calendar. Two nineteenth-century prototypes are preserved in the Victoria and Albert Museum at London and in the Rampur Raza Library. These will be described in section T.

To sum up, the instruments which are extant today were produced between the mid-sixteenth century and the end of the nineteenth century, mainly in the region of Gujarat, Rajasthan and Panjab.

CATALOGUING ASTRONOMICAL INSTRUMENTS

In his *The Astrolabes of the World* of 1932*,* Robert T. Gunther described 317 standard astrolabes, 8 mariner's astrolabes and 11 astrolabe clocks. He also included six ancient and medieval texts on the construction and use of the astrolabe, which is indeed laudable.[41] Derek J. de Solla Price of Yale University and his associates, Sharon L. Gibbs and Janice A. Henderson, prepared in 1973 *A Computerized Checklist of Astrolabes* (= CCA). This list provides the date, reference number, diameter, equinox, precession, type and maker for over 1700 extant astrolabes produced in several cultural areas. Alain Brieux and Francis Maddison embarked on the compilation *Répertoire des Facteurs d'Astrolabes, et leurs oeuvres. Islam, plus Byzance, Arménie, Géorgie et Inde Hindoue* (= Répertoire) as an expanded version of L. A. Mayer's *Islamic Astrolabists and Their Works* (Geneva 1956). This compilation is arranged by the names of instrument makers and lists under each name the various instruments made by this maker in a chronological sequence. The value of the compilation lies in the fact that it provides, besides the date, size, components of the instrument and the bibliography on

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41 These texts are: John Philoponus of Alexandria, *ca.* AD 625, English translation of the Greek text (pp. 61-81); Severus Sebokt, *ca.* AD 650, English rendering of the Syriac text (pp. 82-103); Henry Bates, Malines, Belgium, *Magistralis Composito Astrolabii* of 1274 (pp. 368-376); Hermannus Contractus, b. 1013, Reichenau, Germany, *De Mensura Astrolabii* (pp. 404-408); idem, *De Utilitatibus Astrolabii* (pp. 409-422); Robert Tanner, *The Travailer's Joy*, facsimile of the London print of 1587 (pp. 502-508).

it, also the full text of maker's signature in original language together with a translation in French. Unfortunately, this very useful compilation was never published.[42] David King began to extend the CCA list by assigning numbers beyond 4000 in some of his publications under the rubric 'International Instrument Checklist' (= IIC). But this new list has not been published in a consolidated form so far.

The Mariner's astrolabe is a drastically simplified version of the standard astrolabe for taking altitudes at the high seas. As mentioned above, Gunther described 8 extant specimens (nos. 318-325) in his work. A complete inventory of all the extant specimens was published in 1988 by Alan Stimson in his *The Mariner's Astrolabe. A Survey of known, surviving Sea Astrolabes.* Mariner's astrolabes were not made in India, but an undated specimen survives in the Raza Library of Rampur.[43]

Emilie Savage-Smith prepared a descriptive catalogue of 132 Islamic celestial globes, which include several pieces made in India.[44] In a subsequent publication, she mentions that the total number of extant Islamic celestial globes stands at 175.[45]

In his publication mentioned above, Gunther describes 25 Indo-Persian astrolabes under the heading 'Indian astrolabes' and 9 Sanskrit Astrolabes as 'Hindu astrolabes'. Otherwise Sanskrit astrolabes have not been discussed systematically so far, but for the few specimens at the Time Museum described by Anthony Turner[46] and at the Adler Planetarium by David Pingree.[47] Other Sanskrit instruments were not discussed at all in any of the publications. A large group of over 200 Sanskrit astrolabes and other kinds of instruments are described here for the first time. As Derek Price aptly remarked, '[e]ach instrument is a valuable document in itself, yielding historical and scientific data often unobtainable elsewhere. … however … the full significance of any one instrument

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42 Francis Maddison allowed me in 1993 to copy the pages dealing with Indian instrument makers. In early 2013, somebody told me in Paris that the Répertoire was being printed, but I did not hear anything concrete thereafter.

43 See Sarma 2003, pp. 58-59.

44 Savage-Smith 1985.

45 Savage-Smith 1990.

46 Turner 1985.

47 Pingree 2009.

cannot be properly realised except by comparison with the corpus of all such instruments extant.'[48]

PRESENT CATALOGUE

The present descriptive catalogue aims to study each instrument in the context of all the related extant specimens. Therefore, each instrument type is organized in a separate section identified by the letters of the alphabet. These sections begin with introductory essays on the history of the instrument type and its varieties, followed by the catalogue of the extant specimens. There are also introductory essays on instrument makers. Extracts from some Sanskrit texts describing the construction and use of certain instruments will be given in appendices, together with translations. In the descriptions of individual instruments, all engraved data are reproduced and interpreted as far as possible.[49]

The Lahore instrument makers generally engrave their names and the year of production. Such instruments are arranged chronologically. But sometimes they omit the dates. Such pieces are arranged by the size. Several astrolabes and celestial globes carry neither names nor the dates, some of which can be attributed to a particular maker on stylistic grounds. These too are arranged by size.

Sanskrit instruments do not always carry the names of the makers and the dates of manufacture. Where these are available, the instruments are arranged in chronological order. Otherwise, sometimes instruments with similar features are grouped together, some other times according to the place of production and so on.

The listings in the CCA and in the Répertoire are not based on personal examination, but often on the basis of the data provided by the authorities of the collections. The CCA assigns sometimes two separate numbers to the same instrument, other times it wrongly attributes instruments to a specific collection. Such discrepancies are corrected to a certain extent in the Répertoire. Therefore, under each astrolabe, I

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48 Price 1955, p. 243.

49 The working conditions and the time at my disposal varied from place to place. In several museums, I had to study and photograph the instruments in the display rooms in the midst of visitors who paused to stare at me, or in the open sun. Consequently, the extent of my descriptions and the quality of my photos also vary.

give the reference number from both these compilations. Likewise, in the case of Indo-Persian celestial globes, I refer to the serial numbers in Emilie Savage-Smith's work with the prefix ESS. In this catalogue, each instrument is given an identification code, beginning with a letter of the alphabet and followed by a three-digit serial number. Instruments which I have personally examined are marked with the symbol ⊙. Thus the fitst entry in the catalogue is marked A011⊙.

A. INDO-PERSIAN ASTROLABES BY THE LAHORE FAMILY

عشق اسطرلاب اسرار خدا است

ᶜishq usturlāb isrār-i khudā ast

Love is the astrolabe of the mysteries of God.

— Jalāluddīn Rūmī (13th century)

यस्मिन् करामलकवद् विदिते विदितं भवेद् विश्वम्॥

yasmin karāmalakavad vidite viditaṃ bhaved viśvam

When you know the astrolabe well,
you will know the universe
like a fruit on the palm of your hand.

— Rāmacandra Vājapeyin (1428)

A Mirror for Mathematiques, a Golden Gem for Geometricians,
a Sure Safety for Saylors,
and an auncient Antiquary for Astronomers and Astrologians.

— Robert Tanner (1587)

INTRODUCTION

1. PLANISPHERIC ASTROLABE

The astrolabe is a highly sophisticated astronomical instrument of the Middle Ages, which held its sway from Geoffery Chaucer's England in the west to Firūz Shāh Tughluq's Delhi in the east.[50] It was widely used for observation and computation. As an observational instrument, it was employed in measuring the altitudes of the heavenly bodies and also for ascertaining the heights and distances in land survey. As a computational device, it can be made to simulate the vault of the heavens at any given locality and time. Then one can read off from the dial the time and also note the times of Islamic prayers. One can also directly read off the ascendant for that moment and the other three points where the ecliptic intersects the horizon and the meridian, without resorting to complicated calculations. The knowledge of the these four points (called 'pivots', *atwad* in Arabic) on the ecliptic is essential for casting horoscopes, or for determining the auspiciousness or otherwise of a given moment. More important, the astrolabe works as an analog computer and can be used to solve a number of trigonometrical problems. Jābir al-Ṣufī is said to have listed one thousand problems that can be solved with the astrolabe.[51]

No wonder, the Jaina monk Mahendra Sūri bestows on the astrolabe the Sanskrit name *yantra-rāja* (the king of instruments). Rāmacandra Vājapeyin declares that if one knows the astrolabe well, one will know the universe like a small fruit on the palm of one's own hand (*yasmin karāmalakavad vidite viditaṃ bhaved viśvam*). For Jalāluddīn Rūmī, the famous mystic poet, astrolabe is the sublime metaphor for measuring the immeasurable and for comprehending the incomprehensible. Thus he says: *ishq usturlāb isrār-i khudā ast,* 'love is the astrolabe of the mysteries of God.' Robert Tanner invested his book on the construction and use of the astrolabe with a double title, heaping

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50 The literature on the astrolabe is voluminous, running into some 2000 titles. For the best technical introduction, see Hartner 1968a; Hartner 1968b; North 1974; Pingree 1985; Turner 1985; Proctor 2005; Morrison 2007; Graaf 2011; an important Indian contribution is Khareghat 1950.

51 Michel 1976, p. 83, quips: 'We should be thanked for not taking up the 25 questions expounded by Severus Sebohkt about the year 650, the 43 of al-Khwārizmī about 840, the 21 of Hermann le Boiteux in 1054, the 64 of Blundeville in 1613, to say nothing of the 103 problems of Clauvious and 1000 of Jabir al-Suf.'

rhyming epithets on this wonder-instrument. He named the book *The Travailers Joy and Felicitie,* with a subtitle, *A Mirror for Mathematiques, A Golden Gem for Geometricians, A Sure Safety for Saylors, and an auncient Antiquary for Astronomers and Astrologians.*'[52]

The astrolabe, or more correctly the planispheric astrolabe, is the representation of the three-dimensional celestial sphere on a two-dimensional plane by stereographic projection. Stereographic projection is a projection of the sphere from one of its points onto the plane which is parallel to the plane tangent to that point. This projection has two essential properties. First, the circles on the sphere are projected on the plane as circles; or, if the circles on the sphere pass through the centre of projection, they are projected as straight lines. Second, the angles between intersecting circles on the sphere remain unchanged when projected on the plane.[53]

Besides the planispheric astrolabe, there are two other varieties, viz. the spherical astrolabe[54] and the linear astrolabe,[55] where the projection of the heavens is made respectively onto a sphere and onto a straight line. But these are mere theoretical curiosities and do not have much practical relevance. Therefore, generally whenever the word 'astrolabe' is used, it means the planispheric astrolabe.

Again, the planispheric astrolabe itself can be of different types. The most common type is the northern astrolabe (Arabic: *asṭurlāb shamālī*). Here the stereographic projections on the rete and on the plates are so made that the celestial North Pole becomes the centre of the astrolabe and the outermost periphery is formed by the Tropic of Capricorn. Therefore, on the rete of such an astrolabe, the positions of only those stars can be shown that lie to the north of the Tropic of Capricorn.

In the southern astrolabe (*asṭurlāb janūbī*), on the other hand, the centre is formed by the celestial South Pole and the outer periphery by the Tropic of Cancer. On its rete

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52 Printed at London in 1587; reproduced in facsimile in Gunther 1932, pp. 524-534.

53 Morrison 2007, pp. 45-57.

54 On spherical astrolabe, see Hartner 1968b, pp. 317-318; Maddison 1962; Canobbio 1976.

55 Morrison 2007, pp. 287-293.

can be shown those stars lying to the south of the Tropic of Capricorn and visible to an observer in the northern temperate zone of the earth.[56]

On the relative advantages of the two varieties, Henri Michel states as follows:[57]

> The sky north of the Tropic of Capricorn contains almost everything visible in northern temperate latitudes. Clearly, the northern astrolabe is much better suited for representing the stellar vault for the northern hemisphere, at least for us who live here.
>
> In both the northern and southern astrolabes the instrument provides the north face of the plane of projection. Therefore, we see constellations in the same order as on the southern astrolabe with the apparent motion of the heavens always moving clockwise and longitude and right ascension [increasing] in the opposite direction. The sense of declination is reversed in the southern astrolabe with positive declinations outside the equator.
>
> The southern astrolabe offers advantages if we consider only the apparent position of the Sun. The daily motion of the Sun in summer, when it is between the equator and the Tropic of Cancer, is projected along a longer arc than in winter and the Sun appears higher above the horizon. The apparent motion, therefore, approximates what we are accustomed to seeing. When construction of large clocks began in the fourteenth century, the clockmakers tried to reproduce the Sun's apparent motion. To this end, they used stereographic projection and gave preference to the southern astrolabe projection for these reasons. The oldest astronomical clocks were configured in this way. The primary use of southern astrolabe face has been on monumental clocks and few examples exist on hand held instruments.

The features of the northern and southern astrolabes are combined in the composite astrolabe, called the north-south astrolabe (*asṭurlāb shamālī wa janūbī*), so that it can display the stars belonging both to the northern and the southern celestial hemispheres. These last two varieties are again theoretical curiosities. Very few of such

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56 On southern astrolabes, see Morrison 2007, pp. 155-158.

57 Michel 1976, pp. 12-14.

southern or north-south astrolabes were actually manufactured. Thus the standard variety is the planispheric northern astrolabe. This is the type which was commonly used and which was produced in great numbers in all the cultures where the astrolabe was cultivated. Therefore, henceforth we use the expression 'astrolabe' in the sense of this standard astrolabe, viz. the planispheric northern astrolabe.

1.1. The Astrolabe in Antiquity

The astrolabe was invented in Hellenistic antiquity, but it is not known precisely when or by whom. However, the stereographic projection underlying the construction of the astrolabe is said to have been developed by Hipparchus of Alexandria in the second century BC. Claudius Ptolemy in the second century AD was familiar with the instrument but not with its present name. In the sixth century AD, John Philoponus of Alexandria wrote a treatise in Greek on this instrument; it is the earliest extant text to describe the construction and use of the astrolabe.[58] By this time, the astrolabe was fully developed, for Philoponus mentions all the principal components. In the seventh century, Bishop Severus Sabokt of Nisibis in Syria composed a treatise in the Syriac language, which also survives.[59] Otto Neugebauer is of the view that both these treatises were based on a fourth-century work by Theon of Alexandria which is no more extant.[60] Nor did any actual specimen survive from this period.

1.2. The Astrolabe in the Islamic World

From Hellenistic antiquity, the science of the astrolabe spread, through Syriac stages, to the Islamic world where it attained the highest popularity. Like much of Greek science and philosophy, the science of the astrolabe was also preserved, elaborated upon and disseminated further by the Islamic world.[61] By the ninth century, the astrolabe attained such a pre-eminent position in Islamic civilization that several treatises were

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58 Philoponus, 'Treatise on the Astrolabe. in: Gunther 1932, pp. 61-81; see also Drecker 1928.

59 Sabokt, 'Treatise on the Astrolabe' in: Gunther 1932, pp. 82-103.

60 Neugebauer 1949.

61 On the reception of Greek science in the Islamic world, see, among others, Gingerich 1986; Sabra 1987; Gutas 1998.

composed in this century in Arabic on this instrument.[62] It has been thought for long that Māshā'allāh, a famous astrologer and astronomer at the court of the Caliphs at Baghdad, composed one of the earliest treatises on the astrolabe which survives in Latin translations. But Kunitzsch has shown that 'nothing of the popularized treatise on the composition and the use of the astrolabe generally ascribed to Messahalla can be traced back to this author.'[63] However, there are several other works on the astrolabe that were composed in Arabic in the ninth century. Al-Khwārizmī (ca. 825) wrote two small treatises, one on the construction and the other on the use of the astrolabe. The larger one on the use of the astrolabe is the earliest extant Arabic text on this subject.[64] A literal translation of this treatise on the use of the astrolabe was incorporated in the *Sententie Astrolabii,* a Latin text which was compiled in Spain in the late tenth century. This is the oldest extant medieval western text on the astrolabe.[65] Of the other texts composed in Arabic in the ninth century, there survive a treatise, entitled *al-Kāmil,* by Aḥmad ibn Muḥammad ibn Katir al-Farghānī (ca. 857) on the construction of the astrolabe and another on its use by ᶜAlī ibn ᶜĪsa al-Asṭurlābī al-Ḥarrānī (ca. 880).[66] Al-Farghānī was at the court of the Abbasid Calif al-Ma'mūn in Baghdād; later he moved to Egypt where he composed the *al-Kāmil* in 7 chapters.[67] In the earlier chapters of this work, he discusses the mathematical principles of stereographic projection and provides elaborate tables to help the construction of astrolabes. In chapter 5, he teaches how to construct the northern astrolabe. Interestingly, in the following chapter, he also teaches the construction of the southern astrolabe. Al-Farghānī also compiled a set of tables to facilitate the production of latitude plates; these tables, containing over 13,000 entries,

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62 For an overview of the literature on the astrolabe, see Lorch 2005b.

63 Kunitzsch 1959.

64 It is edited with a translation and commentary by François Charette and Petra Schmidl; see Charette & Schmidl 2004.

65 Kunitzsch 1989d.

66 For an excellent overview of the extant treatises on the astrolabe and of the actual specimens in the Islamic world and in Europe, see Stautz 1999, pp. 1-98.

67 Arabic text, edited with translation by Lorch 2005a.

provide the radii and centre distances of altitude circles and azimuth circles for each degree of altitude and each degree of azimuth, for each degree of terrestrial latitude.[68]

In the production of the astrolabe also, the Islamic world achieved high excellence. Indeed, the production of precision instruments can be said to originate in the manufacture of astrolabes in the Islamic world. Thus the Islamic world did not just receive and preserve the science of the astrolabe, which in itself would have been remarkable. It made significant contributions to the theory and practice of the astrolabe. Moreover, the Islamic world also disseminated the science of the astrolabe, westwards up to England and eastwards up to India. As North observes, '[b]efore the end of the 13th century the planispheric astrolabe was known and used from India in the east to Islamic Spain in the west, and from the Tropics to northern Britain and Scandinavia.'[69] Therefore, the astrolabe can be regarded as the finest gift of the Islamic world to scientific instrumentation. Oliver Hoare has correctly observed that '[t]he ability of Islamic civilization to perfect what it inherited, and to endow what it made with beauty, is nowhere better expressed than in the astrolabe.'[70]

In the Islamic world, the astrolabe (*aṣturlāb* or *aṣṭurlāb*) and the celestial globe (*al-kura*) were the most popular astronomical instruments, and the usual mode of describing a good astronomer was to say that he was adept in the use of the astrolabe and the celestial globe. Astrolabe making became an important profession in the ninth century and the sobriquet *al-Asṭurlābī* indicated a high professional status because the construction involved not just skill in metal-craft but also sound knowledge of astronomy and trigonometry.

Of the early astrolabes made in the Islamic world, there survive some Abbasid astrolabes, but these are not dated.[71] The earliest dated astrolabe which is extant is by Muḥammad ibn ᶜAbd-Allāh Nasṭūlus. Four astrolabes by him are known. One of these is dated in 315 AH (AD 926-27). It is preserved in the Islamic Archaeological Museum,

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68 King 1987b, p. 5.

69 North 1974.

70 Oliver Hoare, in: *The Unity of Islamic Art,* Riyadh 1985, p. 81, cited by King 1995, p. 76.

71 One of these is described by King 2005, pp. 402-437: 'The oldest known astrolabe from the late 8th-century Baghdad'

Kuwait. It has a diameter of 173 mm. The rete and alidade are lost, but the mater and one plate are extant. The two sides of the plate are calibrated for latitudes 33° (Baghdad, Damascus) and 36° (Mosul, Rayy, middle of the fourth climate). The rim of the front is marked for 1° and 5°. On the back, there are four altitude scales on the rim and one circular shadow scale. Otherwise, the back is blank.[72]

The second astrolabe by Nasṭūlus is in Cairo; here only the mater survives with a gazetteer on the front and trigonometric quadrants on the back. The third astrolabe is said to be in London; the rete and alidade are missing; there remain two plates for latitudes 31°, 32°, 33° and 34°. The fourth one, now at the Museum of Islamic Art in Doha, Qatar, is engraved with concentric solar and calendar scales on the rim in the front. It is not exactly an astrolabe in the conventional sense; it is made more for trigonometric and calendrical calculations.[73]

The few surviving astrolabes and their fragments from the ninth century are somewhat plain devices without any ornamentation. Real ornamentation and sophisticated design began to develop in the tenth century. In this connection, the astrolabe made in 374 AH (AD 984-85) by Ḥāmid ibn Khiḍr **al-Khujandī** with elegantly designed rete and throne represents an important landmark in astrolabe production.[74] Khujandī was an eminent astronomer, mathematician and instrument maker. He constructed a large sextant, with a radius of over 20 metres at Rayy (near modern Tehran) and named it *Suds Fakhrī* (Fakhrī sextant) after his patron Fakr al-Dawla, the Buyid ruler of Iran (r. 977-997).[75] With this sextant, he determined the obliquity of the ecliptic as 23;32,21°.[76]

In contrast, the astrolabe he made is rather small with a diameter of 151 mm, but he equipped it for the first time with many features which were taken up by the

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72 King 1995, pp. 76-83.

73 Described in King 2008, where references are made to the second and third astrolabes.

74 Described and illustrated in King 1995 and more elaborately in King 2005, pp. 503-517; 940-941; see also Graaf 2011.

75 This sextant does not exist anymore; a similar sextant, of twice this size, was erected in 1420 in the Samarqand observatory, which is now in ruins. The only extant functional specimen of the Fakhrī sextant can be seen in Jai Singh's observatory at Jaipur under the name *Vṛtta-ṣaṣṭāṃśa-yantra*; cf. Sarma 1986-87b.

76 King 1995, p. 83.

subsequent astrolabe makers, in particular, by the Lahore family of astrolabe makers. King considers that this astrolabe 'represents the culmination of known Muslim achievements in astrolabe construction in the early period.'[77] The *kursī* is worked *à jour* with two lion's heads facing each other. In the rete also attempts are made to make it ornate with six star pointers shaped like bird's heads with long beaks. In the vertical axis are incorporated a quatrefoil, an ornament shaped like an inverted heart with little wings on either side, and a crescent. There are 33 star pointers, which is a fairly large number.

While the five plates serve latitudes 21°, 27°, 30°, 33°, 36° and 39°, projections for latitude 42° are engraved on the inner side of the mater. More important, there are four plate faces which occur here for the first time. The first is a plate for multiple horizons with declination scales, which was orgiginally invented by Ḥabash al-Ḥāsib at Baghadad in the ninth century. The second is a plate for the complement of the obliquity. Taking the obliquity as 23;33°, Khujandī designed the plate for latitude 66;27° (i.e., 90° – 23;33°) with a maximum duration of the daylight 24 hours. On the back of this plate is a double projection for 0° and 90°; here the maximum lengths of the daylight are stated to be 12 hours and 6 months respectively. These serve mainly pedagogic purposes and satisfy intellectual curiosity.

Another plate which also occurs for the first time is marked with astrological houses, each divided into decans, for the latitude of 33° (Baghdad). King states that the plate 'serves to facilitate the otherwise laborious computations relating to the astrological doctrine of casting the rays and is so designated in the cartouche (*maṭraḥ al-shuᶜāᶜ wa-huwa 'l-tasyīrāt*).'[78]

On the back, altitude scales are drawn on the upper half of the rim and a cotangent scale for a base of 12 on the lower half. In the upper left is a trigonometric quadrant with 90 horizontal lines. In the upper right is a solar quadrant with declination arcs upon which a horary quadrant for latitude 33° is superimposed. In the lower half there are several astrological tables in 8 semi-circular scales, containing the names of the 28 lunar

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77 King 1995, p. 83.

78 King 2005, p. 514.

mansions; the names of the 12 zodiac signs; the limits of signs and their regents; the regents of the decans; triplicities and the diurnal and nocturnal regents. As will be seen later, many of these features are emulated in the Lahore astrolabes.

In the subsequent centuries, astrolabe production spread to different centres which in course of time developed regional variations in technical details and ornamentation, especially in the Eastern (*Mashriq*) and the Western (*Maghrib*) parts of the Islamic world.[79]

1.3. The Astrolabe in Europe

From the Islamic world, the astrolabe was transmitted to Europe through Catalonia in Spain where a large number of Arabic texts were translated into Latin. Kunitzsch remarks that '[t] he oldest Latin texts on the astrolabe from the late tenth century show that those Christian scholars had at their disposal both Arabic texts and instruments and, as it seems, also the help of native speakers of Arabic.'[80] One of the earliest Latin treatises on the use of the astrolabe is attributed to Gerbert of Aurillac, who later became Pope Sylvester II (930-1003).[81] It has already been mentioned that one of the earliest compilations made in Latin was the *Sententie Astrolabii* and that its third section dealing with the uses of the astrolabe was a literal translation of a treatise by Al-Khwārizmī.

In the subsequent centuries, the science of the astrolabe spread to much of Europe where a large number of treatises were composed. Notable among them is *A Treatise on the Astrolabe,* also known as *The Conclusions of the Astrolabie* or *Bread and Milk for Children,* composed by Geoffrey Chaucer about 1393. Instead of the customary practice of writing scientific texts in Latin, Chaucer was the first to write such a text in English, for the sake of his son Lewis, whom he addresses thus at the beginning of the work:

> Little Lewis my son, I perceive that thou wouldst learn the Conclusions of the Astrolabe; wherefore I have given thee an instrument constructed for the latitude of Oxford, and propose to teach thee *some* of these conclusions. […] This treatise, divided into five parts, I write for thee in English, just as

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79 For a fine analysis of these regional variations, see Gibbs & Saliba 1984, pp. 22-60.

80 Kunitzsch 1998, p. 114.

81 Bianchini & Senatore 2016.

> Greeks, Arabians, Jews, and Romans were accustomed to write such things in their own tongue. I pray all to excuse my shortcomings; and thou, Lewis, shouldst thank me if I teach thee as much in English as most common treatises can do in Latin.[82]

Production of the astrolabe also spread to other European countries, gradually giving rise to regional variations as in the Islamic world. The earliest extant European astrolabe is known as the Carolingian astrolabe. It was produced in the late tenth century in Catalonia, in Spain.[83] Astrolabe production reached its highpoint in Renaissance Europe, where some of the artistically beautiful specimens were produced, notably in Prague by Erasmus Habermel, the instrument maker of Rudolph II, towards the end of the sixteenth century.[84]

The astrolabe was popular in Europe up to the seventeenth century until the invention of the telescope. But it left a permanent imprint in another respect. A large number of Arabic technical terms which reached Europe through the astrolabe still survive in all the European languages. Thus, for example, 'zenith,' 'nadir' and 'azimuth' are derived from the Arabic.[85] Several of the star names used in European languages are likewise directly taken from the Arabic astrolabes, such as 'Altair' (from *al-Nasr al-Ṭā'ir* for α Aquilla), 'Caph' (from *Kaff al-Khaḍīb* for β Cassiopeiae), or 'Algol' (from *Ra's al-Ghūl* for β Persei) and so on.

1.4. The Lahore Family of Astrolabe Makers

The astrolabe may have been introduced into India in the eleventh century by Al-Bīrūnī who wrote extensively on this instrument. In the following centuries, scholars migrating from Central Asia to the court of the Sulṭāns at Delhi brought astrolabes with them and employed them here. The manufacture of the astrolabe appears to have commenced in India in the second half of the fourteenth century under Sulṭān Fīrūz Shāh Tughluq (r. 1351-1388). The *Sīrat-i Fīrūz Shāhī*, an anonymous chronicle of his rule

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82 This is a paraphrase in modern English of Chaucer's Middle English, by Skeat, cf. Chaucer, pp. 175-176.

83 King 1996b.

84 For an overview of European astrolabes, see Gunther 1932; Stautz 1999, pp. 65-98.

85 Kunitzsch 1982; Kunitzsch 1984.

composed in 1370, has a long account on the astrolabes manufactured under instructions from Fīrūz.[86] However, none of these astrolabes survive today. Fīrūz also sponsored the composition of manuals on the astrolabe both in Persian and Sanskrit. The Persian manual does not survive any more save in extracts in the *Sīrat-i Fīruz Shāhī*. The Sanskrit manual entitled *Yantrarāja* , which was composed by a Jaina monk Mahendra Sūri in 1370, is extant and published.[87]

The earliest extant astrolabes in India pertain to the Mughal period. Among the Mughal emperors, Humāyūn (r. 1530-1556) was much interested in astronomy, astrology and astronomical instruments.[88] He is said to have 'extra-ordinary excellence in the astrolabe, globe and other instruments of the observatory.' Abū al-Faḍl, minister and chief chronicler of Humāyūn's son Akbar, speaks in glowing terms of Humāyūn's interest in astronomy. At one place he refers to Humāyūn thus: 'His Majesty, who in astrolabic investigations and studies in astronomical tables and observations was at the head of the enthroned ones of acute knowledge and who was a second Alexander....'[89] Elsewhere, employing an astrolabic metaphor, he calls Humāyūn 'the alidade of the astrolabe of theory and practice.'[90] Under Humāyūn's patronage, manufacture of astrolabes and celestial globes commenced at Lahore.[91]

The master craftsman (*ustād*) Allāhdād of Lahore and his descendants of four generations dominated the production of astronomical instruments in Mughal India in the second half of the sixteenth century and in the seventeenth century. [92] Neither the names of any members of this Lahore family, nor the instruments produced by them are mentioned in the contemporary documents. The history of this family and of their work

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86 Sarma 2000.

87 Mahendra Sūri

88 On his interest in astrology, see Orthmann 2008.

89 Abū al-Faḍl 1, p. 123.

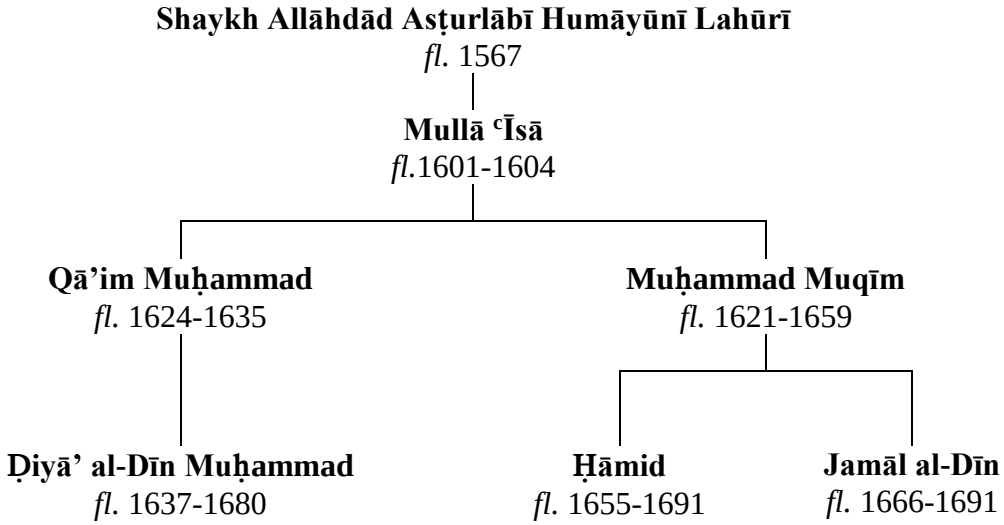
90 Abū al-Faḍl 1, pp. pp. 283-284.

91 Abū al-Faḍl 1, p. 52, states that Mawlānā Maqṣūd of Herat, who was at the court of Humāyūn, made astrolabes and globes which were much admired by people. But none of his instruments survived.

92 Sarma 1994d.

is reconstructed entirely from the signatures of their dated instruments. The credit for discovering the family goes to Sayyid Sulayman Nadvi.[93]

There exist two astrolabes bearing the name of the patriarch Allāhdād (*fl.* 1567). One of these also carries the year of manufacture as 975 Hijrī (AD 1567/58). This is in fact the earliest extant astrolabe produced in India. Allāhdād's son ʿĪsā (*fl.* 1601-1604) is known through three astrolabes. ʿĪsā had two sons, Qā'im Muḥammad (*fl.*1624-1635) and Muḥammad Muqīm (*fl.*1621-1659). Four astrolabes and four celestial globes signed by Qā'im Muḥammad survive. Qā'im's younger brother Muqīm and Qā'im's son Ḍiyā' al-Dīn Muḥammad (*fl.*1637-1680) were very prolific instrument makers. While at least thirty-three astrolabes and one celestial globe crafted by Muḥammad Muqīm are extant in different collections throughout the world, his nephew Ḍiyā' al-Dīn's signature adorns thirty-four astrolabes and eighteen celestial globes. In comparison, Muqīm's two sons, Ḥāmid (*fl.* 1655-1691) and Jamal al-Dīn (*fl.* 1666-1691) have a more modest output. Eleven astrolabes and three celestial globes by Ḥāmid are extant, while Jamāl al-Dīn is known through just four surviving astrolabes. Besides these, there are several unsigned specimens which can be attributed to this family for stylistic reasons.



It is also necessary to stress that the instruments made by them are not mass products cast in the same mould. In fact, each instrument is a unique piece as regards the size, decorations, ornaments and configuration of the various technical elements. In

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93 Sarma 1994d.

the medieval period there has been no other family anywhere, comparable to this one in the long continuous family tradition of instrument making, in the large number of instruments produced, in the artistic and technical excellence of production, or in the innovation in design.

The standard northern astrolabes produced by the members of this family distinguish themselves by the high degree of precision in the engraved stereographic projections and by the pleasing floral traceries used to connect the star pointers on the rete, with a matching design on the *kursī*. The members of this family also show a marked predilection for unusual projections invented in Andalusia in the tenth and eleventh centuries, which they incorporated in some of their standard astrolabes. These will be discussed later.

Obviously the Lahore family had a very discerning clientele among the Mughal nobility to appreciate these innovations. For these dignitaries the astrolabists fashioned highly ornate astrolabes of large dimensions, some inlaid with silver, others with gilded plates, yet others with unusual projections.

In their signatures on the astrolabes and celestial globes made by them, the members of the family refer to themselves proudly as the descendants of Allāhdād Lāhūrī Asṭurlābī Humāyūnī, 'Allāhdād of Lahore, astrolabe maker to the Emperor Humāyūn'. The only dated astrolabe by Allāhdād, the patriarch of the family, was produced in 1567, i.e., eleven years after Humāyūn's death, but that does not preclude the possibility of his producing astrolabes in Humāyūn's lifetime for the use of the emperor. The two extant astrolabes by Allāhdād (A001 and A002) are fairly large instruments in which the prime vertical, the oblique horizon, and the curves for equal hours as counted from the western and eastern horizons are inlaid with silver on all the latitude plates. Surely these astrolabes were not meant for common astrologers/astronomers, but for men of rank.

Qā'im Muḥammad is said to have begun the casting of celestial globes in one single hollow piece by *cire perdue* method. He made one such celestial globe in the eighteenth regnal year of Jahāngīr (1622) for Nawāb Iʿtiqād Khān, brother of Nūr Jahān

Begum, the consort of Jahāngīr.[94] He also fashioned a fabulous astrolabe in 1627 for Nawāb Khwajā Abū al-Ḥasan, a high dignitary at the court of Jahāngīr. Just the rete of this astrolabe survives at Patna: in this unique rete the star pointers are joined not by the usual floral tracery but by a calligraphic design which mentions the year of production in Jahāngīr's regnal years and in Hijrī years and the name of the dedicatee (A011).

Ḍiyā' al-Dīn also fabricated unusual instruments for high nobility. In 1679, he made a celestial globe for Emperor Aurangzeb; here the outlines of the constellations figures are cut out in such way that, when the globe is lit from inside, they would appear as silhouettes. Star positions are marked with tiny holes so that they would sparkle when the globe is lit from inside.[95] In the following year he made a huge *Zarqālī* universal astrolabe for Nawāb Iftikhār Khān, the Fauzdār of Jaunpur (A091).

Such royal patronage clearly promoted the production of very large astrolabes with lavish ornamentation and technical virtuosity. The astrolabes of this Lahore family are masterpieces of Mughal metal-craft and scientific instrumentation. In the astrolabes by Muqīm and Ḍiyā' al-Dīn which are now preserved in the Salar Jung Museum at Hyderabad and in Jai Sigh's Observatory at Jaipur, the latitude plates look as if they were gilded or rubbed with gold dust. At my request, Mr. C. P. Unniyal, the chemist of the Salar Jung Museum, examined the Mughal astrolabes at his museum. He writes: 'The inner parts, which remained unexposed, clearly show remnants of surface gilding effect. This has been produced by smearing gold powder over the bronze or brass surface to enrich the surface looking like golden rather than true gilding.'[96]

It is quite likely that this activity of producing highly ornate astrolabes in Mughal India influenced the revival of astrolabe making in Safavid Persia, in the seventeenth and eighteenth centuries.[97]

Around 2004, Brian Newbury made a metallographic analysis of eight Lahore astrolabes from the Adler Planetarium, Chicago, by applying a new non-destructive

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94 The globe is in the Stonyhurst College Library, Lancashire, UK; see Savage-Smith 1985, catalogue no. 11, p. 224, Figure 12 on p. 37.

95 Savage-Smith 1985, catalogue no. 30, pp. 232-33, Figure 17 on p. 42.

96 Unniyal 1994-95.

97 Maddison 1963, p. 26.

technique of high-energy synchrotron x-ray analysis.[98] Since this technique can be applied only to two-dimensional flat objects, only the maters, retes and plates of the astrolabes were examined.

The analysis revealed that some of these parts have a higher content of zinc than the brass produced by traditional methods.[99] The brass used for these parts (referred to as $\alpha + \beta$ alloy) must have been produced by co-melting copper and metallic zinc. The high percentage of zinc facilitates the fabrication of thin metal sheets from thicker ones by repeated hammering, but without frequent heating. Metallic zinc was produced in Zawar in Rajasthan from the thirteenth century onwards; these astrolabes provide the first datable evidence for brass production by direct alloying of copper and zinc, a process which was unknown in Europe until the nineteenth century.

2. Components of the Astrolabe

Now we describe the various components of the astrolabe and, while doing so, draw attention to the special characteristics of the Lahore astrolabes. The *Sīrat-i Fīrūz Shāhī,* an anonymous chronicle composed at the court of Fīrūz Shāh Tughluq in 1370 states that the astrolabe consists of twelve components: ring (*ḥalqa*), shackle (*ʿurwa*), rivet (*mismār*), throne (*kursī*), mater (*umm*), rim *(ḥajra*), plates (*ṣafāʾiḥ*), rete (*ʿankabūt*), alidade (*al-ʿiḍāda*), pin (*quṭb*), sighting plates (*libna*) and horse-shaped wedge (*faras*).[100]

2.1. The Suspension Apparatus

The main component of the astrolabe is a heavy circular plate with a raised rim all around on one side. In the recess formed by the rim, the heavy plate carries a series of circular discs, just as the mother carries the child in her womb. Therefore, this heavy plate is called *umm* in Arabic and ‘mater’ in Latin and in English. For observation, the mater has to be suspended vertically and, to sight the desired heavenly body, it has to

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98 Cf. Newbury 2006. Two of the these are by ʿĪsā (A005and A006) and the rest by, or attributable to, Ḍiyā’ al-Dīn Muḥammad (A059, A061, A077, A086, A096and A104).

99 The results of the analysis are given in Table 2 (Newbury 2006, p. 210). They show that in these 8 astrolabes, 4 maters are made of $\alpha + \beta$ alloy and 4 are not; 5 retes are made of $\alpha + \beta$ alloy and 4 are not. In A096 and A104, some plates are made of $\alpha + \beta$ alloy, whereas in the rest of the six astrolabes, all the plates are made of this alloy.

100 Sarma 2000.

be turned around the vertical axis. For this purpose, the mater requires a suitable suspension apparatus, consisting of a suspension bracket, a shackle and a ring. The suspension bracket, usually of a triangular shape, is attached to the top of the mater. Generally, the mater and the suspension bracket are cast together as one piece. In some early Islamic astrolabes, the throne verse (*āyat al-kursī*) from the *Qur'ān* (Surah 2:255) is engraved on the suspension bracket, which reads: 'His throne extends over the heavens and the earth'. Therefore, the suspension bracket is called *kursī,* or throne. To the top of the *kursī* is attached a shackle (*ʿurwa*) which has a shape like the upturned Roman character U, with a circular upper part and two straight legs. The ends of the legs or bases are firmly affixed to the top of the *kursī* by means of a rivet (*mismār*). A ring (*ḥalqa*) passes through the shackle. The astronomer pushes his thumb through the ring and lets the astrolabe hang freely. Sometimes, a silken cord (*ʿilaqa*) is also attached to the ring.

This suspensory apparatus allows the instrument to be suspended so that it remains perfectly vertical and can be swung in a circle about its axis, which is perpendicular to the local horizon. This ensures that the east-west line drawn on the back of the astrolabe and also on the plates remains parallel to the local horizon. In Lahore astrolabes, the shackle has invariably a trifoliate shape; this ensures that the ring remains always in the upper loop of the shackle.



Figure A1 – Trifoliate shackle, openwork *kursī,* lobed profiles
in an undated astrolabe by Allāhdād (A002) (photo by S. R. Sarma)

The *kursī* is relatively high and its two profiles are formed by a series of ogees and lobes with a trifoliate finial.



Figure A2 – Trifoliate finial, solid *kursī* with decorative engravings on the surface in an undated astrolabe by Muqīm (A036) (photo courtesy Dr Naseem Naqvi)

The body of the *kursī* is generally cut *à jour* in an artistic floral pattern. Muqīm likes to fashion his *kursīs* with a series of bell-shaped flowers, or tulips, with two flared petals, one petal long and another short, in such a way that the edges of the petals form the profiles of the *kursī.* Sometimes, the surface on both sides is engraved with decorative lines. Occasionally, cartouches are incorporated in the middle of the *kursīs,* for writing the names of the owners. No other inscriptions are engraved on the *kursīs.*

2.2. Limb

The upraised rim on the mater is called *ḥajra* or limb. The surface of the rim is graduated for 360 degrees of the circle and numbered in a clockwise direction in *Abjad* notation, starting from the south point. The south point is situated at the top of the rim just below the throne. With regard to the points of the compass, it must be noted that the Arabs followed a convention that is quite opposite to that in modern maps. In Arabic maps, and also in astrolabes, the point at the top represents south and the point to the proper right is the east.

In Lahore astrolabes, the degree scale consists of two concentric rings. The narrow inner ring is divided in single degrees of arc. In the wider outer ring, groups of 5° or 6° and numbered in *Abjad* notation. Numbering in 5s or 6s begins at the south point and proceeds clockwise. The numbering can be continuous from 5 or 6 up to 360; in some astrolabes, the numbering is done separately in each quadrant, starting from 5 or 6 and reaching clockwise up to 90.

2.3. Rete

Of the plates stacked in the hollow space inside the rim, the uppermost one is called rete or spider (*ᶜankabūt*). It is a perforated or openwork plate containing the ecliptic, the equator and the tropics of Capricorn and Cancer. Against the projection of these circles, there is a star map with pointers (*shaẓiya,* plural *shaẓāyā*) indicating the positions of some bright stars situated close to the ecliptic on the north and the south.

The rete consists primarily of two rings, a peripheral ring which contains the circle of the Tropic of Capricorn and the zodiac or ecliptic ring placed inside off centre. The ecliptic ring is represented completely, but the upper portion of the outer ring is cut off, leaving open the two ends to the east and west of the ecliptic ring. These two rings are held together by an east-west bar and south-north bar, which carry the lines of the equinoctial colure and the solsitial colure respectively. For the sake of balance, so that the rete remains steady at any given position, the two bars are designed with counter changes. Other circles like the celestial equator and the Tropic of Cancer may be represented partially on segments of rings or not at all. To the north and south of the ecliptic ring, the positions of certain bright stars are marked and these points are joined to the mainframe by different forms of supports. Leaving out these rings and straight bars, the rest of the plate is cut off so that the markings on the plate lying beneath the rete can be read.

In the ecliptic ring, the outer rim constitutes the circle of the ecliptic which is the apparent path of the sun through the year. The ring is divided into the twelve signs of the zodiac, and the names of the twelve signs (*al-Ḥamal, al-Thawr, al-Jawzā', al-Saraṭān, al-Asad, al-Sunbula, al-Mīzān, al-ᶜAqrab, al-Qaws, al-Jadī, al-Dalw* and *al-Ḥūt*) are engraved on each division, starting from the vernal equinox (situated at the intersection of the equinoctial colure and the ecliptic circle in the east) and proceeding in an anticlockwise direction. Again each sign is divided into groups of 6 or 5 degrees. The outer rim is divided into single degrees. To the first point of Capricorn is attached a small pointer which aligns the ecliptic ring to the degree scale on the limb. This pointer

is called *al-mūrī r'as al-Jadī* or simply *al-mūrī.* This may be called in Capricorn index in English.[101]

A knob (*mudīr*) is affixed at some point on the outer ring to rotate the rete to the desired position. By rotating the rete, one can see the stars rising above the eastern horizon, culminating on the meridian or setting below the western horizon.

The manner in which the star pointers are shaped and joined to the main frame is determined by the artistic inclinations of the astrolabe maker, who exhibits his artistic skills in fashioning the throne and the rete. In the Mughal astrolabes the star pointers are joined by floral traceries. A common motif is a bell-shaped flower with two flared petals, the tip of the longer petal representing the star position. This motif occurs already in the undated astrolabe by Allāhdād (A002) and is copied by his descendants in innumerable variations. These flower- or leaf-shaped star pointers and their tendrils are arranged in multiple varieties of traceries, but care is always taken to see that the tracery is almost symmetric on both sides of the meridian, so that the rete is evenly balanced in weight. The names of the stars are engraved on the leaves or flowers containing the star pointers. Since the Lahore astrolabists enjoy complex constructions, they fill the retes with dozens of stars, although few would have sufficed for actual observation.

The **star names** are in Arabic. While engraving these names, the Lahore astrolabe makers do not quite adhere to the proper usage. Because of the limited space available for engraving, or even otherwise, the Arabic definite article *al-* is often omitted. The term *ra's* (head) is usually transcribed as *rās*; thus the prominent star Algol (β Persei) which occurs in almost every astrolabe is labelled as *rās al-ghūl* instead of *ra's al-ghūl.* Epithets in masculine gender are added to feminine nouns; thus the stars α and β in the constellation Libra are labelled respectively as *Kiffa Janūbī* and *Kiffa Shamālī* and not as *Kiffa Janūbiya* and *Kiffa Shamaᶜāliya* with feminine epithets; likewise ε Cancri is named *Nathra Saḥābī.* Finally, Procyon carries the label *Shiᶜrā al-Shāmī* and not *Shiᶜrā al-Shaᶜāmiya.* However, in order to retain the peculiarity of the usage, the engravings are transliterated exactly, without making any attempt at assimilation or vocalization.

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101 Turner 2015.

2.4. Plates

Beneath the rete are housed a series of plates, also called tympans, discs or tablets (singular *ṣafīḥa;* plural *ṣafāᶜiḥ*), which are specific to certain terrestrial latitudes.[102] While the rete represents the stellar heavens, the plates represent the earth at different latitudes. Together, they simulate the stars above a particular terrestrial latitude at a given time.

While the rete in the front and the alidade at the back must be free to rotate around the centre, the plates must stay firmly in position inside the rim of the mater. For this purpose, each plate is provided with a projecting tab, which fits into a slot cut into the thickness of the rim. This system is reversed in the astrolabes produced in India. In Indian astrolabes, the rim has the projecting tab at the north point which fits into the slot cut in the plates at the corresponding place.

2.4.1. Latitude Plates

The projection on the plates varies according to the terrestrial latitude of the place where the astrolabe is used. Therefore, several plates are made with projections suitable to different latitudes, so that the astrolabes can be used at different places, usually from Mecca to Samarqand. On these plates are drawn, as on the rete, concentric circles to represent the Tropic of Capricorn (*madār al-jadī*), the tropical equator (*madār al-ḥamal wa al-mīzān*) and the Tropic of Cancer (*madār al-saraṭān*), and the vertical and horizontal diameters. The horizontal diameter represents the horizon at the equator. These circles and the lines are common to all the latitude plates.

Then on each plate are traced, relative to its latitude, stereographic projections of the local or oblique horizon (*ufq,* or *ufq al-mashriq wa al-maghrib*), equal altitude circles, azimuth arcs, lines for seasonal hours, lines for equal hours, and so on. The point where the horizontal diameter, the oblique horizon and the equator intersect in the east is designated as the east point (*nuqṭat al-mashriq*) and the corresponding point on the west the west point (*nuqṭat al-maghrib*). On astrolabes, these two points are labelled respectively as *al-mashriq* and *al-maghrib.*

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[102] On the plates, see Hartner 1968, 293-299; Morrison 2007, pp. 58-63; 67-94.

The **equal altitude circles** or almucantars (*al-dā'ira al-muqanṭara*) are circles parallel to the local horizon drawn from the horizon up to the zenith (from Arabic *samt al-ra's,* 'the direction of the head'). The intervals at which these circles are drawn depends on the size of the astrolabe. On very large astrolabes, they are drawn for every degree; on smaller ones at intervals of 2°, 3°, 5° or 6°. Astrolabes are classified according to the number of altitude circles. Astrolabes with 90 circles drawn for every degree are called complete, perfect or solipartite (*tāmm*), those with 45 circles at intervals of 2° are called bipartite (*niṣfī*), with 30 circles at intervals 3° tripartite (*thulthī*), with 18 circles at intervals of 5° quinquepartite (*khumsī*), and with 15 circles at intervals of 6° sexpartite (*sudsī*).[103] The altitude circles are numbered on both sides of the meridian, so that it becomes easy to read them when the sun or the star is on the eastern or in the western horizon.

In a few astrolabe plates twilight or crepuscular arcs are drawn at 18° below the oblique horizon to help in determining Islamic prayer times.

Equal **azimuth circles** (from *al-sumūt,* plural of *samt,* 'direction') are the great circles passing through the zenith and the nadir; when projected on the astrolabe plate, they radiate from the zenith at appropriate intervals depending on the size of the astrolabe. On some plates, these are drawn above the local horizon, on some below the local horizon, and on others both above and below the horizon. These are also drawn at appropriate intervals depending on the size of the astrolabe. These are numbered from the east and west points up to the north and south points. From the observer's point of view, the altitude circles and the azimuth arcs are mutually perpendicular and the grid formed by them can be used to define the position of a star.

Lines for the seasonal and equal hours are drawn below the local horizon, in the space between the two tropics. **Seasonal or unequal hours** (*al-sāᶜāt al-zamāniya*) are the twelfth parts of day or of the night and vary from season to season. In the Middle Ages time was reckoned, in the daily life and in religious rituals, in these seasonal hours both in the Islamic world and in Christian Europe. These are counted from the sunset at night and from the sunrise in the day; in the Islamic world the day (i.e. the combined

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[103] Hartner 1968, p. 296.

unit of day and night) is counted from the sunset. The lines for the seasonal hours are drawn by dividing the arcs of the two tropics and the arc of the equator lying below the oblique horizon into 12 equal parts and by joining the corresponding points in the three arcs. These are numbered from the western horizon to the eastern horizon from 1 to 12 and serve for counting the hours both at night and in the day.

Equal hours (*al-sāᶜāt al-iᶜtidāl*) are the twenty-fourth parts of the day and night and were used for astronomical purposes. These are constructed by dividing the complete circles of the two tropics and of the equator into 24 equal parts, starting from the point of intersection with the western horizon, and by joining the corresponding points in the three circles. Occasionally the equal hour lines are drawn from the western as well as from the eastern horizon. The lines of the unequal hours and the lines of the equal hours intersect at the equator. Generally the lines of the equal hours are drawn as dotted lines to distinguish them from the lines of unequal hours.

In the space between the oblique horizon and the lower part of the Tropic of Cancer are engraved, on either side of the vertical diameter, the latitude (*al-ᶜarḍ*) for which the plate is calibrated and the maximum duration of the daylight hours (*al-sā'āt*) at that latitude. These values are also recorded in *Abjad* notation. However, on several Lahore astrolabes, care is not taken in recording the correct values of the daylight hours.[104]

In about a dozen astrolabes by Qā'im Muḥammad, Muqīm and Ḍiyā al-Dīn, **lines for *ghaṭīs*** of 24 minutes are also drawn in addition to the lines for equal and unequal hours. *Ghaṭīs* are the traditional units of time in India and the Muslim rulers and common citizens of India adopted them for their secular activities. These are equal units; two and a half *ghaṭīs* make one equal hour. Therefore on some large astrolabes, the lower half of certain plates is cluttered with lines for unequal hours, equal hours and *ghaṭīs*. Usually these lines are drawn on the plates for the latitudes of the three Mughal

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[104] Sometimes just the hours are engraved without the minutes; many times the recorded values of hours and minutes are not correct. Such cases occur often in astrolabes made by Muqīm, e.g., A023, A024, A026, A029, A031 and so on. Ḍiyā' al-Dīn's astrolabes are generally free of this defect; the only cases noticed are in A095, A099, A100 and A101 which are not signed by Ḍiyā' al-Dīn, but are attributed to him. Ḥāmid's astrolabes are also free of this defect; in fact, he mentions the maximum duration in hours, minutes and seconds. Of astrolabes by Jamāl al-Dīn, information is available only of A121; here the maximum duration is mentioned only in hours.

Imperial cities, namely Agra at 27°, Delhi at 29° and Lahore at 32°, but sometimes, other plates are also engraved with such lines (for example, in A051 and A096). Moreover, in the middle of some plates, the duration of the longest day is also expressed in *ghaṭīs* (spelt there as *karīhā*).[105] Strangely in almost all cases, the *ghaṭī* values do not match with the values in hours. This is inexplicable because hours and *ghaṭīs* are in a simple ratio of 60 : 24 or 5 :2.[106]



Figure A3 – Plate for 32° in astrolabe A014 by Qā'im Muḥammad (photo S. R. Sarma).

In Fig. A3 above, the *ghaṭī* lines are dotted;and numbered in *Abjad* from the western horizon, from 1 to 35, below the circle of equator. Plain lines are for seasonal hours; these are numbered in common Arabic/Persian numerals, from 1 to 12, close to the periphery. In the middle of the plate is written *al-ᶜarḍ 32* and *karīhā 35* (latitude 32, *ghaṭīs* 35). In other astrolabes, the duration of the longest day at latitude 32° is given consistently as 14;8 hours; this is equivalent to 35;20 *ghaṭīs* and not just 35 *ghaṭīs*.

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105 These astrolabes are A014, A015, A051, A064, A067, A072, A096, A104 and A112.

106 Equally inexplicable is that in Sanskrit astrolabes also, as will be shown in section C, the *ghaṭī* values and the values in hours for the maximum duration of the daylight rarely match.

2.4.2. Plate of ecliptic coordinates

Besides the plates designed for specific terrestrial latitudes, the Lahore astrolabes invariably contain a plate the two sides of which are designated respectively as *ṣafīḥat mīzān al-ᶜankabūt* (tablet of the ecliptic coordinates) and *ṣafīḥa al-āfāqiya* (plate of horizons). Both occur for the first time in al-Khujandī's astrolabe of 984.

The plate of ecliptic coordinates is basically a plate made for the arctic circle at the latitude of 90° diminished by the obliquity of ecliptic. Al-Khujandī determined the obliquity as 23;33°. Accordingly, he calibrated the plate for the latitude of 66;27°. The Lahore astrolabe makers use the approximate value of 23;30° for the obliquity and design the plates for latitude 66;30°. At this latitude, the ecliptic coincides with the horizon and the ecliptic pole with the zenith. The altitude circles run parallel to the ecliptic and azimuth arcs radiate from the zenith, dividing the ecliptic circle perpendicularly at regular intervals.

Thus, the astrolabic markings on this plate correspond to an ecliptic coordinate system. When the rete is placed on this plate, the ecliptic latitudes and longitudes of the stars represented on the rete can be read directly from the altitude circles and azimuth arcs respectively. Therefore, this plate is called *ṣafīḥat mīzān al-ᶜankabūt*, 'the plate of the balance or measure of the rete'. This plate can be used for converting the coordinates from the ecliptic system to the equatorial system and vice versa.

2.4.3. Plate of horizons

The reverse side of the plate of ecliptic coordinates is designed as the plate of horizons (*ṣafīḥa al-āfāqiya*). It was originally invented by Ḥabash al-Ḥāsib at Baghdad in the ninth century. On this plate are engraved horizons (*ufq,* plural *āfāq*) for several latitudes, many more than those which are available on the other plates. These horizons are useful in solving problems relating to sunrise and sunset, the length of the day and the rising times of stars without requiring a separate plate for each latitude. If complete horizons for all degrees are engraved, the plate would be cluttered. Therefore, half horizons for latitudes up to 66°, at convenient intervals, are arranged in four sets in the four quadrants of the plate. The latitude for each horizon is marked where it begins near the circumference and where it ends near one of the diameters. Along the four radii are drawn graduated declinations scales, between the equator and the tropics, and the last cells of these scales are marked with the value of the maximum declination or the

obliquity of the ecliptic. The scales to the south of the ecliptic carry the label *mayl kullī janūbī* (maximum declination south) and those to the north the label *mayl kullī shamālī* (maximum declination north).

For making use of any of the horizons drawn in one of the four quadrants, the plate should be so placed inside the astrolabe that the east point of the horizon coincides with the east point of the astrolabes. Therefore, notches have to be cut at the four points of the compass on the plate, so that the plug affixed inside the rim at the north point fits into each of the four notches on the plate. But these plates in the Lahore astrolabes rarely have four notches; they have just one notch at the north point. Thus these plates merely serve didactic purposes.

In the astrolabes produced in the Maghreb, the half-horizons are arranged on the plate, not in four sets, but in eight sets. The horizon plate in the undated astrolabe by Allāhdād (A002) is designed in this manner (see Figure A002.4). The horizon plates in all other Lahore astrolabes carry half-horizons in four sets.

2.4.4. Plates with astrological houses

A very small number of astrolabes, in particular those with *zawraqī* horizons on the rete, are equipped with plates on which the astrological houses are marked. The lines that divide the houses pass through the point of intersection of the oblique horizon and the meridian.[107] On some of these plates the houses are numbered with ordinals (starting at the eastern horizon and proceeding counterclockwise): *ṭālic, thānī, thālith, rābic, khāmis, sādis, sābic, thāmin, tāsic, cāshir, ḥādī cashar* and *thānī cashar.*

2.4.5. Double Projection for latitudes 0° and 90°

On one of the plates in his astrolabe, al-Khujandī draws, for the first time, projections for latitudes 0° (equator) and 90° (north pole). The horizon at the equator is represented by the horizontal diameter of the plate. The zenith and nadir lie on the circle of equator. The altitude circles parallel the horizon are drawn as arcs of the circle. As they go higher, they become full circles around the zenith. Azimuth circles are drawn

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107 Kaye 1918, p. 19, n. 4.

as arcs radiating from the zenith. This plate is useful for solving problems related to rising times.

The lower half of the plate carries the projections for latitude 90° (North Pole). Here the horizon coincides with the equator; the altitude circles merge with the declination circles and the azimuth circles with the hour lines.[108]

Because of its didactic value, this double projection of latitudes 0° and 90° is emulated in many Lahore astrolabes, starting from the astrolabe of 1604 by ʿĪsā (A006). This plate should actually have notches at the north and south points so that both halves can be made use of, but the plates in the Lahore astrolabes have just one notch at the north point like the rest of the plates.

The Lahore astrolabes exhibit double projections of other pairs of latitudes also such as latitudes 18° and 72° and so on. In such double projections, the altitude circles of one latitude are ingeniously extended as the latitude circles of the second latitude, creating an interesting pattern like the Roman letter S.

There are also plates with triple projections. A frequently represented combination is for latitude 0° in the upper half and for latitudes 72° and 90° in the lower half. This projection also appears for the first time in the astrolabe attributed to ʿĪsā (A008). These plates display the virtuosity of the engraver.

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[108] Morrison 2007, Fig. 4-10, p. 65: 'The plate for equator is useful for solving problems common in the study of the history of astronomy involving rising times (i.e., elapsed time for a specific number of ecliptic degrees to rise). The horizon at the equator is called "sphaera recta". The horizon at other latitudes is called "ascensio recta" or "right ascension". The astrolabe was commonly used to solve these problems before the development of spherical trigonometry.
'The plate for the North Pole shows declination directly. At the North Pole the horizon is the equator and declinations of anything on the rete can be read directly from this plate. Negative declinations cannot actually be seen from the North Pole but [on] the plate divisions extend up to the Tropic of Capricorn. The azimuth arcs correspond to hour angles of the sun or a star. If the rete is set to 0 hr sidereal time, the azimuth arcs correspond to the right ascension of any point on the rete. Another use of the plate for the North Pole is to locate planets or other objects not included on the rete.'

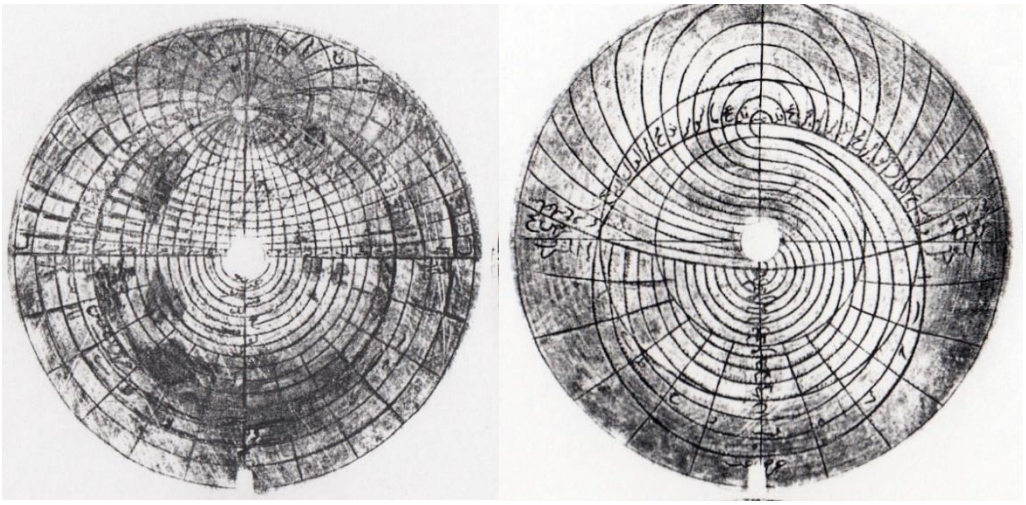


Figure A4 – Double projection of latitudes 0° and 90° on the left;
triple projection of latitudes 0°, 72° and 90° on the right; astrolabe attributable to ʿĪsā (A008).

2.5. Geographical Gazetteer

The inner side of the astrolabe may contain, like the two sides of the latitude plates, projections for one more latitude or a geographical gazetteer with terrestrial coordinates for certain localities. The geographical gazetteer is not really essential for using the astrolabe; it is added just as a memorandum. One can also consult a manuscript for the information provided by the gazetteer on the astrolabe. But presumably, the astronomers and astrologers desired that the astrolabes contain all the necessary astronomical, astrological and geographical information at one place, as in the smart phones today.

The earliest astrolabe to have a gazetteer is one made by Nasṭūlus around 927; of this astrolabe only the mater survives with a small gazetteer engraved on the front and trigonometric quadrants on the back.[109]

2.5.1. Parameters in the Gazetteers

The gazetteers in Islamic astrolabes usually provide five parameters: (i) longitude (*ṭūl*), (ii) latitude (*ʿarḍ*), (iii) *inḥirāf,* (iv) *jihat* and (v) *masāfat*. The longitudes are measured from the Fortunate Islands (*al-Jazā'ir al-Khālidāt*) in the Atlantic, roughly 35° west of Greenwich. The latitudes are well known, they are measured from the equator up to the north pole or up to the south pole. In his path-breaking *Description of*

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109 King 2008, p. 97.

the Persian Astrolabe constructed for Shah Husain Safavi, William Morley explains the last three parameters thus:

> The Inhiráf is an arc of the horizon, intercepted between the meridian of any place and a vertical circle passing through the zenith of such place and that of Makkah, such circle being called the Azimuth of Kiblah; and it is equal to the angle at the zenith of such place, formed by the said meridian and vertical circle, which is measured by the forementioned arc. This angle is the Angulus positionis of our older geographers. The Masáfat is the distance in a straight line, as the crow flies, between any place and Makkah, i.e., it is the arc of the great circle intercepted between the zenith of such place and that of Makkah in the nearest direction; the distance is computed in Fasangs, Miles, or Barids, بريد *posts* (Veredus). The Jihat is the direction of the Azimuth of the Kiblah with reference to any place and the four cardinal points; and it denotes the quarter of the horizon of such place in which Makkah is situated. It is obvious if the Inḥiráf, the Masáfat, and the Jihat, are known at any place, the position of Makkah, with regard to such place, is completely defined. If the place be of the same latitude as Makkah, there is no Inḥiráf; of the same longitude, the Inḥráf is 90°: in either case, the Masáfat and Jihat are sufficient to determine the position of Makkah.[110]

Indo-Persian astrolabes carry a geographical gazetteer on the inner side of the mater and not projections for a latitude. Allāhdād, in the very first extant astrolabe of 1567 (A001), set out to provide the longitude, latitude and *inḥirāf,* and drew five columns on the inner side of the mater for the names of the localities (*al-bilād*), longitude (*al-ṭūl*), latitude (*al-ʿarḍ*), orientation towards Mecca (*inḥirāf*) and the duration of the longest day (*al-sāʿāt*), but left, for no discernable reason, the last two columns blank. Surely he must have had at his disposal some *zīj* with all these

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[110] Morley 1856, p. 23.

parameters from which he had copied the names, longitudes and latitudes, but not the other two items.

He drew the same five columns in his undated astrolabe (A002), but the cell for the *inḥirāf* is often blank; sometimes it is filled by the maker, other times by a later hand in a smaller and scratchy script. Many cells of the longest days are also not filled, especially for places in the Indian subcontinent. In A003, which can attributed to Allāhdād, the gazetteer provides the latitude (*al-ᶜarḍ*), co-latitude (*tamām al-ᶜarḍ*), and longitude (*al-ṭūl*) in this order. This is perhaps the only astrolabe to list co-latitudes (90-φ), which can easily be calculated from the latitudes. In A004, which too can be attributed to Allāhdād, the following data is planned to be provided: name of the locality (*al-bilād*), longitude (*al-ṭūl*), latitude (*al-ᶜard*), *inḥirāf* (*al-inḥirāf*) and the duration of the longest day (*al-sāᶜāt*), but the cells corresponding to the last two items are left blank as in the astrolabe of 1567. This is one of the reasons for attributing this astrolabe to Allāhdād.

His descendants ᶜĪsā, Qā'im Muḥammad, Muqīm and Ḍiyā' al-Dīn give only the longitudes and latitudes. In A093 which is attributable to Ḍiyā' al-Dīn, the longest day appears once again along with the longitude and latitude.

Ḥāmid tries to make up for the omission of his ancestors and provides longitudes, latitudes, *inḥirāf* (which he calls *qibla samt*) and *jihat* in (A113, A114, A115, A116) of his eleven signed astrolabes and also in A119 which is attributable to him.

2.5.2. Sources of the Gazetteers

Obviously these gazetteers were derived from some Arabic or Persian astronomical tables (*zīj*) and similar texts. One of the important records of such geographical information in the Mughal period is the *Ā'īn-i Akbarī,* compiled by Abū al-Faḍl at the court of Akbar. It contains the longitudes and latitudes of some 656 localities arranged according to the climates.[111] I compared the gazetteer on the astrolabe of 1074/1663-64 by Ḍiyā' al-Dīn (A084) with the data in the *Ā'īn-i Akbarī,* but did not

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[111] Abū al-Faḍl 3, pp. 50-116. This gazetteer is rearranged alphabetically in Kennedy 1987a, pp. 569-580.

find much correspondence between the two gazetteers.[112] Ḍiyā' al-Dīn arranges three of his gazetteers according to the regions, starting from Maghreb in the west and reaching up to India in the east (A062, A072, A093; see especially A072). These are derived from Ulugh Beg's geographical tables.[113] Otherwise, we do not know of any other sources used in these gazetteers. However, whichever sources they may have used, the astrolabe makers do not seem to have gathered the data with some consistency from their sources, so much so the geometrical coordinates given for a city by the same astrolabe maker differ from one astrolabe to another.

For example, in Ḍiyā' al-Dīn's astrolabes, Ajmer in Rajasthan, an important centre of Muslim pilgrimage in the Mughal period (and even now) is placed consistently at longitude 111;5° in all the astrolabes, but latitude varies from 24;0° to 25;0° to 26;0°. In the case of Ahmedabad, again an important city in Mughal India, the longitude has the values of 103;40°, 108;0° and 108;40° and the latitude 23;15°, 23;55° and 28;55°. These variations can be explained away by the fact that the forms of *Abjad* numbers look almost alike without the diacritical points. But no such explanation justifies the variation in the case of Iṣfahān; here the longitudes recorded are 82;40°, 85;0°, 86;40° and 87;40. The latitudes are more consistent: often 32;25°, but a few times 34;25°. This is so in the case of the astrolabes by the other members of the family as well. The only cities to have consistently uniform values are Mecca (long. 77;10° and lat. 21;40°), Medina (long. 75;20° and lat. 25;0°), and Lahore (long. 109;20° and lat. 31;50°).

2.5.3. Localities listed in the Gazetteers

While these astrolabe gazetteers seek to cover the entire area of the Islamic world, with the majority of localities enumerated being from the Greater Iran, the geographical information on the eastern and southern parts of the Indian subcontinent is very meagre. The localities usually mentioned in the east are Benares, Jaunpur and Dhākā Bangālah, i.e., Dhaka in modern Bangladesh. The southern localities mentioned are Daulatabad, Golconda (i.e., modern Hyderabad) and Bijapur. This scanty information is particularly surprising in view of the fact that the Mughal Empire extended quite far into the east

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112 Sarma 2003, pp. 43-47.

113 Sédillot 1853, pp. 257-271.

and into the south. Geographical parameters of a large number of Indian localities are compiled in Sanskrit geographical tables, [114] but the Lahore astrolabe makers do not seem to have consulted these sources.

Naturally Agra, Delhi and Lahore, the three Mughal Imperial cities, receive prominence in the Lahore astrolabes. As mentioned already, in many astrolabes there is one plate, one side of which is designed for Lahore at latitude 32° and the other side either for Agra at 27° or for Delhi at 29°. Likewise, as will be show below, on the back of the Lahore astrolabes, there are often curves for the meridian altitude of the sun at the latitudes 27°, 29° and 32°. In the astrolabe gazetteers, the three cities are invariably mentioned. Agra is referred to as Akrah, Akbarābād, Akbarābād Dār al-Khilāfat, or Akbarābād Dār al-Mulk Hind; Delhi as *Haḍrat Dihlī,* Shāhjahānābād, Haḍrat Shāhjahānābad, or Shāhjahānābād Dār al-Mulk Hind; and Lāhūr as Lahāwar, or Lāhūr Dār al-Salṭanat.[115]

One locality deserves special mention. Most of the astrolabe gazetteers mention 'Sarandīb' (also spelt 'Sarāndīb'), which is the Arabic name for Sri Lanka,[116] with the longitude 130° and latitude 10°. While the latitude of 10° is a reasonable approximation for the northern tip of the island, the longitude of 130° places the island far in the East on the same meridian as Dhaka.[117] This is inexplicable because the exact location of the island must have been well known to the Arab sailors.

2.5.4. Arrangement of the Gazetteers

Now some remarks are in order about how the geographical material is organized in the astrolabe gazetteers. Many gazetteers commence from the holy city of Mecca, or from Qairawān (Kairouan in modern Tunisia) and proceed in the order of increasing

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114 Pingree 1996.

115 I must not forget to add that the city of Aligarh, where my wife and I spent most of our professional careers and where our son was born and grew up, is mentioned in almost all the gazetteers as 'Kūl [wa] Jalālī'. Kūl (pronounced Kol) was an old name of Aligarh, often listed with Jalālī which lies some 20 km to the east.

116 The Arabic name *Sarandīb*, which gave rise to the felicitous term 'serendipity' in English, has a close phonetic affinity to the Sanskrit *Śaraṇa-dvīpa,* 'the island of shelter', for Sri Lanka offered shelter to the ships tossed about by the fierce monsoon winds. However, the expression is not attested in any Sanskrit source.

117 Even Abū al-Faḍl 3, p. 57, has the same longitude of 130°, but the latitude there is 12°.

longitudes. Several astrolabes by Qā'im Muḥammad, Muḥammad Muqīm and Ḍiyā' al-Dīn have gazetteers organized according to climates. Classical geography divides the inhabited portion of the northern hemisphere into seven stripes called climes or climates (Arabic *iqlīm,* plural *aqālīm*) parallel to the equator so that the maximum daylight at the middle of each climate is half an hour longer than that in the preceding climate. But these gazetteers start from the equator (i.e., below the first climate) and go beyond the seventh climate. In the astrolabe of 1045/1635-36 by Qā'im (A013), he gazetteer is arranged according to climates, but commences with the second climate so that Mecca is at the beginning of the enumeration; thereafter come the first, third, fourth, fifth, sixth and seventh climates. The same is done in the astrolabe of 1031/1621-22 which is attributable to Qā'im Muḥammad (A014).

A third variety of arrangement is by regions, from the Maghreb in the west up to Hind (India south of Indus) in the east. Such arrangement occurs only in three astrolabes by Ḍiyā' al-Dīn (A062, A072 and A093).

Incidentally these arrangements by climates or regions appears to be peculiar to the Lahore astrolabes only.[118]

2.5.5. Style of Presentation

Aside from the variation in the arrangement of the localities, the gazetteers exhibit also varying styles of presentation, because the large area of the inner surface of the mater allows all kinds of stylistic experimentation. While the rows remain circular, the columns are sometimes curved, all slanting in a single direction and sometimes zigzag. The orientation of the letters also varies; in some gazetteers the upper part of the letters is oriented towards the centre and sometimes towards the outer circumference, and sometimes both in different annuli. In some gazetteers, each piece of data is enclosed in cartouches, the designs of which vary from each circle. Thus the Lahore astrolabe makers invested much technical and artistic efforts to make the gazetteers real objects of art.

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[118] I checked the catalogues Pingree 2009, Gibbs & Saliba 1984, and King 1999b, but do not find such arrangements in any non-Indian astrolabe.

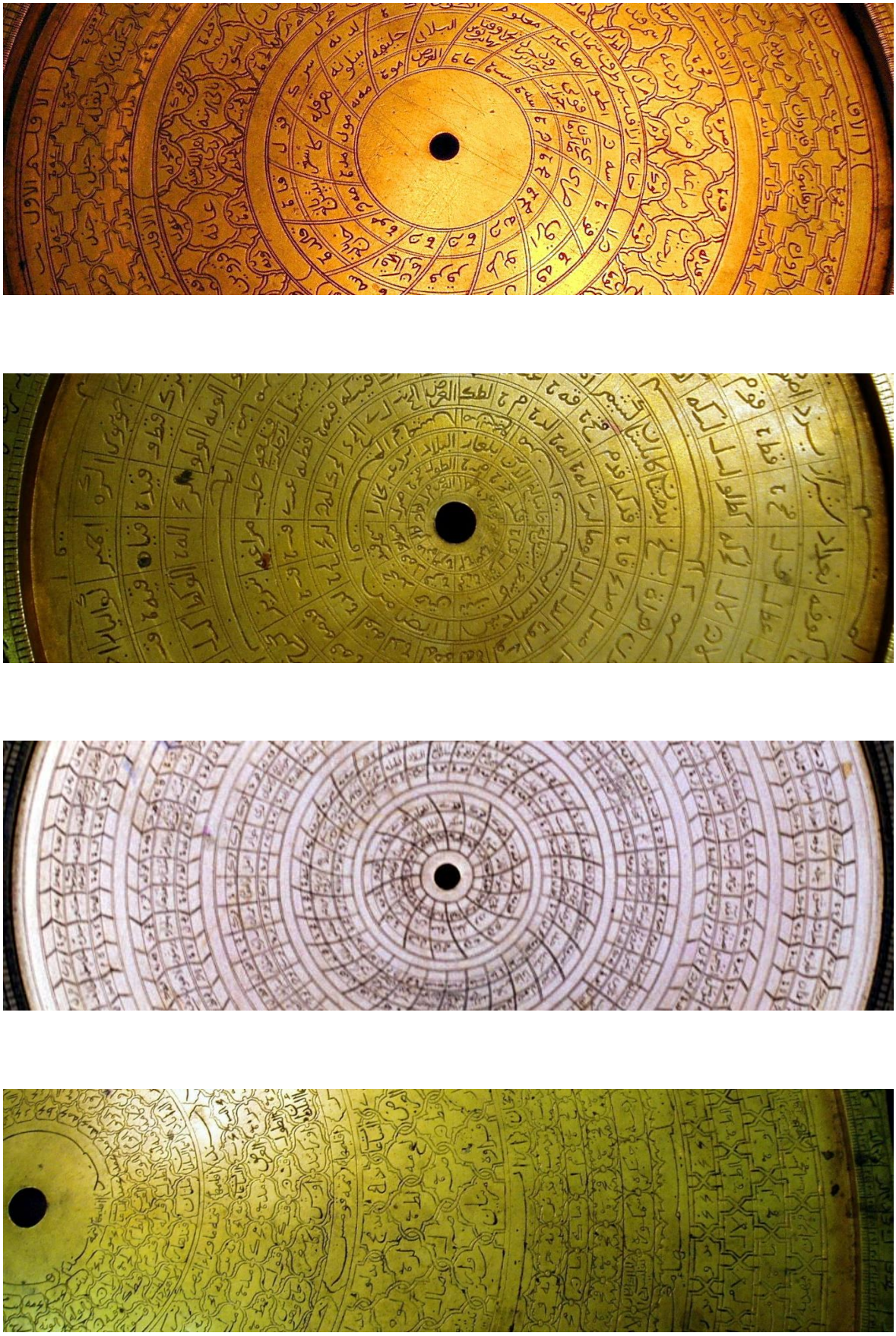


Figure A5 – Different styles of gazetteers (details of gazetteers from A014, A016, A051 and, A093) (all photos by S. R. Sarma)

2.6. Back of the Astrolabe[119]

The back of the astrolabe (*ẓahr al-asṭurlāb*) is divided by the vertical and horizontal diameters into four quadrants which contain much trigonometric, geometric and astrological data. The rim of the two upper quadrants carries two altitude scales on which the altitudes of the heavenly bodies are measured by means of the alidade. Like the limb in the front, the altitude scales on the back also consist of two bands. The narrow inner band is graduated in single degrees. The broader outer band is divided in groups of 5° or 6°, exactly as in the front. But here these groups are numbered from 5 or 6 up to 90, starting at the east and west points and reaching the south point.

2.6.1. Trigonometric Quadrant on the Upper Left[120]

The upper left quadrant carries a sexagesimal trigonometric graph with equally spaced horizontal lines and vertical lines. In some astrolabes the vertical radius is divided into 60 equal parts, and from each point of division are drawn lines parallel to the horizontal radius up to the circumference. In others, both radii are divided in this manner and horizontal and vertical lines are drawn from each point of division. For the sake of clarity, every third or fifth line is highlighted with dots. The angle of the altitude is measured by the alidade on the altitude scale. The portion of the vertical radius intercepted by the horizontal line from the angle is the sine of the angle. Likewise, the portion of the horizontal radius intercepted by the vertical line from the angle is the cosine of the angle. Smaller astrolabes have 30 horizontal lines and 30 vertical lines.

2.6.2. Solar Quadrant on the Upper Right[121]

The upper right quadrant is designed as a solar quadrant which is a kind of yearly calendar. Here the horizontal and vertical radii are divided into six equal divisions. On these divisions are written the names of the signs or their serial numbers in the following manner. Along the vertical radius, from the centre up to the circumference, are written the names of Cancer (3), Leo (4), Virgo (5), Libra (6), Scorpio (7) and Sagittarius (8),

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119 See especially Morrison 2007, pp. 109-142 with a wealth of diagrams explaining how to draw the various projections.

120 Morrison 2007, pp. 126-132.

121 Morrison 2007, pp. 134-143.

i.e., from summer solstice to winter solstice. Along the horizontal radius are written, from the circumference up to the centre, the names of Capricorn (9), Aquarius (10), Pisces (11), Aries (0), Taurus (1) and Gemini (2), i.e. from winter solstice to summer solstice. From the points of division of the two radii, quarter circles are drawn, i.e., for every 30° of solar longitude. These are the arcs of declination. Solar quadrant shows the sun's declination for each sign of the zodiac. In larger astrolabes, arcs are drawn at smaller intervals, usually for every 10° of solar longitude, occasionally also for 6°.[122] On this solar quadrant, curves showing the sun's midday altitude (*khaṭṭ nisf al-nahār*) for each day of the year at selected latitudes are traced.[123] These curves show the relation between the sun's right ascension and the meridian altitude. ʿĪsā introduced these curves in the Lahore astrolabes by drawing a curve for the latitude of Lahore (32°). which is the seat of his family. His son Muḥammad Muqīm usually draws two curves for 29° and 32° which are the latitudes of the two Mughal imperial cities Agra and Lahore; his nephew Ḍiyā' al-Dīn Muḥammad followed this practice on some of his astrolabes. But after Shāh Jahān shifted the Mughal capital from Agra to Delhi, Ḍiyā' al-Dīn began to add a third graph for the latitude of Delhi at 29°. Sometimes, he also drew more curves. In A096, which is attributable to Ḍiyā' al-Dīn, there are curves for as many as nine cities.

In a few astrolabes, lines showing the beginning and the end of the afternoon prayer *ʿasr* are drawn in this quadrant. In a few other astrolabes, lines for a universal horary quadrant are drawn.

2.6.3. Shadow Squares and Cotangent Scales[124]

In the lower half, immediately below the horizontal diameter are engraved two shadow squares.[125] In Islamic astrolabes, the square to the left of the meridian is drawn for the shadows thrown by a gnomon of 7 feet (Arabic *qadam,* plural *aqdām*) and the horizontal and vertical scales are divided into 7 parts each. The vertical scale is labelled

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122 These arcs are equidistant, while in Safavid astrolabes these are drawn stereographically.

123 Cf. Kaye 1918, p. 22; Frank & Meyerhof 1925, pp. 14-15; Gunther 1932, vol. I, p. 184; Morrison 2007, pp. 136-137.

124 Morrison 2007, pp. 114-116, 132-133.

125 See Morrison 2007, pp. 114-116.

as *ẓill aqdām maᶜkūs* (umbra versa, or reverse shadow, in feet), i.e. shadow thrown by a horizontal gnomon on a vertical plane. The horizontal scale is labelled as *ẓill aqdām mustawī* (umbra recta, or direct shadow, in feet), i.e. shadow thrown by a vertical gnomon on a horizontal plane.

The square to the right of the meridian is drawn for the shadows thrown by a gnomon of 12 digits or fingers (Arabic (*aṣbaᶜ,* plural *aṣābiᶜ*) and the horizontal and vertical scales are divided into 12 parts each. The vertical scale is labelled as *ẓill aṣābiᶜ* (umbra versa, or reverse shadow, in digits), i.e. shadow thrown by a horizontal gnomon on a vertical plane. The horizontal scale is labelled as *ẓill aṣābiᶜ mustawī* (umbra recta, or direct shadow, in digits), i.e. shadow thrown by a vertical gnomon on a horizontal plane. In some astrolabes, each division in the scales for 12 digits is further divided into 5 parts, so that the scale contains 60 parts. These scales are labelled as *ẓill sittaynī mustawī* and *ẓill sittaynī maᶜkūs.*[126]

The divisions on the horizontal scales are numbered from the centre onwards and those on the vertical scales are numbered from the top downwards. The relation of a division on the horizontal scale to the whole length of the gnomon corresponds to the cotangent and the relation of a division on the vertical scale to the whole length of the gnomon corresponds to the tangent. These shadow squares are useful in land survey for determining the heights or depths of objects and for calculating distances.

The horizontal scales on the two shadow squares are projected on the rim of the lower half to create there two cotangent scales for the bases 7 and 12 respectively.[127] The divisions are subdivided on an inner band. Muqīm labels them usually as *ẓill aqdām* and *ẓill aṣābiᶜ* respectively. Ḍiyā al-Dīn labels them in some of his astrolabes as *ẓill aqdām mabsūṭ* and *ẓill aṣābiᶜ mabsūṭ* (e.g., A062, A066 etc).

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126 See A030, A067, A072 and A092. Dr François Charette informs me that this sexagesimal scale occurs in several middle eastern astrolabes, e.g. an astrolabe dated 790 AH by Jaᶜfar b Umar b Dawlatshāh (Adler Planetarium, Chicago), cf. Pingree 2009, p. 43; an astrolabe dated 830 AH and most probably dedicated to Ulugh Beg (Copenhagen, Davids Samling), cf. King 2005, pp. 761-763; an astrolabe dated 929 AH by al-Jilānī (National Maritime Museum, Greenwich). But in these astrolabes the sexagesimal scale does not carry a label.

127 Hartner 1968a, p. 302, figure 850.

The Lahore astrolabes do not strictly adhere to the arrangement of scales divided in 7 feet on the left and the scales divided in 12 digits on the right; they often reverse the order.

2.6.4. Astrological Tables

In the space inside the shadow squares and in the space between the shadow squares and the cotangent tables, several astrological tables are engraved on the Lahore astrolabes.[128] The tables engraved on the Lahore astrolabes are broadly of six types.

2.6.4.1. Correspondence between the Zodiac Signs and the Lunar Mansions

In two adjacent semi-circular rows the names of the 12 zodiac signs and those of 28 lunar mansions are written so that one can see which lunar mansions correspond to which zodiac sign. This table occurs on all Lahore astrolabes. Small astrolabes carry just this one and no other astrological table.

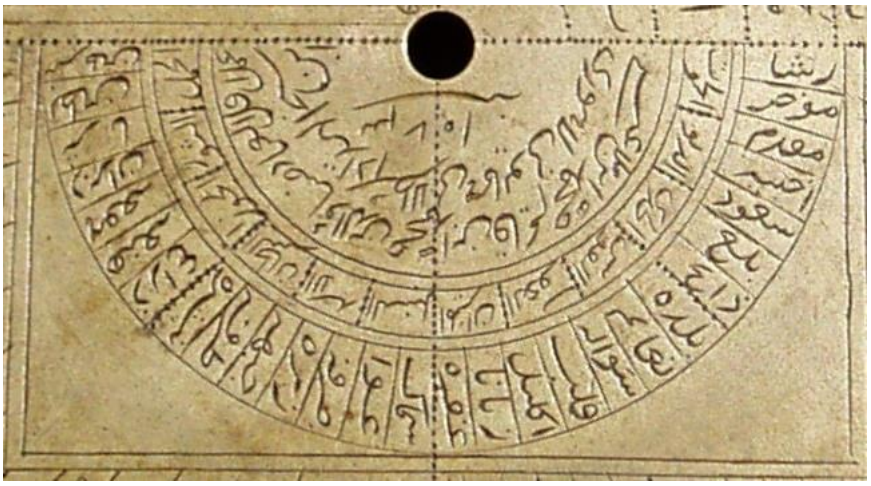


Figure A6 – Zodiac signs and lunar mansions on the back of the astrolabe A080 by Ḍiyā' al-Dīn Muḥammad (photo by S. R. Sarma)

2.6.4.2. Limits or Terms of the Signs

In this system, each zodiac sign has five intervals called *ḥudūd* ('limit' or 'term') of varying lengths which are assigned to the five planets other than the sun and the moon. However, the sequence of the planets and intervals assigned to them vary for

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[128] On astrological tables on the back of astrolabes, see Kaye 1918, pp. 119-126: Appendix B, Astrological Tables; Khareghat 1950, pp. 10-23; Ackermann 2005.

each sign.[129] There are said to be several systems, but the one used frequently is derived from Egypt, hence designated as *jadwal ḥudūd misriyan*.

The intervals assigned to each planet are shown in two ways. In one the exact amount of each interval are shown in degrees of arc as in the following table on the back of an astrolabe dated 1045/1635-36 by Qā'im Muḥammad (A013).

Table A1 Limits of the Signs

Aries	Jupiter	6	Venus	6	Mercury	8	Mars	5	Saturn	5
Taurus	Venus	8	Mercury	6	Jupiter	8	Saturn	5	Mars	3
Gemini	Mercury	6	Jupiter	6	Venus	5	Mercury	7	Saturn	6
Cancer	Mars	7	Venus	6	Mercury	6	Jupiter	7	Saturn	4
Leo	Jupiter	6	Venus	5	Saturn	7	Mercury	6	Mars	6
Virgo	Mercury	7	Venus	10	Jupiter	4	Mars	7	Saturn	2
Libra	Saturn	6	Mercury	8	Jupiter	7	Venus	7	Mars	2
Scorpio	Mars	7	Venus	4	Mercury	8	Jupiter	5	Saturn	6
Sagittarius	Jupiter	12	Venus	5	Mercury	5	Saturn	4	Mars	4
Capricorn	Mercury	7	Jupiter	7	Venus	8	Saturn	4	Mars	4
Aquarius	Mercury	6	Venus	6	Jupiter	7	Mars	5	Saturn	5
Pisces	Venus	12	Jupiter	4	Mercury	3	Mars	9	Saturn	2

This shows that, of the five limits of Aries, the first is presided by Jupiter whose quantity of influence is 6, the second is presided by Venus whose influence is 6 and so on. The total influence of all the five planets is 30 degrees in each sign.

The other method is cumulative; it shows the interval assigned to a planet plus the sum of the intervals assigned to all the preceding planets. In this method, the limits of the sign Aries are displayed as follows:

Aries	Jupiter	6	Venus	12	Mercury	20	Mars	25	Saturn	30

In the tables prepared according to these two methods, as well as in all other astrological tables, the signs of the zodiac are denoted by their serial numbers and the

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[129] Cf. Kaye 1918, pp. 122-123; Khareghat 1950, p. 17;

planets by the final consonant of their Arabic names. The symbols used for the planets are shown below.

Planet	**Sun**	**Moon**	**Mars**	**Mercury**	**Jupiter**	**Venus**	**Saturn**
Arabic Name	*shams*	*qamar*	*mirrikh*	*ʿauṭārad*	*mushtarī*	*zuhrah*	*zuḥal*
Symbol	س	ر	ح	د	ی	ھ	ل

2.6.4.3. Decans or Faces (*al-wujūh*) and their Regents

Decan (sing. *wujūh*; plural *wajah*) is one-third of a sign, or 10 degrees. The decans are numbered for each sign as 10, 20, 30 in *Abjad* and the presiding planets are indicated by alphabetical symbols.[130]

Table A2 **Decans and their Regents**

Signs	***10º***	***20º***	***30º***
Aries	Mars	Sun	Venus
Taurus	Mercury	Moon	Saturn
Gemini	Jupiter	Mars	Sun
Cancer	Venus	Mercury	Moon
Leo	Saturn	Jupiter	Mars
Virgo	Sun	Venus	Mercury
Libra	Moon	Saturn	Jupiter
Scorpio	Mars	Sun	Venus
Sagittarius	Mercury	Moon	Saturn
Capricorn	Jupiter	Mars	Sun
Aquarius	Venus	Mercury	Moon
Pisces	Saturn	Jupiter	Mars

It may be noted that the sequence of planets in each column is that of weekdays.

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130 Cf. Kaye 1918, p. 123; Khareghat 1950, p. 13.

2.6.4.4. Trigons or Triplicities and their diurnal and nocturnal Regents

Trigons or Triplicities are four sets of three signs which are 120 degrees apart. These four sets are characterized as fiery (Arabic *nārī,* Persian *ātishī*), earthy (Arabic *tarābī,* Persian *khākī*), airy (Arabic *hawā'ī,* Persian *bādī*) and watery (Arabic *māhī,* Persian *ābī*) and are assigned different regents in the daytime and at night.[131] The table is entitled *arbāb muthallathāth yawmī wa laylī* , 'the regents (*rabb,* 'lord', plural *arbāb*) of the triplicities (*muthallath,* 'triangle', plural *muthallathāth*).[132]

Table A3 Triplicities and their Regents

Regents of the Trigons, diurnal					**Regents of the Trigons, nocturnal**			
Fiery	*Earthy*	*Airy*	*Watery*		*Fiery*	*Earthy*	*Airy*	*Watery*
Aries	Taurus	Gemini	Cancer		Aries	Taurus	Gemini	Cancer
Leo	Virgo	Libra	Scorpio		Leo	Virgo	Libra	Scorpio
Sagittarius	Capricorn	Aquarius	Pisces		Sagittarius	Capricorn	Aquarius	Pisces
Sun	Venus	Saturn	Venus		Jupiter	Moon	Mercury	Mars
Jupiter	Moon	Mercury	Mars		Sun	Venus	Saturn	Venus
Saturn	Mars	Jupiter	Moon		Saturn	Mars	Jupiter	Moon

2.6.4.5. Excess of Revolution

This table is entitled *jadwal faḍl al-dawr* (table of excess of revolution). Excess of revolution is the difference between the approximately correct length of the tropical year and 365 days which is taken to be 87;33°. The table displays the multiples of this value from 1 to 9 and then by 10s up to 90. It occurs for the first time in the astrolabes of Muqīm (A018 and others). The multipliers in the first and third columns (counted from the right) are expressed by the standard Arabic / Persian numerals, and the products in the second and fourth column in *Abjad* notation.[133]

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131 Persian terms are also used sometimes in these tables.

132 Khareghat 1950, pp. 19-23.

133 Cf. Kaye 1918, p. 24.



Figure A7 – Table of excess of revolution on the astrolabe of 1059/1649-50 by Ḍiyā' al-Dīn (A062)

2.6.4.6. Climates

In Ptolemaic geography, the inhabited portion of the northern hemisphere is divided into seven climates in such a manner that the maximum duration of daylight at the middle of each climate is half an hour longer than in the previous one, and this notion was adopted by the Islamic world. [134] Abū al-Faḍl explains the system of the climates in the third volume of his *Āī'in-i Akbarī* and also mentions the latitudes at the beginning and middle of each climate and the duration of the longest days at these climates.[135] Such data in tabular form is engraved on the back of three astrolabes by Muḥammad Muqīm with slight differences. In A024, the table is entitled *mubādī aqālīm sabᶜa* (beginnings of the seven climates) and gives the latitudes and the hours of the duration of the daylight at the beginning of the seven climates and at the end of the seventh climate. The other two astrolabes (A041 and A051) display the latitudes (*arūḍ*) and the hours (*sāᶜāt*) of the maximum daylight at the beginning (*mabdā'*) and the middle (*wasaṭ*) of the seven climates (*aqālīm*).

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134 For a table of climates with corresponding latitudes for different values of obliquity, see King 2005, p. 927.

135 Abū al-Faḍl 3, pp. 51-54.



Figure A8 – Table of climates on the back of A051

2.6.4.7. Table of the Rising Times of Signs at Different Latitudes in India

(zadwal sāᶜāt ṭulūᶜ burūj bi-ᶜarḍ baᶜḍī az bilād mulk al-hind)

This table occurs in three astrolabes by Ḍiyā' al-Dīn with slight variations. The table on A072 provides the rising times of the signs at each degree of latitude from 20° to 39°[136], A092 has a table from 20° to 40° and A093 from 21° to 40°.

2.6.4.8. Zodiac and Calendar Scales

Many European and some Islamic astrolabes contain a calendar scale together with the zodiac scale, both drawn all around inside the rim. The zodiac scale is divided into the 12 signs of the zodiac and labelled with the names of the signs. Each sign is divided into 30 degrees and numbered in 6s. The calendar scale is drawn in an eccentric circle, offset from the centre of the instrument on the line of apsides by Ptolemaic eccentricity. The circle is then divided into 365 equal divisions, which are distributed in 12 months. These two scales are necessary for determining the solar longitude of the given date, expressed in terms of the zodiac. The alidade is placed on the given date in the calendar scale and the corresponding longitude is read off from the zodiac scale. This value is used for positioning the rete on the front.[137]

Two Indo-Persian astrolabe are engraved with these scales on back. In the astrolabe made by Qā'im Muḥammad in 1045/1635 (A013), there is an eccentric calendar scale, labelled with the names of *Rūmī* (Syro-Macedonian or Byzantine) solar months, together with the number of civil days in each month. In Ḍiyā' al-Dīn Muḥammad's *Zarqālī* universal astrolabe (A091) there is a similar calendar scale, but it

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136 This table is reproduced in Kaye 1918, p. 23.

137 Morrison 2007, pp. 111-114.

is concentric. All other Indo-Persian and Sanskrit astrolabes anticipate that the solar longitude is obtained from astronomical tables, either an Arabic or a Persian *zīj,* or a Sanskrit *pañcāṅga.*

2.6.5. Signature of the Astrolabe Maker

The astrolabe maker engraves his name, together with the names of his ancestors up to Allāhdād and the year of manufacture in the lower half of the back. In some astrolabes, the space inside the shadow squares is filled by one or two rectangular tables. The signature is then engraved above these tables and below the horizontal diameter. In some other astrolabes, the space inside the shadow squares is filled by two semi-circular rows with the names of the signs and lunar mansions. The signature is placed above the two semi-circulars rows. There are also other slight variations which will be mentioned in the descriptions the corresponding astrolabes. The signature begins either with *ᶜamal* (work), or with *ṣanᶜat* (work), or *ṣanaᶜahu* (he made). The astrolabe maker usually adds a phrase of humility before his name: *aqall al-ᶜibād,* 'the least of the servants [of God], *aḍaᶜf al-ᶜibād,* 'the weakest of the servants [of God]', or *aḥqar al-ᶜibād,* 'the most contemptible of the servants [of God]'.

Then follows the year in the Hijrī era. Sometimes the year is mentioned also in the *Rūmī* (Syro-Macedonian era) which commences from 1 October 312 BC. In a few cases the Old Persian Yazdegerd era is employed which begins on 19 June 632 AD. Occasionally the regnal years of the ruling Mughal emperor are also mentioned. While most of the astrolabes carry just the year in which the astrolabe was completed, Ḥāmid likes to mention the exact date on which a particular astrolabe was completed. Thus the very last dated astrolabe made by him was completed on 24 Ramaḍān 1102 which translates to 21 June 1691.

2.7. Alidade, Pin and Wedge[138]

On the back of the astrolabe a diopter is pivoted to the centre. This diopter, called 'alidade' from the Arabic *al-ᶜiḍāda*, is the observational part of the instrument, with

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138 Some science museums offer excellent astrolabe assembling kits, together with descriptions of the components, e.g., National Maritime Museum 1976; Webster & MacAlister 1984.

which the heights or altitudes of the heavenly bodies are measured. It is a flat rectangular strip, roughly of the same length as the diameter of the astrolabe. Its two ends are tapered to sharp points. Near each end is attached a rectangular sighting plate (*libna*) at right angles to the surface of the main bar. Generally two apertures are bored in the sighting plates, one larger and the other smaller. Since the sun should not be viewed directly, the alidade is pointed towards the sun, so that the sun's ray enters the aperture in the upper sighting plate and passes through the aperture in the lower sighting plate and then falls on the observer's palm or on a paper. The stars can of course be viewed by placing one's eye below the lower sighting plate. Then the angle of the altitude can be read on the altitude scales in the upper left, if the sun is in the eastern hemisphere, or in the altitude scale on the upper right if the sun is in the western hemisphere. The angle then can be converted to the corresponding sine or cosine on the trigonometric quadrant.



Figure A9 – Alidade from an astrolabe by Jamāl al-Dīn (= Figure A121.7)

To facilitate this process, the two arms or halves of the alidade are engraved with appropriate scales.[139] The upper register of the right half is engraved with a sexagesimal scale numbered in 6s from the centre to the tip as 6, 12, 18 … 60 and the sloping edge is graduated in single units, so that this scale matches with the divisions of the vertical radius of the upper left quadrant. The left half of the alidade is marked with declination arcs as in the upper right quadrant on the back and labelled with the names or the serial numbers of the zodiac signs and their subdivisions.

The alidade can also be employed as a sundial by placing it in a horizontal position with the sighting plate towards the sun. Then the sighting plate on the right functions as the gnomon and throws its shadow on the surface of the alidade. A scale to measure the unequal hours from this shadow is marked on the lower register on the right hand side,

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[139] Cf. Gibbs & Saliba 1984, pp. 57-59.

numbered from 1 to 6 from the sighting plate towards the centre and from 7 to 12 in the reverse direction.

The alidades in the Lahore astrolabes have ornate ends and a matching centre piece. However, these are all straight bar alidades without any counter-change at the centre.

A large hole is bored at the centre of the centre, the plates, the mater and the alidade, through which passes a broad-headed pin to hold these parts together. The exact centre of the rete and of the plates is the celestial pole, called *quṭb* in Arabic. Since the pin passes through the pole, it too is designated as *quṭb.* The pin is inserted through the holes of the components with the broad head on the back above the alidade. The other end of the pin which projects out of the assemblage in the front is pierced with a longitudinal hole through which a wedge is pushed to secure the entire ensemble.

One end of the wedge is traditionally shaped like the head of a horse from at least the time of the celebrated astrolabe made by al-Khujandī in 984. Therefore, the wedge is usually called *faras,* Arabic for ‘horse’. Sometimes, washers are added in the front to make the wedge tighter.



Figure A10 – Horse from astrolabe A105

To protect the astrolabe from the vagaries of weather, it is carried in a leather pouch; or it is placed in a cloth bag and then preserved in a specially made wooden case which imitates the outlines of the astrolabe. A few such cases exist, but they may or may not be contemporary with the astrolabes they now house.



Figure A11 – Astrolabe A080 in a leather pouch (photo by S. R. Sarma)



Figure A12 – Astrolabe case, Saidiya Library, Hyderabad
(photo courtesy Ahmad Athaullah)

2.8. How to use the Astrolabe

When one wishes to use the astrolabe, the first task is to place the latitude plate designed for the place of observation beneath the rete. The other plates are stacked below this plate. Then by means of the alidade at the back, the altitude of the sun is measured; or that of a bright star, if it is night. Since the Lahore astrolabes do not have a calendar scale at the back, the exact position of the sun or of the star for that moment has to be found from an almanac or from other astronomical tables. Then turning the astrolabe to the front, the rete should be rotated so that the point on the ecliptic

representing the position of the sun or of the star coincides with the circle of the altitude previously measured. When the rete is thus set up on the latitude plate, these two together simulate the position of the heavens upon the observer's latitude.

Then time can be measured either in seasonal hours or in equal hours, horoscopes can be cast for that time, the auspiciousness or otherwise of the moment for any undertaking can determined and the myriad problems in spherical astronomy listed by various writers can be solved. [140]

3. Non-Standard Astrolabes and Astrolabic Elements

Anthony Turner aptly remarked that 'the multiplication of complexity and a delight in the unusual seem to be typical of the astrolabe-makers of Lahore'.[141] Indeed, they show a marked predilection for unusual projections invented in Andalusia in the tenth and eleventh centuries, such as the universal plates invented by al-Zarqālluh, Ibn Bāṣo and 'Alī ibn Khalaf al-Ṣaidalānī; they were also attracted to the *zawraqī* or ship astrolabes invented by Abū Saʿīd Sijzī, to the north-south astrolabes, to the *qibla*-indicators, and to the 'circle of visibility of Canopus' of unknown origin.

With the exception of the north-south astrolabes and *qibla*-indicators, there had been no tradition of making the other types of instruments in the immediately preceding centuries either in India or in the adjacent countries. The astrolabe makers of Lahore could not have any actual models to follow and their knowledge must have been derived entirely from Arabic treatises on these instruments.[142]

These non-standard features will be discussed here briefly; the full descriptions will be given under the relevant instruments. It may be noted that many of these non-standard features occur mainly in the astrolabes produced by Ḍiyā' al-Dīn Muḥammad.

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140 On the use of the astrolabe, see especially Morrison 2007; Graaf 2011.

141 Turner 1985, p. 83.

142 It should be worthwhile to explore the manuscript collections in Pakistan and India, especially in Lahore, to see whether these contain any manuscript resources which may have been used by the Lahore family.

3.1. ʿAlī ibn Khalaf's Universal Plate

One of the major contributions of the Islamic world to the construction of the astrolabe is the universal plate that could be used at all latitudes.[143] Perhaps the first attempt in this regard was made by Ḥabash al-Ḥāsib of Baghdad when he invented the plate of horizons in the early ninth century, to which reference has been made earlier in 2.4.3. But this plate is not completely universal because it cannot be used at all latitudes.

A single plate that could be used at all latitudes was developed in Toledo in the eleventh century by ʿAlī ibn Khalaf al-Ṣaidalanī, also known as al-Shakkāz. The plate contains a vertical projection of the celestial sphere instead of the polar stereographic projection as in the common astrolabes. The equator is represented by the vertical diameter of the plate and the ecliptic by another diameter which intersects the equator at an angle which is tantamount to the obliquity of the ecliptic. On either side of the equator and the ecliptic parallels are drawn up to their respective poles on the periphery of the plate.

This plate is accompanied by a specially designed rete. One half of this rete contains the star map as in common astrolabes, but its periphery represents the equator and not the Tropic of Capricorn. The other half is filled with a net of parallels of the equator and of the meridian.[144] This plate is known as the *Ṣafīḥa Shakkāziyya* after the name of the inventor.

In 729/ 1328-29 ibn al-Sarrāj produced a specimen in Syria by substantially modifying the original design of al-Shakkāz. David King considers this specimen to be 'the most sophisticated astronomical instrument from the entire medieval and renaissance periods.'[145] This fourteenth century specimen is relevant for India in so far as it was imitated in the seventeenth century. The rete and the mater of this astrolabe (A125) which are extant do not carry any signature or date, but David King attributes these parts to Jamāl al-Dīn.[146]

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143 Turner 1985, pp. 151-166; King 2005, pp. 57-73.

144 Turner 1985, p. 152-153.

145 King 2005, pp. 694-700.

146 King 2005, pp. 821-829.

3.2. Zarqālī Universal Astrolabe

Abū Isḥāq Ibrahīm ibn Yaḥyā al-Naqqāsh (d. 15 September 1100), known as al-Zarqālluh (in Latin writings, Azarquiel, Arzachel) was a contemporary of ᶜAlī ibn Khalaf.[147] He simplified the latter's universal plate by dispensing with the rete. Instead he added a diametral rule with a sliding cursor. On the plate, he drew celestial coordinates for both the ecliptic and equatorial axes and marked the positions of several stars.

Al-Zaqālluh designed another universal plate where he superimposed two *shakkāzīya* markings at an angle equal to the obliquity of the ecliptic. On the back are the usual degree scales, zodiacal calendar, sine diagram, shadow squares and such elements as in the common astrolabes. This plate was equipped with an alidade at the back; in the front there is a diametral rule and a sliding cursor attached at right angles to the rule; both the rule and the cursor are graduated. Al-Zarqālluh named this universal plate *al-ᶜabbādiyya* in honour of the King of Sevilla, al-Muᶜtamid b. ᶜAbbād, but it became popular under the name *Safīḥa Zarqāliyya* (in Latin Saphaea Arzachelis).[148]

Anthony Turner lists nine extant specimens.[149] The most spectacular specimen of the *zarqālī* astrolabe was constructed by Ḍiyā' al-Dīn Muḥammad for a high Mughal dignitary Nawāb Iftikhār Khān in 1680 (A091).

Turner adds that 'the plate was difficult to use because of the profusion of markings.' For example, consider the complex procedure for measuring time as explained by Turner:[150]

> First the observer measured the altitude of the sun (or at night one of the stars marked on the astrolabe) by means of the alidade and the degree scale engraved on the back of instrument. Turning the astrolabe over, he set the rule to the latitude of the place of observation against the degree scale on the edge. When thus set, the position of the rule represented the place of

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147 On his biography, see Vernet.

148 Cf. Kaye 1918, pp. 27-30, plate VII; Hartner 1968b, pp. 316-317; Turner 1985, pp. 151 –179; Puig 1985; Puig 1989.

149 Turner 1985, pp. 177-178.

150 Turner 1985, p. 155.

observation. Having found, from the zodiacal calendar on the back, the sun's position in the ecliptic for the day of observation, the cursor was slid along the rule until the graduation on the cursor corresponding to the observed altitude of the sun met the parallel representing the sun's position in the ecliptic. The meridian of the equatorial pole that passed through this point (and which is equivalent to an hour arc) then indicated the time. If a star had been observed, the cursor was moved until the graduation corresponding to the star's observed altitude met one parallel of the star as marked on the instrument, the time being read off from the meridian passing through this point.

3.3. Ibn Bāṣo's Universal Plate

In the thirteenth century Ibn Bāṣo of Toledo developed yet another universal plate by combining the elements from the universal astrolabes designed by ᶜAlī ibn Khalaf and ibn al- Zarqalluh. [151] According to Emilia Calvo, this plate is difficult to use in practice, it serves more theoretical or pedagogical purposes. This plate was apparently very popular; Calvo enumerates some 27 specimens, most of them produced in the Maghreb. Allāhdād is the only astrolabe maker in India who incorporated this universal plate in his undated astrolabe (A002) and in an unsigned and undated astrolabe that can be attributed to him (A003). His descendants did not emulate him in this respect, although they were interested in other types of universal plates.

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[151] Calvo 2000, p. 266.

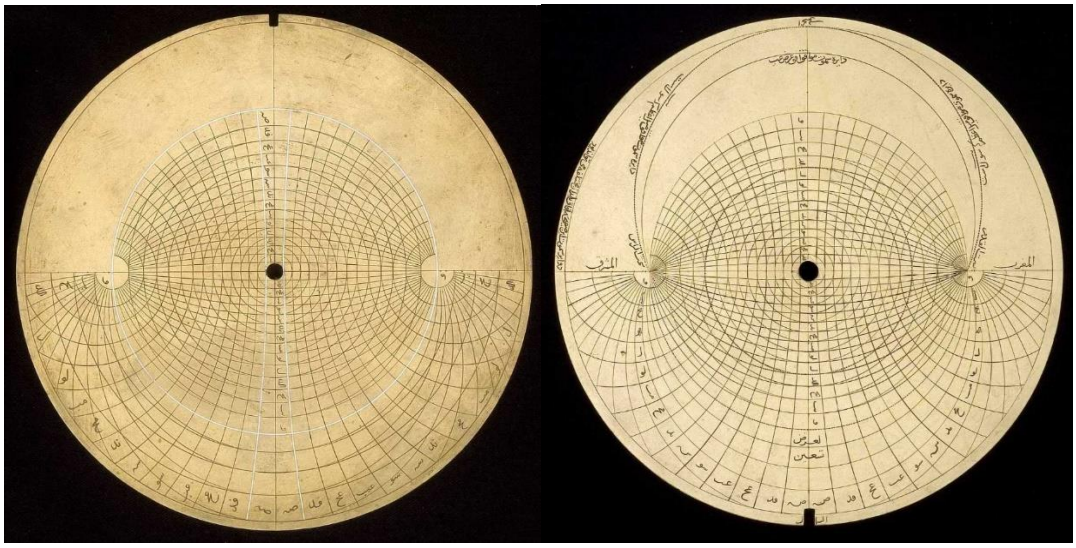


Figure A13 – Ibn's Bāṣo's universal projection; left: Allāhdād's undated astrolabe (A002); right: astrolabe attributable to Allāhdād (A003) (© Museum of the History of Science, Oxford)

3.4. North-South Astrolabes

While the standard astrolabes are northern astrolabes (*asṭurlāb shamālī*), there was a certain fascination in India for north-south astrolabes (*asṭurlāb shamālī wa janūbī*). Sulṭān Fīrūz Shāh Tughluq is reported to have commissioned three north-south astrolabes, one in brass, another in silver and the third in brass, but with large dimensions, which was designated as *Asṭurlāb-i Fīrūz Shāhī*.[152] The first Sanskrit manual on the astrolabe composed at his court by Mahendra Sūri also devotes the third chapter to the construction of northern astrolabes (*saumya-yantra*), southern astrolabes (*yāmya-yantra*) and the composite north-south astrolabes (*saumya-yāmya-yantra*). The north-south astrolabe to which these sources refer is one in which the combined northern and southern projection is drawn on the rete and on the plates with five concentric circles representing the Tropic of Capricorn, Equator and the Tropic of Cancer, Equator and the Tropic of Cancer, in this order.[153] In the middle of the nineteenth century, Buhlomal constructed two north-south astrolabes which probably are of this type.[154]

The Lahore astrolabes exhibit three other variants. One of these astrolabes is made by Ḍiyā' al-Dīn Muḥammad in 1674 (A090) and the other two are attributable to him

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152 Sarma 2000.

153 See Ôhashi 1997, p. 215, Fig. 9.

154 Sarma 2015b, pp. 270-271, Fig. 7. These will be described in section B.

on stylistic grounds. In the first variant, the obverse side of the single plate is engraved as a latitude plate for 33° N and on it is superimposed a northern projection of the ecliptic circle together with the positions of 46 stars,[155] while the reverse side is designed for latitude 35° N on which a southern projection of the ecliptic circle is drawn and the positions of the same 46 stars, but with southern orientation, are marked. On both sides the positions of many stars are indicated by dots enclosed in small circles. There is a minimal rete consisting of just the zodiac ring. There is an alidade on which a slender sighting tube is mounted.

In the second variant (A103), the obverse side carries a double projection for latitudes 36° and 32°. On this is superimposed the ecliptic circle in its northern projection. The reverse side carries a quadruple projection for 22°, 25°, 27° and 29°. Upon these is superimposed the ecliptic circle in its southern projection. On both sides, many star positions are marked by dots inside small circles. Presumably it had the same type of rete and alidade but these are now missing.

The third variant (A104) is constructed much more elaborately. There are two nicely reticulated retes with northern and southern orientation respectively. There are seven plates. Some sides carry northern projections and some others southern projections.

Yet another variant can be seen in an unsigned and undated Sanskrit astrolabe with a single plate (D025) which will be described in section D below. The obverse side carries the northern projections for latitude 27°; on the reverse side, an attempt to was made to trace the altitude circles with the southern orientation and these were not completed. There are two openwork retes with northern and southern orientations respectively.

3.5. *Zawraqī* Horizons and the associated Plates

An Andalusian feature incorporated in several astrolabes is the so-called ‘ship’ horizon or *zawraqī* horizon. It is represented on the rete as an arc straddling the

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[155] This plate shows close resemblance to the back of an astrolabe by ᶜUmar ibn Dawlatshāh ibn Muḥammad al-Kirmānī in 726 AH (AD 1325-26); see Linton 1980; no. 163, pp. 90-91; see also King 2005, p. 57, Fig. 5.1.3.

equinoctial bar. It looks like the lower outlines of a boat (*zawraq*), the corresponding segment of the vertical meridian looking like the upright mast of the boat. Therefore, this arc is designed as *zawraqī* or ship horizon.

The *zawraqī* astrolabe was invented by al-Bīrūnī's contemporary Abu Saʿīd Sijzī.[156] The main source of our knowledge of this variety of astrolabe is Josef Frank's *Zur Geschichte des Astrolabs*, [157] which deals with several non-standard astrolabes described by al-Bīrūnī in his *Kitāb fī istiʿāb al-wujūh fī ṣan'at al-asṭurlāb.* Frank describes the astrolabe as follows:

> Of very special interest is the boat-shaped (*al-zauraqī*) astrolabe of Abū Saʿīd al-Sijzī, which, in its construction, abandons the geocentric model that was generally accepted at his time, in so far as the horizon he designed is movable. The astrolabe consists of a fixed and a movable part. The former is the plate of the northern astrolabe without the azimuth lines. On the plate are drawn, furthermore, the projections of the zodiac and of the fixed stars, as they are shown in the rete of the northern astrolabe. … The movable part is an arc cut out from a metal plate which can be rotated … at the point through which the axis of the astrolabe passes. The convex edge of the arc is the projection of the horizon of the locality for which the plate is calibrated; … Firmly attached to the arc is a ruler with a pointed end—attached in such a way that when the arc coincides with the horizon line drawn on the plate, the ruler rests on the meridian line. … The main advantage of this astrolabe against the common astrolabe is the simple shape of the movable part; the use is, however, much more complicated.'[158]

Frank dwells on the various uses of this astrolabe and concludes with the remark:

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156 Wilfred de Graaf informs me (personal communication dated 4.6.14): 'A treatise by Sijzi on the Zawraqi astrolabe is found in a unique manuscript in Istanbul, Topkapi Palace Library, Ahmet III, 3342. There are no figures in this treatise. As you mentioned, the Zawraqi astrolabe is described in great detail by Biruni. The text by Biruni has recently been edited by Sayyid Muhammad Akbar Jawad Husayni and published in Mashhad in 1422 H (lunar). In this publication, however, partly incorrect figures appear. Slightly better figures can be found in an original manuscript, which is now in Leiden (ms. Leiden, Or. 591).'

157 Frank 1920, pp. 18-21.

158 My translation from Frank's German with slight modifications.

> ‘From the foregoing, one can see that for solving even simple problems two or more operations are necessary, whereas just one operation would often suffice with the common astrolabe.’

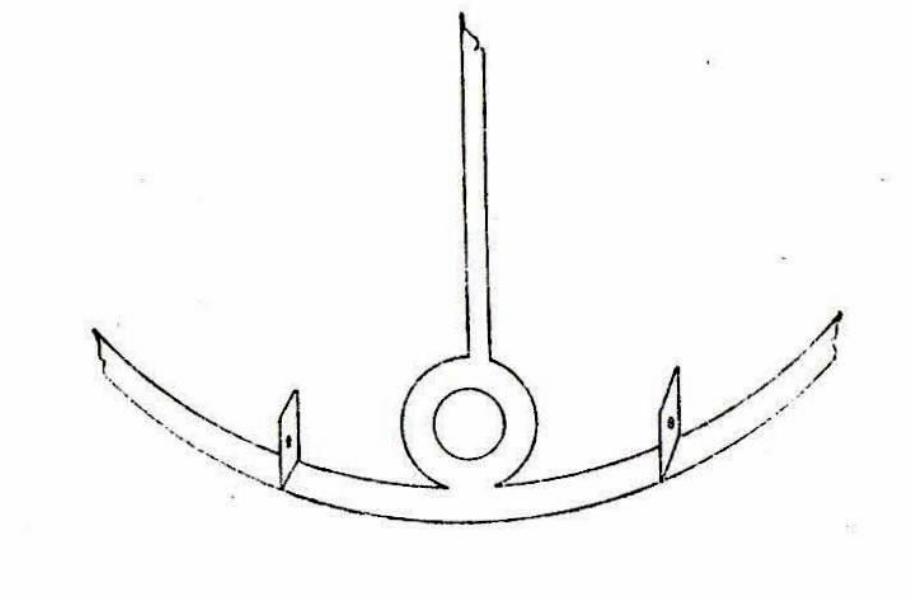


Figure A14 – The rete of a *zawraqī* astrolabe (from Frank 1920)

Astrolabes with this design may have been made and used at the time of its invention in the eleventh century and later, but no such astrolabes are extant today. All that exists now are the ten Lahore astrolabes in which one or two *zawraqī* horizons are incorporated in the otherwise standard retes and which contain a special plate to be used along with the *zawraqī* horizons.

The first step in this direction seems to have been taken by Qā’im Muḥammad who incorporated two arcs in the rete of an astrolabe he made in 1635 (A013).[159] Here both the arcs are curved towards the north; on the upper arc are engraved the names of six zodiac signs from Aries to Virgo; the function of this arc is not known. The lower arc carries the legends ‘The Horizon of the Western Solid’ and ‘The Horizon of the Eastern Solid.’[160] Obviously this arc is the proper *zawraqī* horizon. This has to be used with a special type of projection engraved on one of the plates, which Gunther describes thus: ‘a complicated plate in the centre of which is a miniature tablet for lat. 42°, hours

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159 Oxford, Museum of the History of Science, accession no. 42730. See also Gunther 1932, no. 71, pp. 191-197, Plates XLV-XLVI, figs. 94-97.

160 Rendered thus by Gunther 1932, p. 192.

15. Across the bottom is written "A table of the projection of rays", which according to Albiruni is also called "equalization of houses".'[161]

Two short mutually intersecting horizons for latitudes 30° and 33° are added to the rete in an unsigned astrolabe that can be attributed Qā'im Muḥammad (A016). Some plates are missing in this astrolabe; it is not known whether there was a plate to be used with the *zawraqī* horizons. Seven astrolabes by Ḍiyā' al-Dīn (two are signed by him: A073 and A082; others are attributable to him: A093, A099, A100, A101 and A103) carry these *zawraqī* horizons. Finally, a horizon for 40° occurs in an astrolabe by Jamāl al-Dīn (A121).

There is some variation in the horizons and in the plates that accompany them. In some astrolabes, the horizons are rather short, drawn inside the ecliptic ring. In others they are long, passing through the two equinoxes and reaching up to the Capricorn ring on both sides. The latitudes for which the horizons are drawn also vary.

In four astrolabes by Ḍiyā' al-Dīn, the horizons are for latitudes 29° (Delhi) and 32° (Lahore). In one astrolabe, he has just one horizon for latitude for 32° (Lahore) and in another for latitude 24° (Tropic of Cancer?). Finally, in one astrolabe (A102), there is a special rete consisting of just two horizons for latitudes 37° and 38°. On the other hand, in one of his astrolabes, Qā'im Muḥammad has just one horizon probably for 42° (A013) and in the other for latitudes 30° and 32°. Finally, Jamāl al-Dīn has a horizon for 42°.

The plates which are designed for use are highly complex. These are broadly of two types, those to be used with the short horizons and those to be used with the longer horizons. On the plates to be used with short horizons, first the oblique horizons at the desired latitudes are drawn and then the astrological houses or rather the markings for determining the astrological 'projections of the rays', divided for every 6° at these desired latitudes. Then inside the circle of Cancer a miniature plate is engraved with oblique horizons and markings for determining the 'astrological rays'. In addition, there are engraved a graduated ecliptic ring and the positions of some stars indicated by dots enclosed in small circles. The whole plate is designated as *ṣafīhat maṭraḥ al-shuᶜāᶜ*

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161 Gunther 1932, p. 194.

kahtrd (?) *abī rayhān taswīyat al-buyūt khwānand,* ‘plate for finding the projection of the astrological rays according to (?) Abū Rayhān [al-Bīrūnī] [and] equalization of the astrological houses’ (see A013, A082 and A093).



Figure A15 – Short horizons at latitudes 29° and 32° on the rete of the astrolabe made by Ḍiyā’ al-Dīn in 1663 (= Figure A082.3)

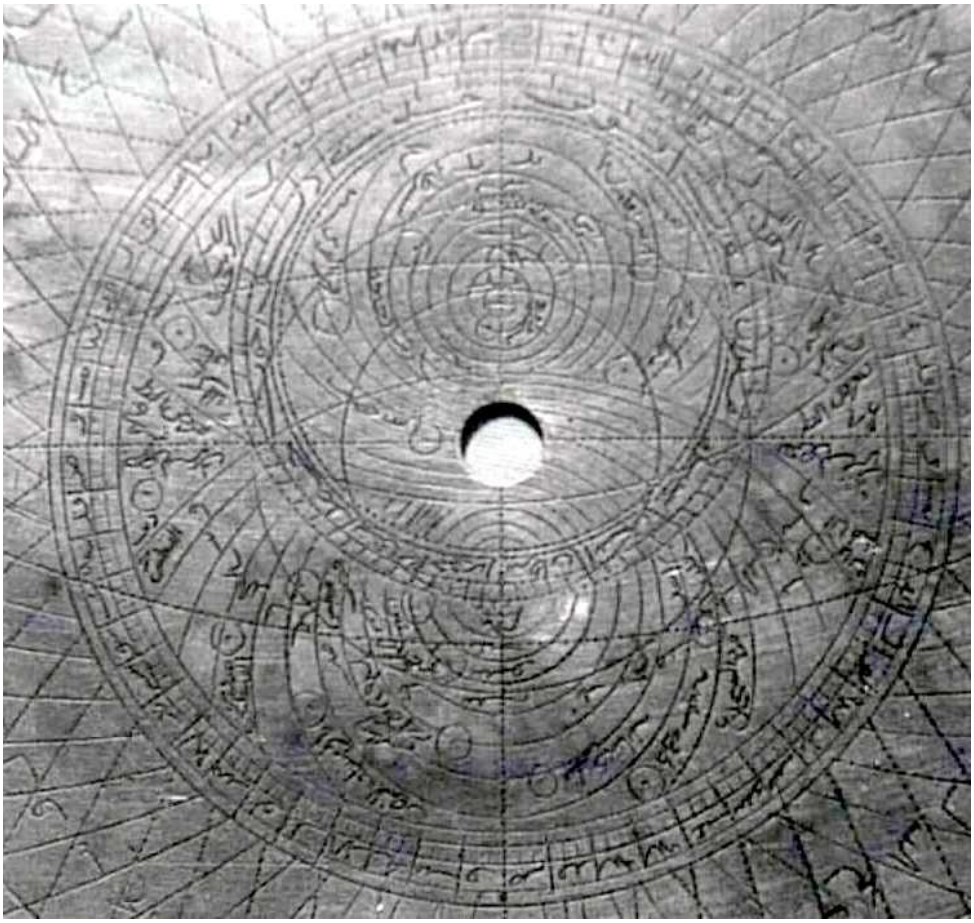


Figure A15. Miniature plate for use along with the short horizons in the astrolabe made by Ḍiyā' al-Dīn in 1663 (= detail of Figure A082.4)

The plates to be used with the long horizons are engraved with the oblique horizons and astrological houses at the desired latitudes. The positions of the stars which are on the rete are marked here by dots inside small circles. For example, two long horizons at latitudes 29° and 32° are incorporated in the rete of the astrolabe A099 which is attributable to Ḍiyā al-Dīn. Two separate plates are designed for using with these horizons. First there is a plate on which astrological houses are marked for the latitudes 29° and 32°. The second plate carries projections of the altitude circles, azimuth arcs and hours lines for latitude 29° as in a normal plate. Superimposed upon these is the ecliptic circle, divided into signs and groups of 6°, and also the positions of the same 46 stars which are on the rete.[162]

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[162] Like the obverse side of the North-South astrolabe by Ḍiyā' al-Dīn (A090), described previously, this plate also shows close resemblance to the back of an astrolabe by ʿUmar ibn Dawlatshāh ibn Muḥammad al-Kirmānī in 726 AH (AD 1325-26); see Linton 1980; no. 163, pp. 90-91; see also King 2005, p. 57, Fig. 5.1.3.



Figure A16. Long horizons at latitudes 29° and 32° in the rete of an astrolabe attributable to Ḍiyā al-Dīn (= Figure A099.2)

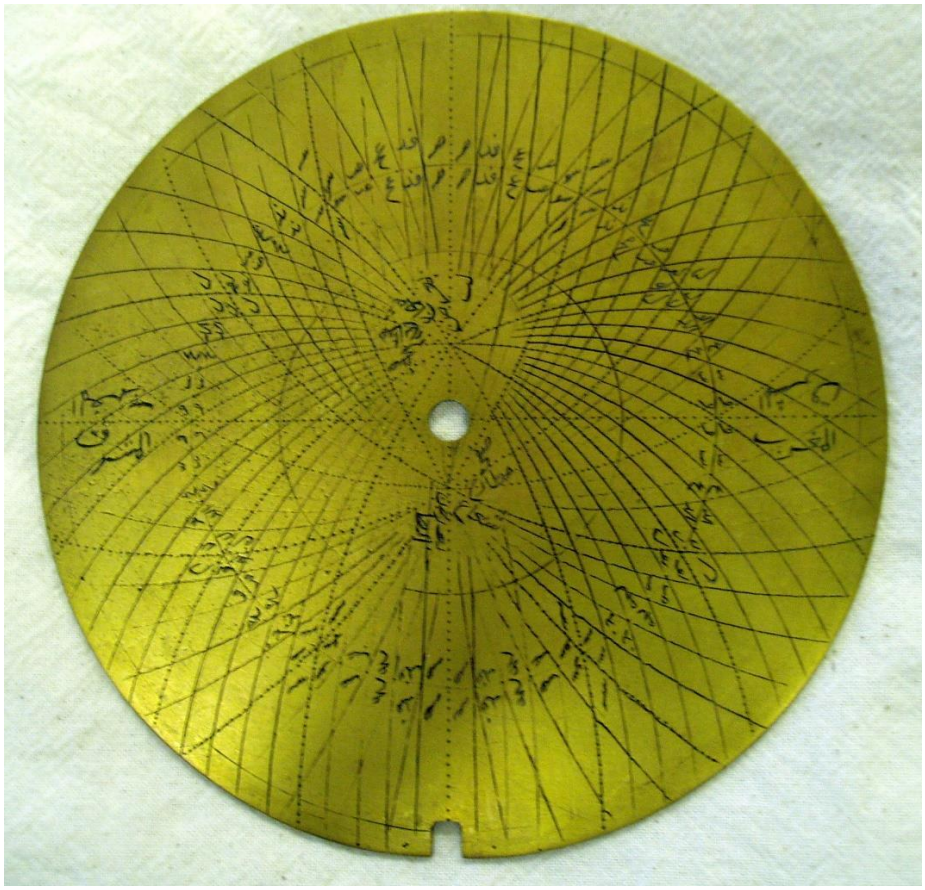


Figure A16 – Astrological houses at latitudes of 29° and 32° in an astrolabe attributable to Ḍiyā al-Dīn (= Figure A099.3)



Figure A17 – Plate for latitude 29° with the ecliptic and the positions of 46 stars marked with their names an astrolabe attributable to Ḍiyā al-Dīn (= Figure A099.4)

The following table gives a consolidated overview of the *zawraqī* horizons and the plates with special markings in the ten Lahore astrolabes.

Table A4 *Zawraqī* Horizons and Plates

	Astrolabe number	***Maker and Date***	***Horizons***	***Special plate***
1	A013	Qā'im 1635	1 short arc for 42°	Plate with a miniature plate inside in the circle of Cancer
2	A016	Qā'im attributable	2 short Arcs for 30° + 33°	Not available

	Astrolabe number	***Maker and Date***	***Horizons***	***Special plate***
3	A073	Ḍiyā' al-Dīn 1657	1 short arc for 32°	Plate with a miniature plate
4	A082	Ḍiyā' al-Dīn 1663	2 short arcs for 29°+32°	Plate with a miniature plate
5	A093	Ḍiyā' al-Dīn attributable	2 short arcs for 29°+32°	Plate with a miniature plate
6	A099	Ḍiyā' al-Dīn attributable	2 long arcs for 29°+32°	Plate for 29° with several star positions; another plate with markings for astrological 'projections of the rays' at 32° and 36°
7	A100	Ḍiyā' al-Dīn attributable	2 long arcs for 27°+36°	Plate for 27° with a graduated ecliptic ring and some 24 star positions; another plate for 36° with a graduated ecliptic and about 23 positions of stars, some of which are not identical with those marked on the plate for 27°
8	A101	Ḍiyā' al-Dīn attributable	Long arc for 24°	Plate for 24° with several star positions marked, but no markings for astrological 'projections of the rays'
9	A102	Ḍiyā' al-Dīn attributable	Separate rete for oblique horizons of 37° and 38°	There is no plate designed for use with these *zawraqī* horizons
10	A121	Jamal 1666	Long arc 40°	Plate for 40° with star positions; another plate with markings for astrological 'projections of the rays' at latitudes 32° and 36°

What advantages these 'ship' horizons and the associated plates bestow is not clear. We may recall Joseph Frank's remark that 'for solving even simple problems [with the *zawraqī* astrolabe] two or more operations are necessary, whereas just one operation would often suffice with the common astrolabe.' Is this merely a case of piling up complexities for displaying virtuosity?[163]

3.6. *Qibla* Maps

By the thirteenth century, the Islamic astrolabes are generally equipped with geographical tables with the longitudes, latitudes, *inḥirāf* (azimuth of *qibla,* i.e., the direction of Mecca), *jahat* (compass direction of Mecca in relation to the observer's locality) and *masāfat* (the linear distance to Mecca). The next step in this development are the maps on which the *qibla* direction is graphically displayed.

In his astrolabe of 1666 (A121), Jamāl al-Dīn engraved a *qibla* map on the inner surface of the mater. There the left hand side carries a geographical gazetteer arranged according to climates. On the right half is the *qibla* map where some 17 localities are marked by means of small circles in the appropriate positions with respect to Mecca.

Twenty years later, in 1686, Jamāl al-Dīn's brother Ḥāmid produced a massive instrument which contains a standard astrolabe and a *qibla* indicator (A112). On several plates, Mecca is placed at the centre and radial lines all around are connected to different localities mainly in India and Greater Iran.

3.7. Circle of the Visibility of Canopus (*Suhayl*)

The last non-standard feature in the Lahore astrolabes is a circle indicating the visibility of the star *Suhayl* (α Carinae, Canopus) which Qā'im Muḥammad engraved on most of the plate faces of his astrolabe of 1635 (A013). On plates for 32°, 35° and 38°, it is seen as a full circle, but on the plates for lower latitudes the circle is not complete. On the western side of this circle is the label *l'mᶜarifat al-ṭalūᶜ al-suhayl,* 'for the knowledge of the rising of Canopus' and the eastern side *l'mᶜarifat al-gharūb al-suhayl,* 'for the knowledge of the setting of Canopus'.

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163 King 2005, p. 806, emphasises the necessity of studying '*zawraqī* markings which have still not been properly explained in the modern literature, in order to document their origin in earlier (that is 9th- and 10th-century) textual sources.' It is still a desideratum.

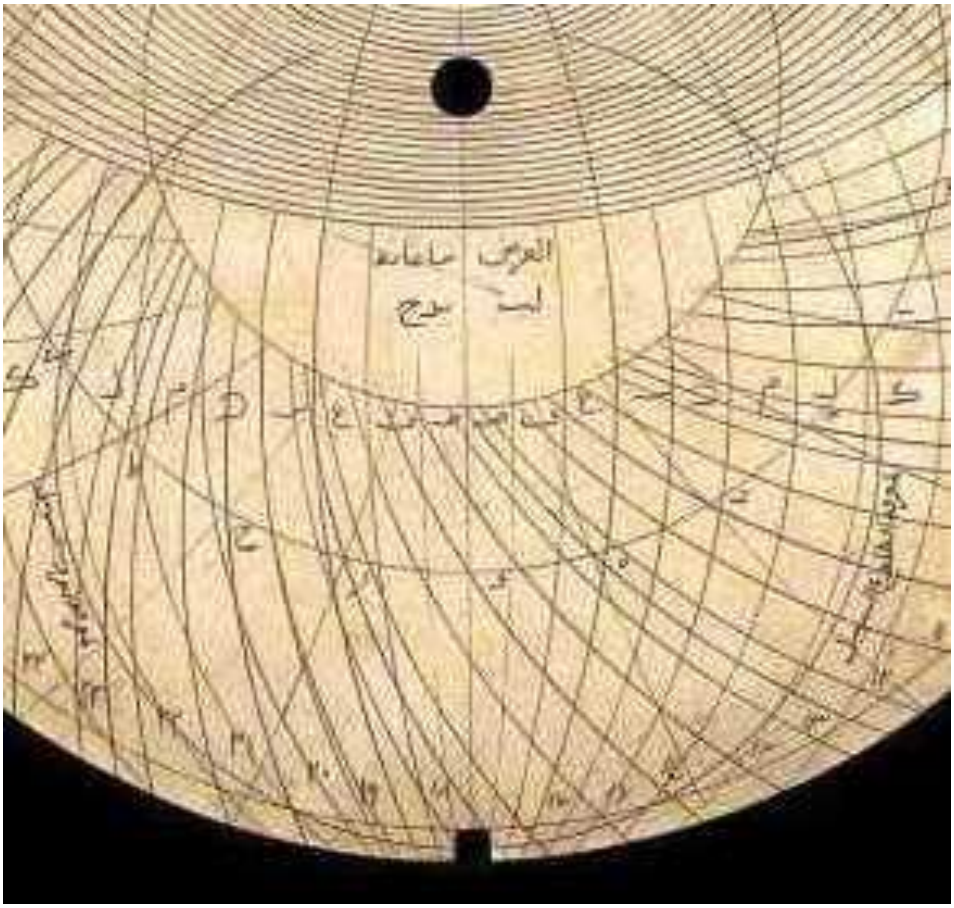


Figure A18 – Canopus circle on the plate for latitude 32° (detail of Figure A013.3) (© Museum of the History of Science, Oxford)

Canopus is the second brightest star in the heavens. Because of its extreme southern location, it is not represented on astrolabe retes, but on celestial globes it is shown in the lower rudder of the ship Argo Navis.[164] It has a declination of about 52;30° south and therefore it is not visible above the horizon at latitudes lower than 37;30° N.[165]

In Sanskrit, the star is called *Agastya* and Hindus celebrate the first visibility of Canopus after the rainy season with a certain ritual called *Agastya-pūjā* (worship of Canopus). On this, Michio Yano writes as follows:

> The heliacal rising (the first appearance before dawn) of the star *Agastya* (Canopus) is an important astronomical phenomenon concerned with

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164 Savage-Smith 1985, pp. 200-201, Fig. 81; see also Kunitzsch 1959, pp. 208-210.

165 In a personal communication of 28 May 2015, Professor Michio Yano informs me as follows: 'Since Canopus (Agastya)'s declination is about 52.5 degrees south, it can be seen at the place whose geographical latitude is lower than 37.5 degrees north. The lower the latitude the longer is the period of its visibility. At the latitude of Delhi, the star can be seen after mid-August and for quite a long time.'

> weather prognostics. With this phenomenon the rainy season comes to an end and the sky clears. *Pūjā* was performed in the dawn of the first appearance of *Agastya,* and the fortunes of the kings, individuals, and states were foretold. … The date of *Agastya's* first appearance depends on the geographical latitude.[166]

It is highly doubtful that Qā'im Muḥammad was aware of this Hindu custom. No other Lahore astrolabe carries this circle; in fact, no other astrolabe anywhere seems to have this circle as it is not mentioned in any published literature on the astrolabes. It is, therefore, difficult to determine Qā'im Muḥammad's source. That the star does not rise very high above the horizon is indicated by the placement of the circle mostly below the horizon. But it is strange that Qā'im draws the circle of visibility also on the plate for latitude 38° where the possibility of Canopus rising above the horizon is minimal.

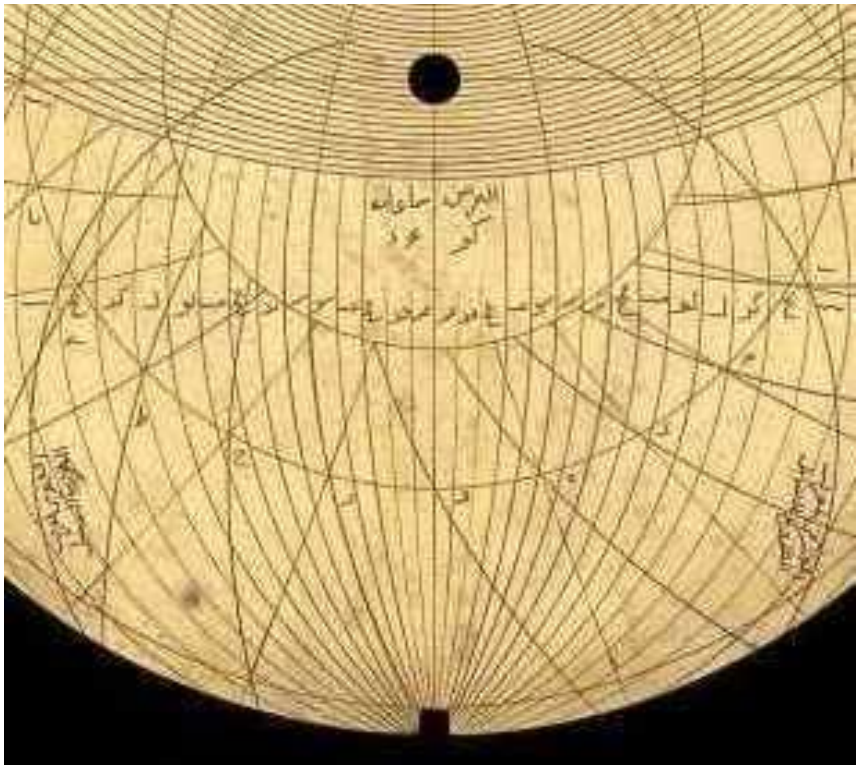


Figure A19 – Canopus circle on the plate for latitude 27° in astrolabe A013
(© Museum of the History of Science, Oxford)

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166 Yano 1994, pp. 233. In the following pages, he cites the statements of several Sanskrit texts on the time of the first visibility of Canopus in terms of the sun's position in the zodiac and then a table showing the heliacal risings for each degree from 20° to 37°. See also Rao et al 2016.

I append here the remarks on the plate for latitude 32° verbatim, which James Morrison kindly sent me on 26 and 27 May 2015.

> I took a quick look at the visibility of Canopus at a latitude of 32 deg N. It culminates at only about 5.3 deg above the horizon. This altitude can never be reached on a normal astrolabe plate, which is limited to declinations greater than -23.5 deg. Based on a very quick look, it appears that Canopus would be visible for at least part of a day from about April to early November. That is, Canopus is above the horizon when the Sun is below the horizon. …
>
> I've been looking at the visibility of Canopus at latitude 32 deg. I have been using my program, 'The Electric Astrolabe' to visualize it. It looks to me like it goes something like this: (all dates and positions are for 1635). On about 21 Feb (Pisces 4) Canopus rises just as the Sun sets. Canopus is then visible above the horizon until it sets 4:48 hrs later.
>
> It will continue to be visible at night until it rises just before the Sun on about 28 August (Virgo 4). So, Canopus is visible at night for about 6 mos. of the year. The rising time changes daily by the length of a sidereal day. Canopus' rising time will be about 4 min. earlier each day. This time difference is reflected by the Sun's daily change in longitude on the ecliptic.
>
> When Canopus is visible it is above the horizon for the same amount of time each day; 4:43 (approx.) The question the maker may have been trying to resolve is which 4:43 it can be seen. That is, the rising time of Canopus. His problem was how to represent Canopus when Canopus cannot be shown on the astrolabe. The circles must be his solution.
>
> I notice the Canopus arcs intersect the horizon at the azimuth angle equal to the plate latitude. Could this be a clue? Also, the star Alkaid rises very close to the rising of Canopus and could be used. That is, if Alkaid is visible, so is Canopus. I have not found another star with the same setting time. What mystifies me is why the arcs are circular.

ALLĀHDĀD

The patriarch of the Lahore family of astrolabe makers is Allāhdād (*fl.* 1567).[167] Two astrolabes signed by him are extant. The first is dated AH 975 (AD 1567-68) and is now with the Salar Jung Museum at Hyderabad (A001). The second one, which is not dated, is preserved in the Museum of History of Science at Oxford (A002). On both these astrolabes, he signed his name as Ustād Allāhdād Asṭurlābī Lāhūrī, thus proclaiming himself to be a master craftsman (*ustād*) and a resident of Lahore (*lāhūrī*). Allāhdād's son ᶜĪsā refers to himself, on his own astrolabes, as the son of 'Allāhdād Asṭurlābī Lāhūrī Humāyūnī.' Thereafter, this practice is followed by all members of the family; on the astrolabes and celestial globes crafted by them,[168] they mention their full ancestry beginning with Allāhdād Asṭurlābī Lāhūrī Humāyūnī.

There has been some controversy about the meaning of the epithet *humāyūnī* which, in conjunction with *asṭurlābī,* can only mean the 'astrolabe maker to Humāyūn.' Gunther renders the epithet *humāyūnī asṭurlābī* as the 'royal astrolabe maker'[169] and Nabia Abbott supports this view.[170] Sulaiman Nadvi refutes this saying that the term *humāyūnī* does not have the connotation 'royal'.[171] On the other hand, he speculates that Humāyūn must have invented a special kind of astrolabe which was called *humāyūnī asṭurlāb* and that the members of the Lahore family who manufactured such astrolabes received therefore the sobriquet *asṭurlābī humāyūnī*.[172] But there is no basis for this hypothesis; the astrolabes made by the members of the Lahore family are largely of the conventional type and some of the innovations they made there, as will be shown in this Catalogue, were originally invented in Andalusia in the tenth and eleventh centuries and not by Humāyūn in the second half of the sixteenth century.

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167 His name is variously transliterated in modern literature: Ilāhādād, Allāh Dād, al-Haddād and so on; cf. Abbott 1937, p. 146; Savage-Smith 1985, p. 301, n. 138 and Dar 1994, 174.

168 Except when the instruments are too small for the long signature.

169 Gunther 1932, pp. 187, 197, 208.

170 Abbott 1937, p. 146.

171 Nadvi 1937a.

172 Nadvi 1935, p. 626.

Savage-Smith argues 'that the name Humāyūnī was used to indicate contemporaneity of Allāhdād with Humāyūn and that even if the founder of the workshop [at Lahore] had enjoyed royal favour, his descendants probably did not.'[173] In fact, the descendants also did enjoy royal patronage as will be shown in the following pages. Savage-Smith herself describes a special kind of celestial globe made by Ḍiyā' al-Dīn Muḥammad for Aurangzeb in 1679 and states that on this globe Ḍiyā' al-Dīn refers to himself as the descendant of Allāhdād Humāyūnī.[174] Surely, on this globe made for the Emperor Aurangzeb, Ḍiyā' al-Din would not be using the attribute *humāyūnī* with the name of his ancestor merely to express Allāhdād's contemporaneity with Humāyūn, but to stress the fact that Allāhdād made astrolabes for Humāyūn and that his family enjoyed the patronage of Mughal royalty from Humāyūn onwards.

It is, however, true that Allāhdād's only dated astrolabe was made in 1567, i.e. eleven years after Humāyūn's death. But this does not preclude Allāhdād's manufacturing other astrolabes in Humāyūn's lifetime for the use of the emperor who is said to have been interested in astrolabes and celestial globes. Humāyūn's sister Gulbadan Begam reports that when he became impatient of waiting for Hamīdā-bānū Begam's consent to marry him, 'his Majesty took the astrolabe into his own blessed hands, and having chosen a propitious hour, summoned Mīr Abū'l-baqā and ordered him to make fast the marriage bond.'[175] It would be nice to imagine that the astrolabe which Humāyūn took into his blessed hand was crafted by Allāhdād. It is also perfectly legitimate that Allāhdād's descendants should commemorate the royal patronage extended to their ancestor by calling themselves the descendants of the Asṭurlābī Humāyūnī.

Allāhdād's grandson Muḥammad Muqīm adds sometimes 'Shaykh' to Allāhdād's name (A021 etc) and once 'Mullā Shaykh' (A032).[176] Allāhdād's great-grandson Ḍiyā' al-Dīn Muḥammad adds often 'Mullā' to Allāhdād's name (A059 etc) and once to the

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173 Savage-Smith 1985, p. 37.

174 Savage-Smith 1985, pp. 42-43, 232, Figure 17.

175 Gulbadan Begam, p. 151.

176 According to Steingass 1892, the epithet *Shaykh* has the following meanings: venerable old man, man of authority, chief, learned in religion and law, etc.; the term *Mullā* connotes a learned man, judge, priest and so on.

names of all the ancestors, i.e. father Qā'im Muḥammad, grandfather ᶜĪsā and great-grandfather Allāhdād (A061) and once even to his own name (A064).

The two astrolabes which carry Allāhdād's signature are unusually large and heavy. The dated piece at Hyderabad measures 199 mm in diameter. The other one at Oxford is still larger with a diameter of 256 mm. On the various plates in both these astrolabes, some of the circles are inlaid with silver, a feature not met with in any other astrolabe. Obviously these astrolabes were not made for the daily use of common astronomers but were meant for the high nobility as ostentatious show-pieces. The two astrolabes differ from one another not only in size but in respect of ornamentation as well. In the Hyderabad astrolabe, the crown-like projection at the top (*kursī*) is solid and the various star-pointers in the rete (*ᶜankabūt*) are joined by archaic patterns. In the astrolabe at Oxford, on the other hand, the *kursī* is pierced with a finely cut design and the star-pointers are joined by a delicate floral tracery. These two features became the hallmark of the Lahore astrolabes.

The Hyderabad astrolabe has five plates to serve the latitudes 21;40° (Mecca), 28;20° (Delhi?), 30°, 33;15° (Baghdad), 34°, 37°, 38°, 39;37° (Samarqand), 45°, and a plate of horizons of the eastern type. The astrolabe at Oxford has six plates calibrated for latitudes 21;40° (Mecca), 27° (Agra?), 30°; 33;25° (Baghdad), 34;30°, 37°, 38°; 39;47° (Samarqand), 45°, a plate of ecliptic coordinates, a plate of horizons of the western type, and a universal plate for all latitude originally designed by Ibn Bāṣo. Thus, the plates are not latitude-specific, but locality-specific. Although Allāhdād calls himself *lāhūrī,* it is surprising that in either astrolabe there is no plate for Lahore which lies on 31;50°. Interestingly, the Oxford astrolabe shows two uncommon features: the plate of horizons of a type which is common in the astrolabes made in the Maghreb and the universal plate for all latitudes which was originally invented by Ibn Bāṣo in Andalusia in the eleventh century.

On the inner side of the mater, Allāhdād engraves a geographical gazetteer with five separate columns for the names of cities, their latitudes, longitudes, *inḥirāf* and the duration of the longest day. The majority of these cities are from the Middle East, starting from Mecca at 21;40° and reaching up to Samarqand at 39;37°. But there are also a few Indian cities, and this number increases with each successive descendant. The Hyderabad astrolabe has a gazetteer of 96 cities, but the cells meant for the *inḥirāf* and

the longest day are not filled in at all. The Oxford astrolabe contains a gazetteer of 157 localities. Here the cells meant for *inḥirāf* and the longest day are filled partially, some by the astrolabe maker himself and some by a later hand in a much smaller script; but there are many cells in these two columns which are blank.

On the back, in both astrolabes, the upper half of the rim carries the altitude scales and the lower half cotangent scales. There is a sexagesimal trigonometric quadrant in the upper left with 60 horizontal lines and a solar quadrant in the upper right with equidistant arcs of the signs of the zodiac. In the lower half are engraved two shadow squares and inside these an elaborate table which combines several astrological tables.

Besides these two astrolabes, there are two other astrolabes which share some of the features of these two astrolabes and are therefore attributable to Allāhdād. One of these is in the Museum of the History of Science at Oxford (A003) and the other in the National Maritime Museum at Greenwich (A004). There is a great similarity in the workmanship of 0 and A003; their retes are almost alike in their design and have exactly the same 36 star pointers. Both contain Ibn Bāṣo's universal plate for all latitudes.

Likewise, there is much in common between A001 and A004. Both have solid *kursīs* of identical design and the retes in both are similar. As in A001, the geographical gazetteer in A004 has provisions for longitudes, latitudes, *inḥirāf* and the duration of the longest day, but the last two columns are not filled in. There are five plates in A004; some of the sides were engraved by Allāhdād and some by another person. The limb on the front of the mater was engraved by Allāhdād, but the back by another person who drew a graph for the midday solar altitude at latitude 32°. Therefore, this second person must be contemporary and worked on the astrolabe together with Allāhdād; it is quite likely that this second person was Allāhdād's son ʿĪsā whose astrolabes contain graphs for the midday solar altitude at latitude 32°.

A001 and A004 are stylistically alike and must have been produced about the same time ca. 1567. The other two A002 and A003 show greater refinement in design and must have been produced some time later.

Since his descendants invariably trace their genealogy back to Allāhdād, it may be assumed that he migrated to Lahore and set up his workshop there at the behest of Humāyūn. He may have come from Samarqand. The diversity of styles in astrolabes, the absence of a latitude plate designed for the latitude of Lahore and the incomplete

gazetteers indicate that he was experimenting with various features. However, in the two astrolabes at Oxford (A002 and A003) can be seen the beginning of the stylistic peculiarities which characterize the Lahore school.

A001⊙ ASTROLABE BY ALLĀHDĀD, 975 AH (AD 1567-68)

Diameter 199 mm

Hyderabad, Salar Jung Museum (#113/1/xxxv)

CCA 1120; Répertoire 1



Figure A001.1 – Front of the astrolabe (photo by S. R. Sarma)

This is the earliest extant astrolabe manufactured in India. In fact, it is the earliest dated scientific instrument of India that is extant today. It is a rather large and heavy piece with silver inlay. It could not have been meant for the daily use of a common astronomer, but only as an ostentatious showpiece kept by a high nobleman.

Components

Body with *kursī* (d. 199, h. 244, t. 11.5) with shackle and ring, rete for 28 stars, and 5 plates. The alidade with a sighting tube, bolt and wing nut are recent replacements.

Front

The astrolabe is suspended by a circular ring with a diamond-shaped cross-section. To this is attached a shackle. Its upper part has a trefoil shape with a hexagonal cross-section. The lower part of the shackle is riveted to the top of the *kursī*.

The *kursī* is high and solid, with seven lobes in each profile. The lower-most lobe is longer and more prominent; it is pierced by a hole, a feature that occurs in several middle-eastern Kufic astrolabes. The *kursī* is surmounted by trifoliate finial. On the front of the *kursī* a geometrical pattern is engraved on the surface. With a few exceptions, all other astrolabes produced in the family have openwork *kursīs*, and none have such a surface decoration with a geometrical pattern. Indeed, Allāhdād's second astrolabe at Oxford has an exquisitely pierced *kursī*.

The body, the rim and the *kursī* are cast as one piece. The rim of the mater measures 12 mm in width and carries two scales. The outer one is graduated in groups of 5° and labelled clockwise from 5° to 360° in *Abjad* notation. The inner scale is graduated in single degrees of the circle.

Rete

The rete consists of the three rings of the Tropic of Capricorn, the celestial equator and the ecliptic which are held together by the equinoctial bar which is counter-changed at the middle. The solstitial bar is shown only in the upper half.



Figure A001.2 – Rete of the astrolabe (photo by S. R. Sarma)

Large arcs of the circle representing the equator are shown both within and below the ecliptic. The ecliptic ring is divided into 12 signs of the zodiac and labelled with their names. Each sign is further subdivided in groups of 6° and 2° but not labelled. The most distinctive feature of the rete is the segment of the equator with several star pointers enclosed inside the ecliptic ring; two large pointers arising from the ecliptic ring above cross this segment of the equator.

There are 28 star pointers on the rete. These exhibit an archaic pattern of tiger's claws, sometimes with two or three lobes. This style is not emulated by any other member of the family. Even in his second astrolabe (A002), Allāhdād adopts a floral tracery to connect the star pointers, and this becomes the hallmark of the retes manufactured not only in this family but of all Mughal astrolabes in general. Moreover, the present rete contains a higher content of copper than the other components of this

astrolabe. Therefore, one is inclined to consider this rete to be a replacement for a lost original which may have contained a floral tracery. However, retes with such design occur in three other astrolabes.[177] All these three could not have been replacements. This rete design, therefore, appears to represent a minor tradition of Lahore.

Table A001-1 Stars on the Rete

	Star Name	Identification
1	*Rās al-Ḥūt*	γ Piscis
2	*Rijl al-Musalsala*	γ Andromedae
3	*Rās al-Ghūl*	β Persei
4	*Mirfaq al-Thurayyā*	α Persei
5	*ᶜAyn al-Thawr*	α Tauri
6	*Al-ᶜAyyūq*	α Aurigae
7	*Rijl al-Jawzā' al-Kubrā*	β Orionis
8	*Yad al-Jawzā' al-Yusrā*	γ Orionis
9	*Al-Shiᶜrā Yamānī*	α Canis Majoris
10	*Al-Shiᶜrā al-Shāmī*	α Canis Minoris
11	*Fard al-Shujāᶜ*	α Hydrae
12	*Qalb al-Asad*	α Leonis
13	*Ẓahr al-Asad*	δ Leonis
14	*Janāḥ al-Ghurāb*	γ Corvi
15	*Al-Simāk al-Aᶜzal*	α Virginis

177 Similar retes are to be seen in two other astrolabes of this family: an unsigned and undated astrolabe at the National Maritime Museum, Greenwich, which is attributed to Allāhdād (A004) and an undated astrolabe by Muḥammad Muqīm at the Lahore Museum (A034). A similar rete occurs also in an astrolabe (B001) at the Oriental Museum, Moscow, which is said to be a copy made by an unknown person in 996/1587 at Lahore of the original astrolabe made in Khorasan for Mīrzā Bāysunghur, who is probably identical with Mīrzā ibn Bāysunghur (1422–1457), the son of the Timurid prince Ghiyāth al-Dīn Bāysunghur; cf. Maslikov & Sarma 2016.

	Star Name	Identification
16	*Al-Simāk al-Rāmiḥ*	α Bootis
17	*Nayyir al-Fakkah*	α Coronae Borealis
18	*ᶜUnuq al-Ḥayyah*	α Serpentis
19	*Rās al-Hawwā'*	α Ophiuchi
20	*Al-Wāqiᶜ*	α Lyrae
21	*Minqār al-Dajājah*	β Cygni
22	*Al-Nasr al-Ṭā'ir*	α Aquilae
23	*Dhanab al-Dālfīn*!	ε Delphini
24	*Al-Ridf*	α Cygni
25	*Mankib al-Faras*	β Pegasi
26	*Matn al-Faras*	α Pegasi
27	*Dhanab al-Qayṭus*	ι Ceti
28	*Al-Khāḍīb*	β Cassiopeiae

PLATES

There are 5 plates containing stereographic projections for nine different latitudes and the plate of horizons. On all the plates, vertical and horizontal diameters are drawn, and also the three concentric circles of the tropics and equator. On the latitude plates, altitude circles are drawn for each 2°. The numbers of these circles move inwards from the outer to the middle circle and then up to meridian, forming a rounded M shape. Azimuth arcs are drawn only below the horizon for each 10° and numbered along the lower half of the equatorial circle. Lines are drawn for seasonal hours and for equal hours counted from the western and eastern horizons.

The prime vertical, the oblique horizon, and the curves for equal hours counted from the western and eastern horizons are inlaid with silver. This is an unusual feature, not to be met with anywhere in the extant astrolabes.

Below the horizon the words *al-maghrib* and *al-mashriq* are engraved in the west and east respectively. The latitude and the duration of the longest day at this latitude are engraved in the space between the horizon and the circle of Cancer to the right and left of the meridian line respectively.

The plates serve the following latitudes:

Table A001-2 Plates

	φ	Longest day	(locality)
1a	21;40°	13;20 hours	(Mecca)
1b	33;25°	14;12 hours	(Baghdad)
2a	30;0°	13;57 hours	
2b	37;0°	14;34 hours	
3a	38;0°	14;40 hours	
3b	45°	15 hours	
4a	28;20°	12;49 hours[178]	(Delhi?)
4b	Plate of horizons		
5a	34;0°	14;17 hours	
5b	39;37°	14;52 hours	(Samarqand)

The latitude plates are locality specific rather than latitude specific. Although Allāhdād calls himself a Lāhūrī, 'resident of Lahore,' there is no plate for the latitude of Lahore. It is also strange that the latitude of what is probably Delhi is widely off the mark. Plate no. 4a mentions it as 28;20° but in the geographical gazetteer it is mentioned as 28;15°. But the more accurate value 28;39° was known as early as 1370.[179]

The plates for 21;40° and 33;25° are clearly intended for Mecca and Baghdad. Remarkable is also the fact that the five plates exhibit slightly different colouration,

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178 12;49 hours is clearly a mistake. It should read 13;49.

179 Cf. Mahendra Sūri, p. 18 et passim.

suggesting that they were cut from different sheets of brass with varying proportion of copper. But the style is the same; they were made by the same man. The rete also appears to contain more copper than the rest of the components.

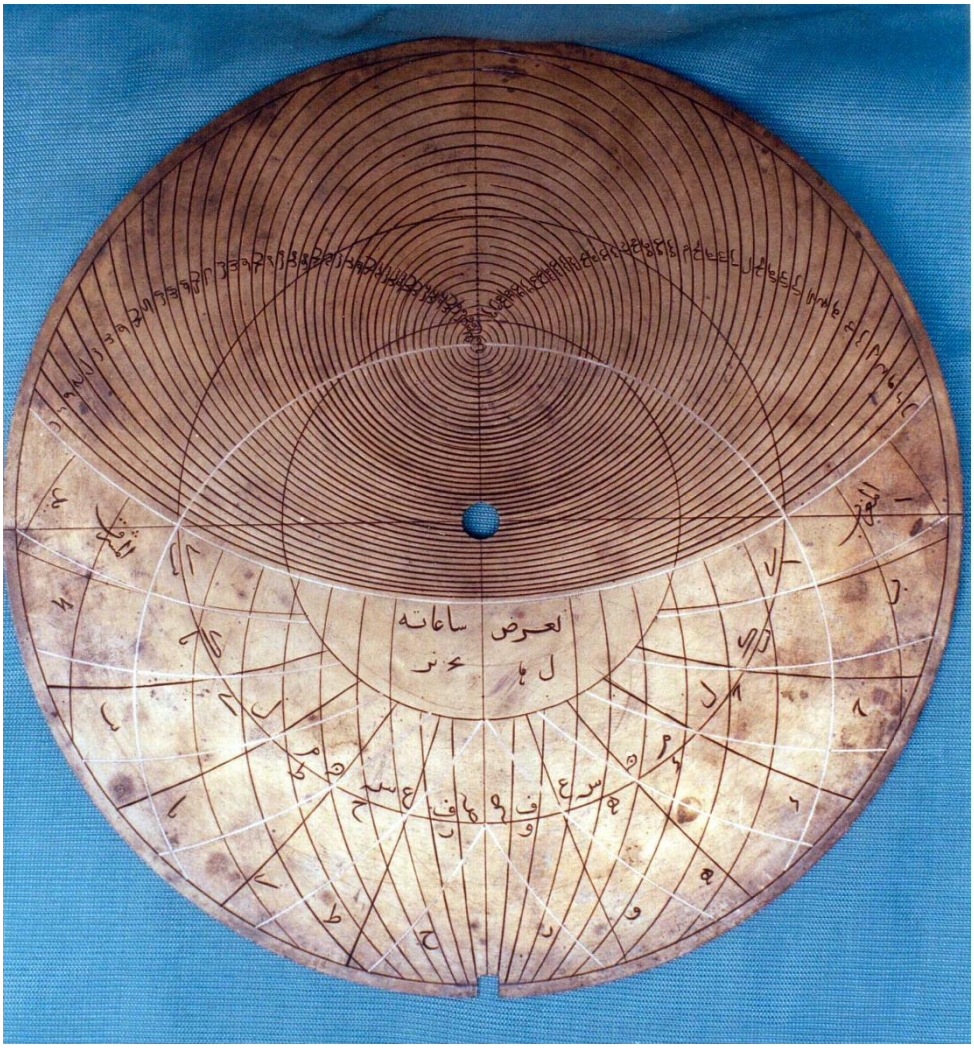


Figure A001.3 – Plate for the latitude of 30° (photo by S. R. Sarma)

Plate 4b bears four sets of half-horizons for latitudes from 10° to 72°. There are no declination scales. The latitudes served are:

10	18	26	34	42	50	58	66
12	20	28	36	44	52	60	68
14	22	30	38	46	54	62	70
16	24	32	40	48	56	64	72



Figure A001.4 – Geographical Gazetteer (photo by S. R. Sarma)

GEOGRAPHICAL GAZETTEER

On the inner side of the mater, there is a geographical gazetteer of 95 cities, engraved in two circles of five concentric rows. For each entry, five cells are allotted to carry respectively the names of the localities (*al-bilād*), their longitudes (*al-ṭūl*), latitudes (*al-ʿarḍ*), their orientation towards Mecca (*al-inḥirāf*) and the duration of the longest day (*al-sāʿāt*) at that latitude. The majority of the localities is from the Middle East, starting from Mecca at 21;40° N and reaching up to Samarqand at 39;37° N

latitude. But there are also a few (about 10) Indian cities, and this number grows with each successive descendant. Surprisingly enough, the last two cells meant for the *inḥirāf* and the longest day are left blank for all localities. In the case of Najaf, except the name all other cells are empty. The argument is given only in the first circle, to the right of the vertical diameter. The gazetteer is read from the top centre in anti-clockwise direction, from right to left.

Table A001-3 Geographical Gazetteer

	Place Name	L	φ
	Outer Circle		
1	Makka Mubārak	77;10	21;40
2	Madīnat Rasūl	75;20	25;0
3	Bayt al-Maqdis	66;30	31;50
4	Iskandariyya	61;54	30;18
5	Miṣr	63;20	30;20
6	Dimashq	70;0	33;15
7	Ḥalab	77;10	35;50
8	Qusṭanṭiyya	59;50	45;0
9	Marāgha	82;0	37;20
10	Tabrīz	82;0	38;0
11	Ardabīl	82;30	38;0
12	Shamākhī	84;30	40;50
13	Kūfa	79;30	31;30
14	Baghdād	80;30	33;25
15	Baṣra	84;0	30;0
16	Shīrāz	88;0	29;36
17	Hamadān	83;0	35;10
18	Sāwa	85;0	35;0

	Place Name	L	φ
19	Qazwīn	85;0	36;15
20	Iṣfahān	86;40	32;25
21	Kāshān	86;0	34;0
22	Qum	84;40	34;45
23	Rayy	86;20	35;00
24	Astarābād	89;35	36;50
25	Samnān	88;0	36;0
26	Damghān	88;50	36;20
27	Bisṭām	89;30	36;20
28	Shīrwān	91;30	36;0
29	Nishābūr	92;30	36;21
30	Ṭūs	92;30	37;0
31	Turshīz	92;0	35;0
32	Ṭabas Gīlakī	92;0	33;0
33	Tūn	92;30	34;30
34	Qā’īn	93;20	31;40
35	Harān	94;20	34;30
36	Bādhghīs	94;30	20;35
37	Sarkhas	94;30	37;0
38	Marw	97;0	37;40
39	Fariyāb	99;0	36;45
40	Balkh	80;0	36;41
41	Khujand	105;35	41;15
42	Ṭāliqān	102;50	36;25

	Place Name	L	φ
43	Narjisat ?	104;25	36;10
44	ᶜĀrā	97;30	39;50
45	Samarqand	99;16	40;0
46	Kashghar	106;0	44;0
47	Chīn ?	125;0	24;0
48	Banjahīr	104;40	35;0
49	Mūltān	106;35	29;40
50	Qandahār	106;40	33;0
51	Dihlī	113.35	28;15
52	Kashmīr	108;0	35;0
53	Lāhūr	109;20	31;50
54	Kannawj	105;50	26;35
55	Nahlawāra	102;30	27;0
56	Sawmnāt	107;10	22;15
57	Sarandīb	104;0	10
58	Mansūra Sind	104;0	27;40
59	Hurmūz	92;0	24;0
60	Ḥims	69;40	34;0
61	Qulzum	66;30	28;0
62	ᶜAdan	70;0	11;0
63	Ṣanaᶜā’ az Yaman	70;0	14;30
	Inner Circle		
64	Hajar Baḥrayn	83;0	25;35
65	Qaṭif Baḥrayn	72;0	22;0

	Place Name	L	φ
66	Jazīraat Ḥarrān	73;0	36;40
67	Mosul	77;0	36;30
68	Barda^{c}	83;0	40;0
69	Bulghār	79;0	34;0
70	Shūstar	84;30	31;30
71	Yazd	89;0	32;0
72	Sāriya	88;0	36;0
73	Jurjān	90;0	36;15
74	Iṣṭakhr	88;30	35;0
75	Dhābid	74;20	14;10
76	Tubbat	110;0	40;0
77	Akra	93;0	27;39
78	Bandar Tāna	84;5	19;20
79	Kajmakarān	99;0	28;0
80	Sirjān	90;20	39;30
81	Suhraward	83;20	37;0
82	Kāzrūn	87;0	29;0
83	Khuway	79;6	37;40
84	Bandar Qulzum	64;0	29;0
85	Ṣuḥār ^{c}Amān	84;0	14;20
86	Ba^{c}albak	70;45	33;15
87	Akhlāṭ	75;45	29;20
88	Madā’īn	72;0	33;10
89	Laḥasā	83;30	24;0

	Place Name	L	φ
90	Wāsiṭ	81;30	32;20
91	Andarāb	103;45	36;0
92	Tā'īf	77;30	21;20
93	ᶜĀbān	84;30	30;0
94	Lār	90;0	28;0
95	Najaf	—	—

BACK

On the back, the upper half of the rim is graduated, as in the front, in groups of 5° and then in single degrees. The former are labelled in *Abjad* notation from 5° to 90° and then from 90° to 5° (5—90; 90—5). These are the scales of altitude.

The back is divided into four quarters. In the upper left quadrant, there is a trigonometric grid with 60 horizontal parallels. Every tenth of these is extended into the upper right quadrant as a quarter circle, to form a solar quadrant there, with a quarter circle for each 30° of solar longitude or one zodiacal sign. The signs are labelled along the vertical and horizontal radii by their serial numbers (0 for Aries, 1 for Taurus and so on). Thus the numbers engraved along the vertical radius from the centre up to the circumference are 3 to 8, i.e. summer solstice to winter solstice; those engraved along the horizontal axis from the circumference up to the centre are 9 to 11; 0 to 2, i.e. from winter solstice to summer solstice.

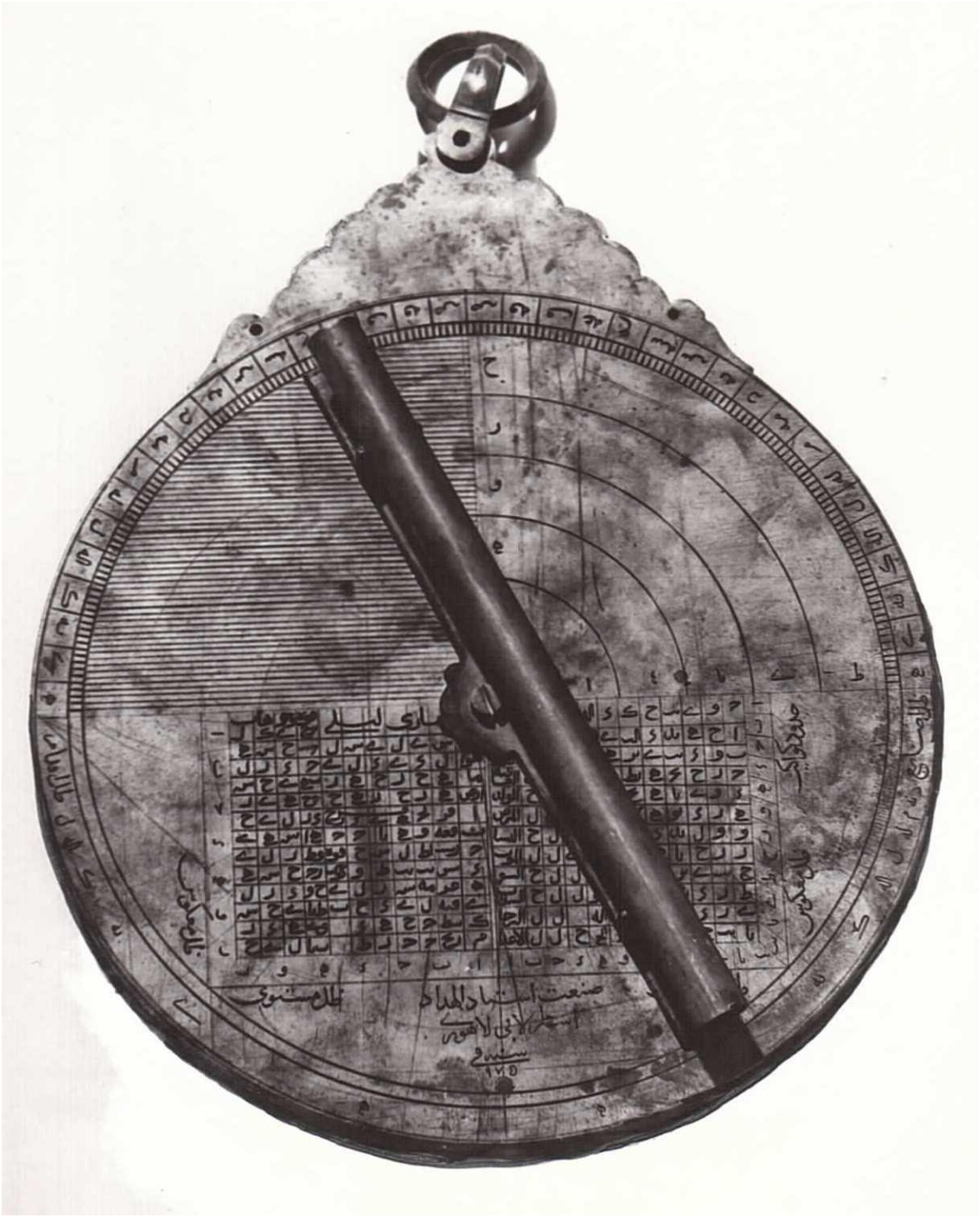


Figure A001.5 – Back of the astrolabe (photo courtesy Salar Jung Museum)

In the two lower quadrants are engraved the shadow squares. The square on the left is for the gnomon of 7 feet. The vertical scale is divided in 7 parts and numbered from 1 to 7 starting from the horizontal diameter of the astrolabe; it has the label *ẓill maᶜkūs* (umbra versa or reverse shadow). The horizontal scale is divided in 7 parts and numbered from the centre onwards; it carries the legend *ẓill mustawī* (umbra recta or direct shadow).

The square on the right is for the gnomon 12 digits. The vertical scale is divided in 12 parts and numbered from 1 to 12 starting from the horizontal diameter of the astrolabe; it has the label *ẓill maᶜkūs* (umbra versa or reverse shadow). The horizontal scale is divided in 12 parts and numbered from the centre onwards; it carries the legend *ẓill mustawī* (umbra recta or direct shadow).

Inside these shadow squares is a rectangular grid containing four astrological tables. This rectangular arrangement is exactly the same in the next astrolabe (0). The four astrological tables will be discussed there.

The lower half of the rim carries the two cotangent scales and their subdivisions. The scale on the left is in feet; the unequal divisions are numbered from the meridian onwards anti-clockwise as 5, 10, 15, … 40, 45, 50, followed by the label *ẓill aqdām* (shadows in feet). The scale on the right is in digits; the unequal divisions here numbered as on the left, clockwise from the meridian onwards, followed by the label *ẓill aṣābiᶜ* (shadows in digits).

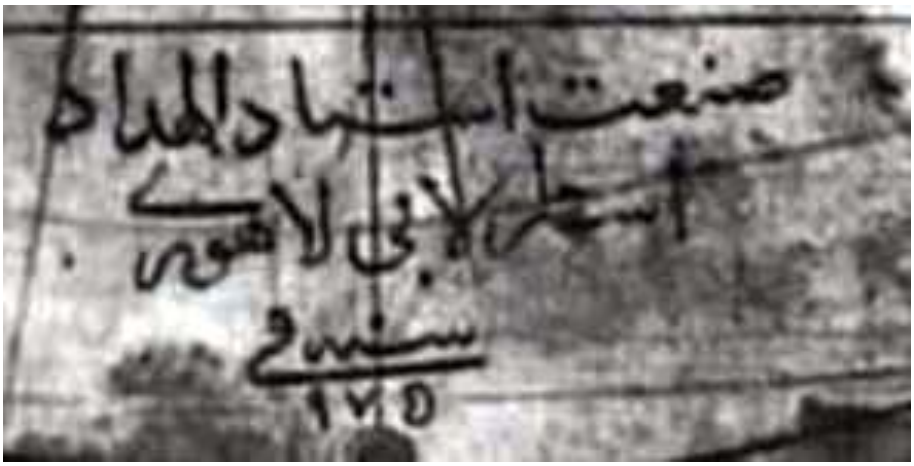


Figure A001.6 – Signature of the astrolabe maker (detail from Figure A001.5) –

INSCRIPTION

The maker's inscription is engraved below the shadow squares in three lines:

ṣanᶜat ustād allāhdād

asṭurlābī lāhūrī

fī sanah 975

'Made by Master Allāhdād, the astrolabe maker of Lahore, in the year 975 [Hijrī = 1567-68 AD].'

ALIDADE, PIN AND HORSE

The original alidade, pin and horse are missing. Now there is a straight alidade with turtle-head-shaped ends and a five-lobed centre piece. A cylindrical sighting tube is attached to the sights. The pin and the horse are replaced by a modern bolt and a wing nut.[180]

BIBLIOGRAPHY

Nadvi 1935.

Sarma 1996a, pp. 7-11, pls. 1-3.

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[180] In fact, all the six astrolabes at the Salar Jung Museum are equipped with the same type of alidades with sighting tubes, bolts and wing nuts. It appears that all the six astrolabes were acquired from a single dealer who may have added these modern replacements to the astrolabes.

A002⊙ ASTROLABE BY ALLĀHDĀD, NOT DATED

Not dated, late 16th century, Lahore

Diameter 255 mm

Oxford, Museum of the History of Science (# 47376)

CCA 1089; Répertoire 2



Figure A002.1 – Front of the astrolabe
(© Museum of the History of Science, Oxford)

This is a massive astrolabe with a diameter of 255 mm and a thickness of 14 mm; the *kursī* and rete are elegantly crafted with matching floral design.

COMPONENTS

Body with crown (d. 255, h. 317, t. 14) with shackle and ring, rete (d. 229) for 36 stars, 6 plates (d. 229), alidade (230, w. 16, t. 4), pin, wedge, rule.

FRONT

A very massive ring with diamond-shaped cross-section and sharply pointed edges, smaller shackle also with diamond-shaped cross-section; seen from the side the shackle has the trifoliate form, the bases of the shackle are circular and plain.

The crown is elegantly reticulated with fine decorative lines engraved on the surface. There are decorative lines at the back also. On the edge of the main body are engraved alternately long and short cartouches, probably for an inscription but are not filled in. General pattern of decorations on the crown and rete consists of tulips with two or three petals.

On the limb is engraved the degree scale in three bands. In the outer band, groups of 5° are marked and numbered in 5s from 5 to 360 in *Abjad* symbols. The two inner bands are divided in single degrees. Probably the innermost band was intended to be divided into three parts of twenty minutes each, but this was not done. On the back, the upper half of the rim is also calibrated in this manner, but at the bottom of the upper right quadrant, the innermost band is divided into 20 minutes each in the first unit of 5°.

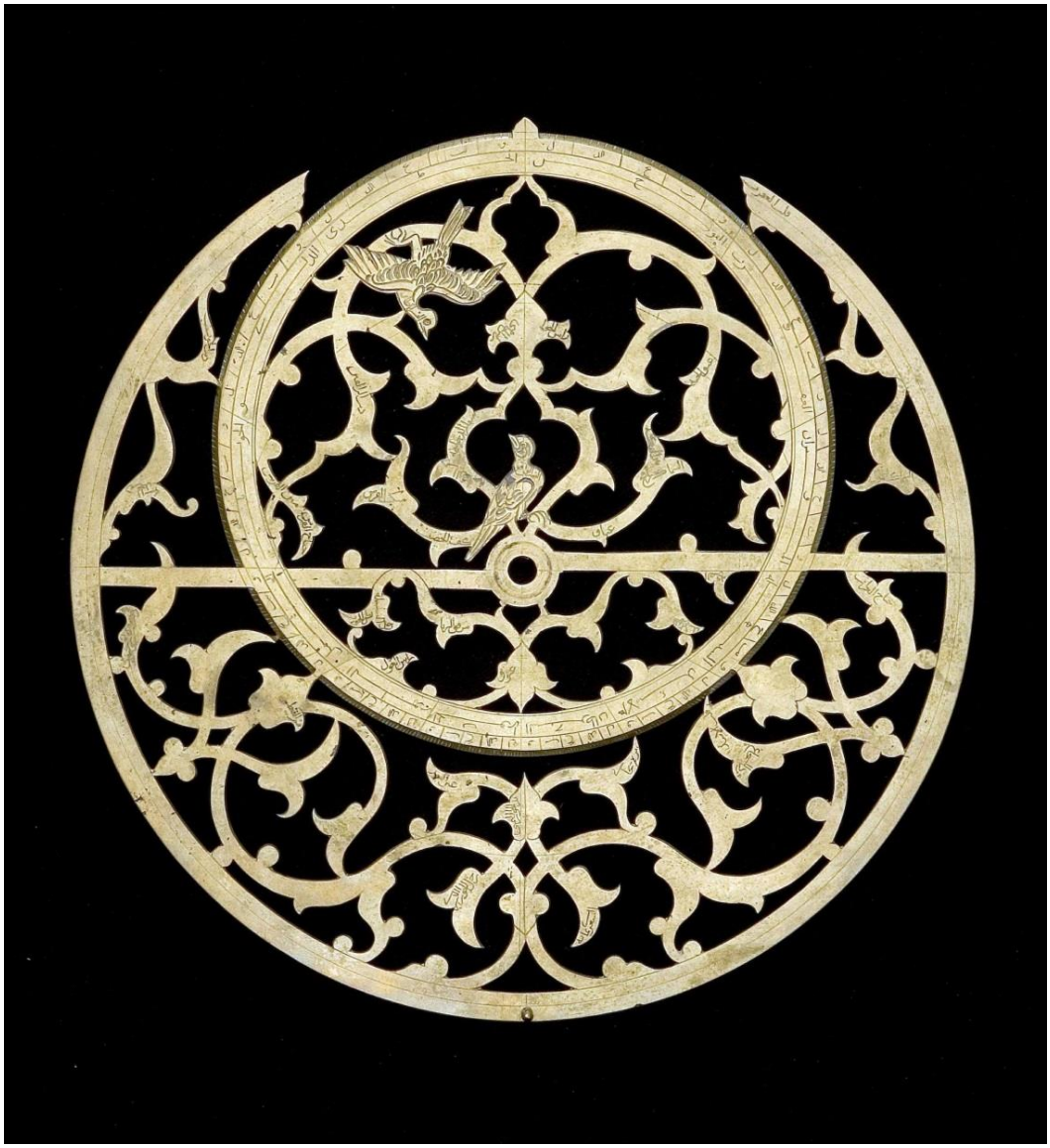


Figure A002.2 – Rete of the astrolabe (© Museum of the History of Science, Oxford)

RETE

The rete is constituted by the two rings of Capricorn and ecliptic which are held together by the equinoctial bar which is counter-changed at the centre. The equator is not represented. The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names, starting from the vernal equinox and proceeding counter-clockwise. Each sign is divided into groups of 6° and numbered as 6, 12, 18, 24, 30 also proceeding counter-clockwise. The sloping edge of the ecliptic circle is marked with the divisions of 1°.

The star pointers are shaped like the flared petals of tulip flowers which are joined by a very elegant floral arabesque tracery. The floral tracery in the rete and a matching design of the openwork *kursī*, which became the hall mark of the Lahore astrolabes, has

its beginnings in this astrolabe. On the rete, the two stars Vega and Altair are shown by cut-out and engraved figures of birds; the former seated and the latter soaring. The outstretched wings of Altair are filled with deeply cut lines so that a series of feathers can be seen. These birds are decorated also at the back with engraved lines.[181]

There is a small handle at the north point on the Capricorn ring. A small triangular projection on the ecliptic ring represents *al-murī,* the zero point of Capricorn.



Figure A002.3 – Detail of Figure A002.2 showing the zoomorphic representation of α Lyrae (Vega) and α Aquilae (Altair)

Listed below are the stars shown on the rete in the order of their increasing right ascension.

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[181] Later on, Muḥammad Muqīm, one of his two grandsons, would be filling the rete of his astrolabe with more than two dozens of similar cut-out figures of zoomorphic star pointers in A049.

Table A002-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab Qayṭus Janūbī*	β Ceti
2	*Baṭn al-Ḥūt*	β Andromedae
3	*Rijl al-Musalsala*	γ Andromedae
4	*Fam al-Qayṭus*	γ Ceti
5	*R'as al-Ghūl*	β Persei
6	*Mirfaq al-Thurayyā*	α Persei
7	*ᶜAyn al-Thawr*	α Tauri
8	*ᶜAyyūq*	α Aurigae
9	*Rijl al-Jawjā' al-Yusrā*	β Orionis
10	*Yad al-Jawjā' al-Yumnā*	α Orionis
11	*Al-Shiᶜrā Yamānī*	α Canis Majoris
12	*Mirzam Saḥābī*	β Canis Minoris
13	*Fard al-Shujāᶜ*	α Hydrae
14	*Qalb al-Asad*	α Leonis
15	*Ẓahr al-Asad*	δ Leonis
16	*Al-Ṣarfa*	β Leonis
17	*Janāḥ al-Ghurāb*	γ Corvi
18	*Al-Simāk al-Aᶜzal*	α Virginis
19	*ᶜAnāq*	ζ Ursae Majoris
20	*Al-Simāk al-Rāmiḥ*	α Bootis
21	*Nayyir al-Fakkah*	α Coronae Borealis
22	*ᶜUnuq al-Ḥayyah*	α Serpentis
23	*Qalb al-ᶜAqrab*	α Scorpii
24	*R'as al Ḥawwā*	α Ophiuchi

	Star Name	Identification
25	*R'as al Jāthī*	α Herculis
26	*Al-Nasr al-Wāqiᶜ*	α Lyrae
27	*Minqār al-Dajājah*	β Cygni
28	*Al-Nasr al-Tā'ir*	α Aquilae
29	*Dhanab al-Dulfīn*	ε Delphini
30	*Dhanab al-Dajājah*	α Cygni
31	*Dhanab al-Ḥūt*	α Gruis
32	*Mankib al-Faras*	β Pegasi
33	*Matn al-Faras*	α Pegasi
34	*Janāḥ al-Faras*	γ Pegasi
35	*Dhanab al-Jadī*	δ Capricorni
36	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are six plates of varying thickness with the following specifications.

Table A002-2 Plates

	φ	longest day	(locality)
1a	21;40°	13;20 hours	(Mecca)
1b	30°	13;57 hours	
2a	33;25°	14;12 hours	(Baghdad)
2b	34;30°	14;20 hours	
3a	37°	14;32 hours	
3b	38°	14;40 hours	
4a	39;37°	14;50 hours	(Samarqand)

	φ	longest day	(locality)
4b	45°	14;27 hours!	
5a	27°	13;43 hours	(Agra ?)
5b	Plate of horizons (western type)		
6a	Plate of ecliptic coordinates		
6b	Universal plate for all latitudes designed by Ibn-Bāṣo		

As in the other astrolabe by Allāhdād (A001), the plates in this astrolabe are locality specific rather than latitude specific.[182] On these, altitude circles are drawn for each 1°, every third circle is interrupted once on both sides of the meridian and its serial number is engraved in the space created by the interruption. This is a unique feature; in other astrolabes the numbers are written in the spaces between the lines; here the numbers form a semi-circular arc and not the rounded figure of M as in the other astrolabes. No lines are highlighted.

The azimuth circles are drawn for every 6° below the horizon and numbered along the equatorial circle. Lines are drawn for seasonal hours and for equal hours drawn from the western horizon as well as from the eastern horizon, both reaching up to the meridian, but numbered from the western horizon. In plate 4a equal hours are not numbered.

Under the intersection of the oblique horizon and the prime vertical on the west is written *al-maghrib* and in the east *al-mashriq.* Below the horizon is engraved on either side of the meridian the latitude and the duration of the longest day, but both inscriptions

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182 Four plates (1a, 1b, 2a, 3b) in this astrolabe are common to those in the astrolabe at Hyderabad (A001). In other plates, there are certain differences. In the Hyderabad astrolabe there is a plate for 28;20 (probably Delhi); here there is a plate for 27 (Agra?). At Hyderabad there is a plate for 34°, here for 34;30. In three cases, the durations of the longest day differ.

37°	Hyderabad	14;37	Oxford	14;32
39;37°	Hyderabad	14;52	Oxford	14;50
45°	Hyderabad	15	Oxford	14;27.

In the plate of horizons at Hyderabad, half-horizons are engraved in four sets; here in eight sets.

are in a single line and not in two lines as in other astrolabes. Thus on plate 1a, there is *al-arḍ k-a-m* and *al-saᶜāt y-j k.*

On all plates calibrated for a particular latitude, the horizon lines, the prime meridian and the lines of equal hours are inlaid with silver wire. On plate 5a for 27°, the prime meridian is shown only below the horizon; on other plates, it is shown as a full circle extending above and below the horizon.

On plate 5b is engraved a plate of horizons of the western type. On 6a is the plate of ecliptic coordinates and on 6b there is a universal plate which was designed by Ibn Bāṣo.

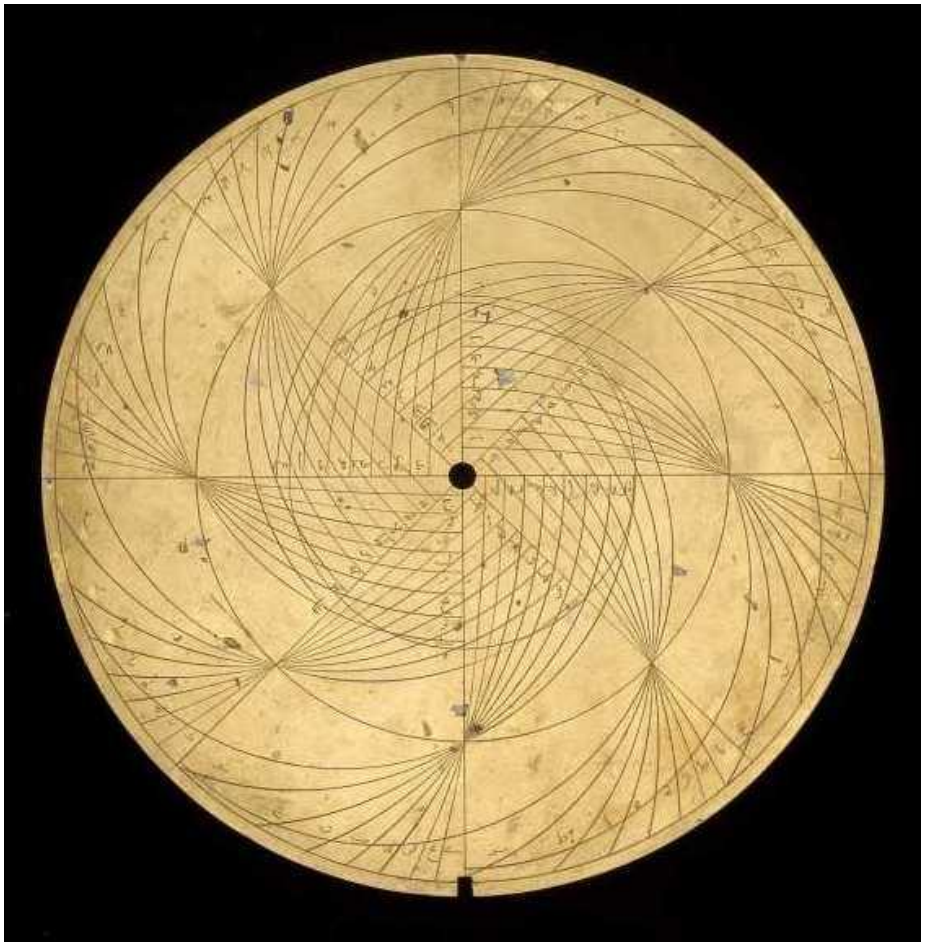


Figure A002.4 – Plate of horizons (© Museum of the History of Science, Oxford)

5a. Plate of horizons

While Allāhdād's other astrolabe (A001) contains a plate of horizons of the eastern type, this astrolabe has a plate of horizons of the western type where the half-horizons are arranged in eight groups. The horizons for latitudes ranging from 8° to 71° are arranged at intervals of 8° in eight batches in the following manner:

8	16	24	…	48	56	64
9	17	25	…	49	57	65
10	18	26	…	50	58	66
11	19	27	…	51	59	67
12	20	28	…	52	60	68
13	21	29	…	53	61	69
14	22	30	…	54	62	70
15	23	31	…	55	63	71

The horizons are numbered at both their extremities, i.e., at the periphery of the plate and at the radials drawn from the centre. There are no declination scales, nor is there a label on the plate. This is the only case of western type of the plate of horizons in Indo-Persian astrolabes.

6a. Plate of ecliptic coordinates

On this plate are drawn the equator, the ecliptic and the two tropics. The ecliptic circle is inlaid with silver. Concentric circles of ecliptic latitudes (= altitude circles for the latitude of 90° – obliquity) are drawn for every 5° and numbered on both sides of the meridian.

Arcs of ecliptic longitudes (= azimuth arcs for the latitude of 90° - obliquity) radiating from the centre are drawn for every 5°. Every sixth of these arcs is inlaid with silver, these constituting the boundaries of the twelve signs of the zodiac. But the names of the signs are not written along the circumference of the ecliptic; instead groups of 5° (of azimuth/ celestial longitude) are numbered along its entire circumference 5—90; 90—5; 5—90; 90—5.

There is no label on the plate. This occurs in most of the Lahore astrolabes.

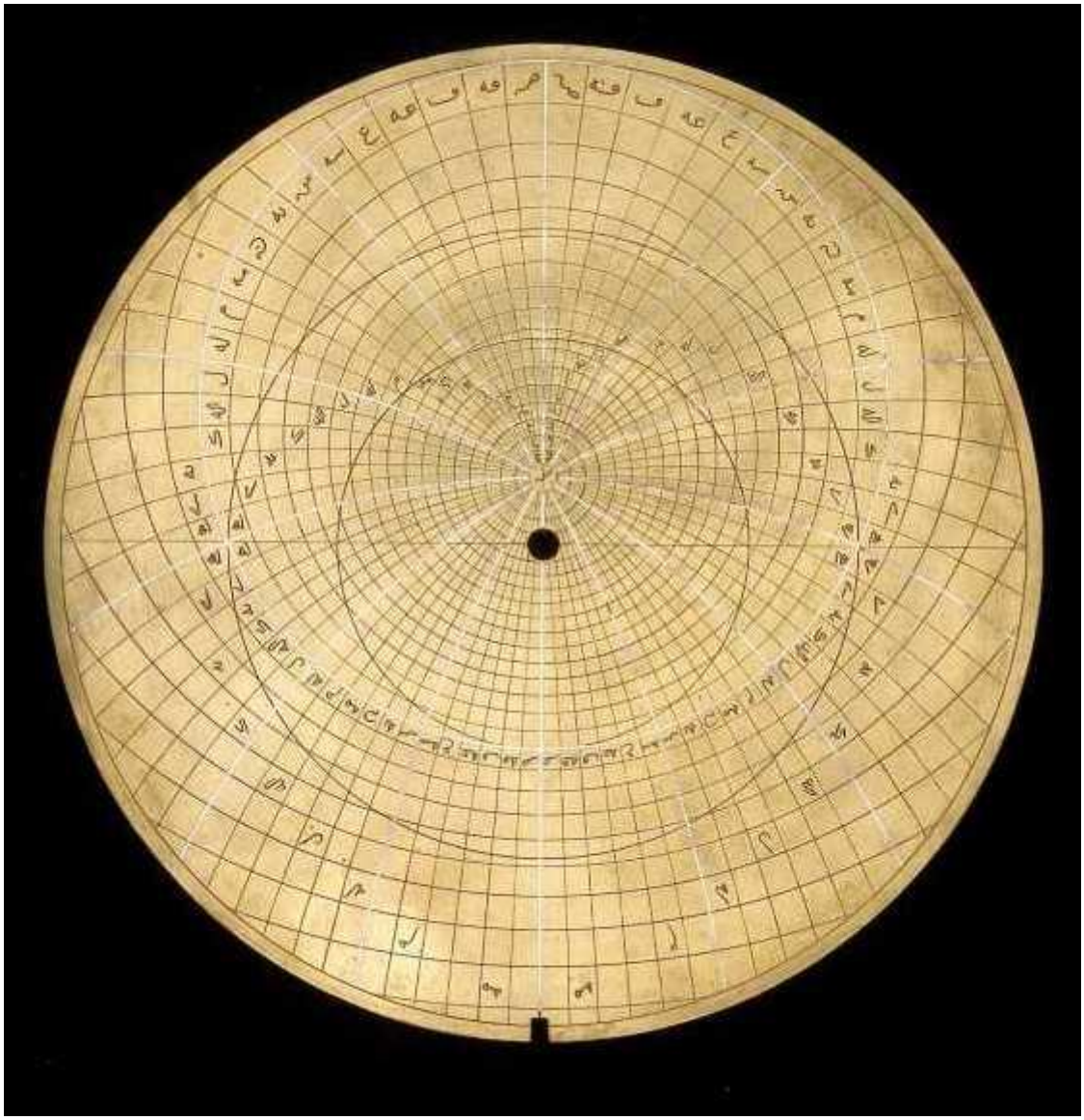


Figure A002.5 – Plate of ecliptic coordinates (© Museum of the History of Science, Oxford)

6b. Universal plate for all latitudes

On the reverse side of the plate of ecliptic coordinates is engraved a universal plate for all latitude which was designed by Ibn Bāṣo in the thirteenth century in Andalusia.[183] It combines the features of the latitude plate (*ṣafīḥa*) and the plate of horizons. On this plate are drawn three families of circles.

First, there is a series of 30 arcs of great circles passing through the east and west points. These are horizons for each 6° of terrestrial latitudes from +90° to -90°. These are not numbered.

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183 On Ibn Bāṣo, see Calvo 2007; on the construction and use of the universal plate, see Calvo 2000.

Then around the east and west points are drawn 15 arcs each at 6° intervals. These arcs divide horizons into equal parts. The outermost arcs are inlaid with silver. The numbers of these arcs start from the east and west points and proceed along lower periphery up to the meridian line.

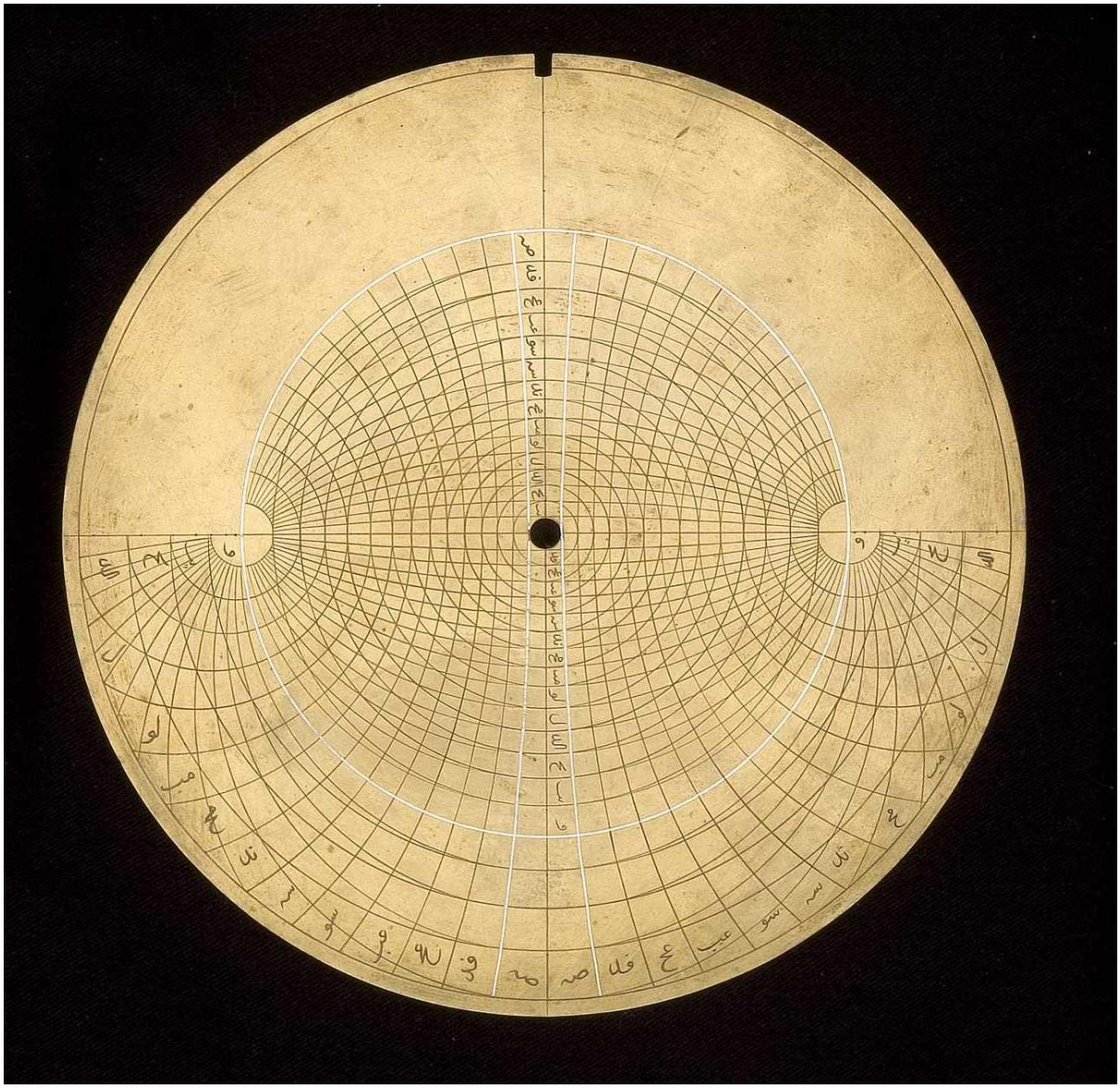


Figure A002.6 – Universal plate after Ibn Bāṣo
(© Museum of the History of Science, Oxford)

Third, around the centre are drawn 14 concentric circles at 6° intervals. These are altitude circles for the latitude of 90°. Ibn Bāṣo calls them *madārāt* (parallels of declination). These circles are numbered along the vertical diameter both above and below the centre. Above from 6 up to 90 at the centre, and again from 6 at the centre to 90 below. The outermost circle here, which is the projection of the equator, is inlaid with silver.

Between this circle of the equator and the outer circle of the plate are drawn three semi-circles, only in the northern half. These are called by Ibn Bāṣo *anṣāf dawā'ir al-mayl* (semicircles of declination).

There is no label on this plate either. In an unsigned which can be attributed to Allāhdād and which will be described next (A003), there is a similar plate which bears the label *al-ṣafīḥa al-jāmiᶜa li-jāmīᶜ al-ᶜurūḍ* (universal plate for all latitudes).

Geographical Gazetteer

The geographical gazetteer is engraved in three concentric circles, providing the name (*al-bilād*), longitude (*al-ṭūl*), latitude (*al-arḍ*), *inḥirāf* (*al-inḥirāf*) and the longest day (*al-arḍ sāᶜāt*) in 5 cells situated one below the other for 165 localities.

The cell for the *inḥirāf* is often blank; sometimes it is filled by the maker, some other times by a later hand in smaller and scratchy script. These additions by the different hand are marked bold in the following table. Many cells of the longest days are also not filled, especially for places in the Indian subcontinent. As compared to the previous astrolabe, there are more localities from India (about 20) in this gazetteer. The data is read from the right to the left, starting at the topmost point.



Figure A002.7 – Geographical gazetteer (© Museum of the History of Science, Oxford)

Table A002-3 Geographical Gazetteer

	Place Name	L	φ	*inḥirāf*	Longest Day
	Outer Circle				
1	Makka Mubārak	77;10	21;40	**0;0**	13;20
2	Madīnat Rasūl	75;20	25;0	**36;10**	13;36,33
3	Bayt al-Maqdis	66;30	31;50	29;36	14;50
4	Iskandariya	61;54	30;58	39;36	14;0
5	Miṣr	63;20	30;20	60;24	13;18
6	Dimashq	70;00	33;15	30;16	14;12
7	Ḥalab	72;10	35;50	**34;10**	14;26,27
8	Qusṭanṭiyya	59;50	45;0	38;0	15;14,27
9	Marāgha	82;0	37;20	15;50	14;32
10	Tabrīz	82;0	38;15	15;30	14;42
11	Ardabīl	82;30	38;30	15;30	14;42
12	Shamākhī	82;30	40;50	**15;30**	14;16,38
13	Kufa	79;30	31;30	**12;31**	14;3,43
14	Baghdād	80;0	33;25	13;0	14;3
15	Baṣra	84;0	30;0	18;24	13;12
16	Shīrāz	88;0	29;36	11;23	13;15
17	Hamadān	88;0	35;10	25;30	14;24
18	Wah	85;0	35;0	29;14	14;29
19	Qazwīn	85;0	36;15	26;30	14;30
20	Iṣfahān	86;40	32;25	40;23	14;9
21	Kāshān	86;0	34;0	36;8	14;19
22	Qumm	85;40	34;45	**32;13**	14;24
23	Rayy	86;20	35;0	**31;33**	14;24

	Place Name	L	φ	*inḥirāf*	Longest Day
24	Tā'īf	87;30	21;20	—	13;18,15 !
25	Samnān	88;0	36;0	39;40	14;30
26	Damghān	88;50	36;30	28;30	14;31
27	Bisṭām	89;30	36;10	36;30	14;30
28	Sabzwār	91;30	36;5	38;42	14;30
29	Nīsābūr	92;30	36;21	45;3	14;31
30	Ṭūs	92;30	37;0	45;45	14;30
31	Turshīz	92;0	35;0	48	14;21,50
32	Tabas Gilakī	92;0	33;0	12;0	14;12
33	Tūn	92;30	34;30	**12;3**	14;19,9
34	Qā'īn	93;20	31;40	**12;1**	14;15!
35	Herāt	94;20	34;30	13;50	14;21!
36	Badᶜās	94;30	35;20	—	14;25
37	Sarhan?	94;30	34;0	**51;57**	14;19
38	Marw	94;0	37;40	50;45	14;40
39	Fāriyāb	99;0	36;45	—	14;32
40	Balkh	100;0	36;40	54;30	14;32
41	Khujand	105;35	41;55	45;0	14;16!
42	Tāliqān	102;50	36;25	**29;33**	14;31
43	Badakhshān	104;25	36;10	**65?**	14;30
44	Bukhārā	97;30	39;50	14;30	14;49
45	Samarqand	99;16	40;0	49;0	14;12!
46	Kāshghar	106;30	44;0	14;25	15;3
47	Chīn Banjū	125	24;0	75;45	13;25

	Place Name	L	φ	*inḥirāf*	Longest Day
48	Banjahir	104;40	35;0	—	14;29
49	Multān	106;35	29;40	80;43	13;15
50	Qandahār	106;40	33;0	**75;0**	14;12
51	Dehlī	115;45	28;15	86;26	13;48
52	Kashmīr	108;0	35;0	68;12	14;29
53	Lāhūr	109;20	31;50	—	14;5
54	Qannawj	115;50	26;35	—	—
55	Nahlawara	102;30	22;0	45;30	12;28
56	Swmmnāt	103;10	22;15	66;30	12;39
57	Sarandīb	130;0	10;0	18;0	12;13
58	?	104;0	22;40	—	13;43
59	Hurmūz	92;0	24;0	78;45	13;39
60	Ṭārabulus	69;40	34;0	78;12	14;20
61	Qulzum	66;30	28;4	**86;3**	13;48
62	ᶜAdan	76;0	11;0	5;50	12;16
63	Sanaᶜān Yaman	74;0	14;30	**1;15**	—
64	Zabīl	74;20	14;10	**24;25**	—
65	Qaṭif Baḥrayn	72;0	22;0	—	12;38
66	Harrān Jarīna	73;0	36;40	—	14;32
67	Mawṣil	77;0	36;30	**3;54**	14;31
68	Bardaᶜ	83;0	40;0	**16;36**	14;12!
69	Bulghār	79;0	34;0	—	14;20
70	Shushtar	84;30	31;30	35;20	14;3,43
71	Yazd	89;0	32;0	44;14	14;5

	Place Name	L	φ	*inḥirāf*	Longest Day
72	Sāriya	88;0	35;0	**34;54**	14;29
73	Jurjān	90;0	36;45	36;15	14;34
74	Iṣṭakhar	88;30	35;0	—	14;29
75	Tubbat	110;0	40;0	—	14;12/52
76	Laḥasā	83;30	24;0	**69;30**	13;39
77	Akra	93;0	27;36	**45;3**	13;43
78	Bandar Tāna	104;5	19;20	—	—
79	Kach Kamrān	99;0	28;0	—	13;48
80	Sīrkhān	90;20	29;30	59;0	13;55!
81	Suhraward	83;20	37;0	—	—
82	Kāzirūn	87;0	29;15	**51;57**	13;14
83	Khuway	79;40	37;40	**18;3**	14;40
84	Bandar Qulzum	64;0	29;30	—	13;15
85	Ṣuhār ᶜAmān	84;0	14;20	**40;32?**	—
86	Baᶜalabak	70;45	33;15	—	14;12
87	Akhlāṭ	75;85!	39;20	—	—
88	Madā’īn	77;0	33;10	28;1	14;12
89	Baghdād	80;0	33;25	13/20;0	14;13
90	Wasit	81;30	32;20	**20;57**	14;8
91	Baṣra Mᶜaran (?)	70;0	32;0	—	14;5
92	Andarāb	103;45	36;0	—	14;30
93	Abādān	84;45	36;0	—	13;14/2
94	Jand Nīsābūr	85;0	33;0	**62;9**	14;12
95	ᶜAskar (?) Mukrām	84;30	31;55	—	14;5

	Place Name	L	φ	*inḥirāf*	Longest Day
	Middle Circle				
96	Astarābād	89;35	36;50	36;3	14;24
97	Lār Sarār	90;0	28;0	66;30	13;48
98	Najaf	**?;15**	**32;5**	**14;34**	—
99	Ḥilla	79;15	32;15	32;40	14;7
100	Karbalā	**83;55**	**32;40**	**14;0**	—
101	Jadda	76;30	21;45	—	13;21
102	Sardārmanī	79;45	34;52	**200;85!**	14;25
103	Madīnat Sanā (?)	77;0	14;0	—	—
104	Bam	94;0	28;30	69;0	13;49,01
105	Dar ab-Charad	90;15	28;15	—	13;48
106	ᶜArnīn	84;20	33;35	**70;0**	14;14,18
107	Abhar	14;30	36;45	**25;0**	14;31,35
108	Ṭāram	84;0	36;30	—	—
109	Sārī	88;0	37;0	—	—
110	Āmal	88;20	36;15	33;21	14;31
111	Damāwand	57;20	36;10	**32;44**	—
112	Sulṭāniyā	83;30	36;36	26;40	14;33
113	Basā	93;30	37;40	—	—
114	Kāshgar	106;30	44;30	15;3	14;25
115	Khotan	107;0	47;0	**20**	—
116	Aḥmadābād	—	—	—	—
117	Khanbāyich	109;10	22;20	—	—
118	Bahroj	102;5	21;20	—	—

	Place Name	L	φ	*inḥirāf*	Longest Day
119	Mandu	110;45	22;35	—	—
120	Qalanjar?	106;0	25;25	—	—
121	Kawaliyār	115;35	26;33	—	—
122	Bānāras	117;20	26;15		
123	Munkher	119;10	22;0	—	—
124	Chanlawa?	121	22	—	—
125	Manārkānū?	124;0	22;0		
126	Kulbarkā	109;11	17;40		
127	Bījāpūr	108;30	17;20		
128	Bīdar	110;13	33;35!		
129	Aḥmadnakar	—	—	—	—
130	Dābal	—	—	—	—
131	Juyūl	106	19;0	—	—
132	Dawlatābād	—	—	—	—
133	Tālankānd	—	—	—	—
134	Dībal	80;30	38;0	—	—
135	Kābul	104;40	34;30	**70;37**	—
136	Arna	104;20	33;25	—	—
137	Ahwāz	84;0	31;0	—	—
138	Jazīra …	84;30	33;0	—	—
139	Fīrūzābād	87;30	28;10	—	—
140	Dīnūr	83;0	35;0	22;31	—
141	Bākuna	84;30	39;30	**20;53**	—
142	Taḥshab	98;0	39;0	—	—

	Place Name	L	φ	*inḥirāf*	Longest Day
	Inner Circle				
143	Abarqū	88;10	31;30	45;0	14;2
144	Kermān	92;30	30;5	63;2	13;18!
145	Sābkārā	89;0	28;28	13;28	13;49
146	Kartān	—	—	34;30	—
147	Husum	15;10	37;0	33;31	14;33,0
148	Sūs	15;30	22;0	74;30	12;38
149	Mūqān	83;0	38;0	38;34	14;39,15
150	Khwārizm	102;0	42;0	14;30	15;7
151	Bajīram?	107;30	26;30	76;15	—
152	Karkān	—	—	39;3	—
153	Qūniya	66;30	40;0	62;16	14;17,13
154	Jarmī Ḥabasha	65;30	9;30	45;0	12;12
155	Lāhjān	86;50	36;25	28;34	14;31
156	Khatlān	37;0	84;10	28;35	14;35
157	Barbar	65;0	14;0	39;10	12;4
158	Arsāhbal	82;0	19;4	39;0	12;12
159	Himṣ	70;45	33;15	—	14;16,28
160	Mārdīn	74;0	37;15	—	14;34,34
161	Khān Bāligh	124;0	46;0	—	14;34,8
162	Khabīṣ	93;0	31;5	—	14;1,16
163	Jīrfat	93;0	27;30	—	13;43
164	Maᶜazar Lambān	24;0	33;40	—	33;25!
165	Naṭīr	86;0	33;15	—	14;12

Baghdād occurs twice at 14 and 89 and Kāshghar at 46 and 114! In as many as 18 cases, the duration of the longest day is given in hours, minutes and also in seconds (see, e.g., nos. 2, 7, 8 and so on).

BACK

The back of the astrolabe is almost the same as in the previous astrolabe, with two minor differences. In the previous astrolabe, the shadow square for 7 is on the left and that for 12 on the right. Here it is the reverse. In the previous astrolabe, the name of the maker is followed by the year of manufacture. Here the year is not mentioned.

The upper half of the rim carries the two altitude scales which are divided in 1° and 5° and numbered as 5—90; 90—5. The lower half of the rim carries the two cotangent scales in feet and in digits respectively.

In the upper left is the trigonometric quadrant with 60 horizontal parallels. There are no labels or dotted lines. In the upper right is the solar quadrant with a declination arc for each 30° of solar longitude or one zodiacal sign. The signs are labelled along the vertical and horizontal radii by their serial numbers (0 for Aries, 1 for Taurus and so on). Thus the numbers engraved along the vertical radius from the centre up to the circumference are 3 (Cancer) to 8 (Sagattarius), i.e. summer solstice to winter solstice; those engraved along the horizontal axis from the circumference up to the centre are 9 (Capricorn) to 11 (Pisces); 0 (Aries) to 2 (Gemini), i.e. from winter solstice to summer solstice.

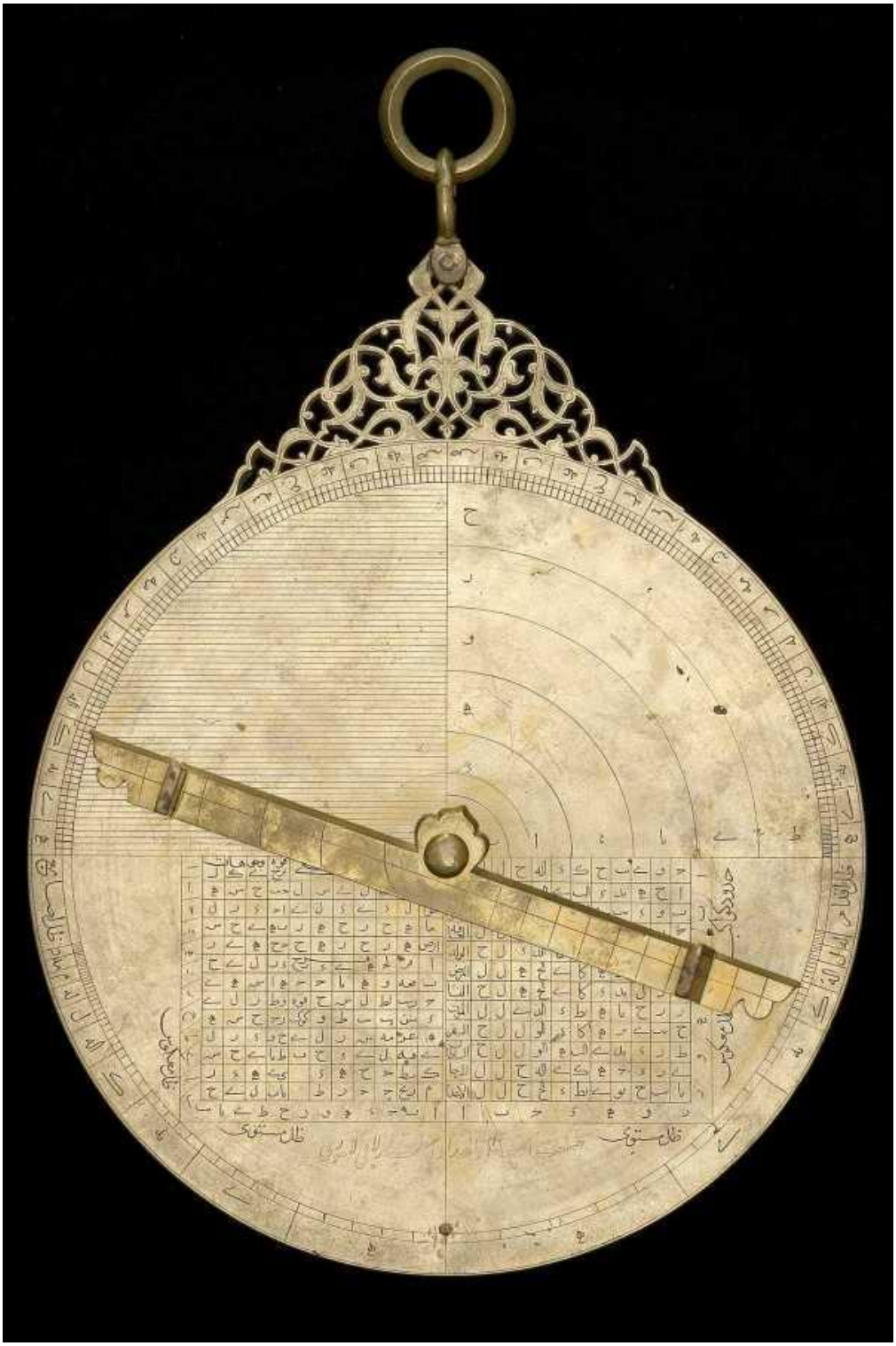


Figure A002.8 – Back of the astrolabe (© Museum of the History of Science, Oxford)

In the lower half are shadow squares, on the left for 12 digitd and on the right for 7 feet.

ASTROLOGICAL TABLES

Inside the shadow squares is a large rectangular grid containing four astrological tables, exactly as in A001.

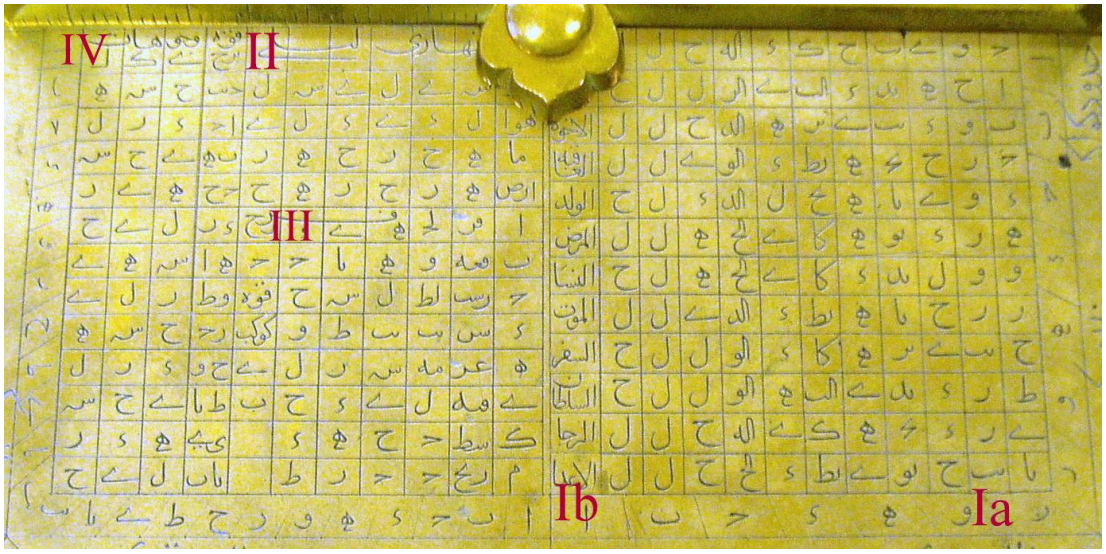


Figure A002.9 – Astrological tables on the back (photo by S. R. Sarma)

Ia Table of limits or terms of the signs (*al-ḥudūd*)

Starting from the right, the first is the table of the limits or the terms of the signs in 11 columns and 12 rows. The corresponding label *ḥudūd kawākib* is engraved on the right hand side, outside the vertical scale of the shadow squares. Here the 30 degrees of each sign are divided into 5 intervals of unequal size and each interval is assigned to a planet other than the sun and moon. In the table here, the first column on the right carries the arguments, namely the 12 signs of the zodiac, represented here by the serial numbers from 0 to 11 in *Abjad* notation.[184] Thereafter, alternate columns display the numerical values of the limits in *Abjad* and the names of the planets represented by the last letters of their names in Arabic. There are two systems of indicating the intervals, either each interval separately, or the cumulative sum of the all the preceding intervals. The latter system is followed in the present table.

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[184] The first cell of the column carries the symbol for "3" instead of "0" by mistake and this mistake is repeated in A001 as well.

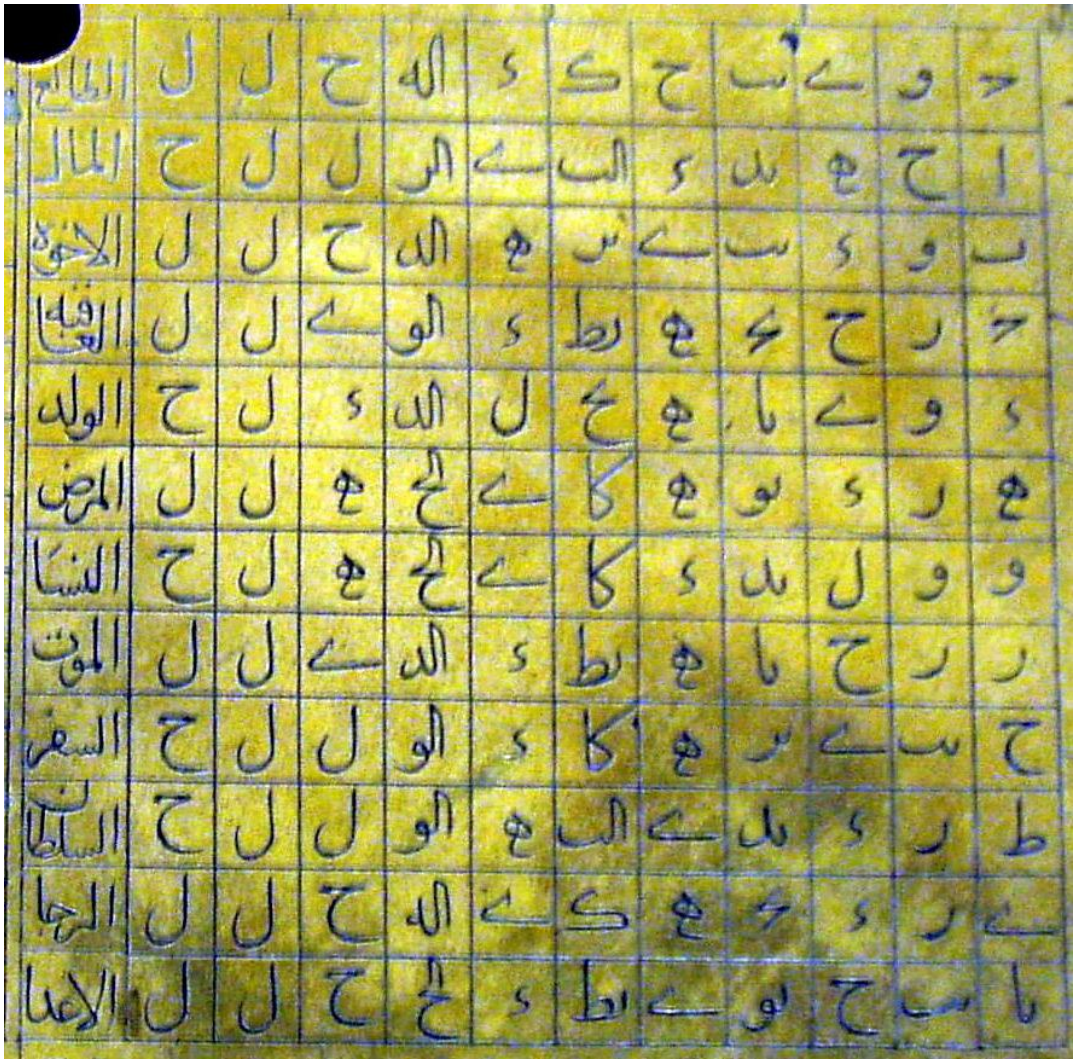


Figure A002.10 – Table of limits (detail of Figure A002.9)

In the following table, instead of the symbols, the full names of the signs and planets are shown.

Table A002-4 Limits of the Signs

0[185]. Aries	6	Jupiter	12	Venus[186]	20	Mercury	25	Mars	30	Saturn
1. Taurus	8	Venus	14	Mercury	22	Jupiter	27	Saturn	30	Mars
2. Gemini	6	Mercury	12	Jupiter	17	Venus	24	Mars	30	Saturn
3. Cancer	7	Mars	13	Venus	19	Mercury	26	Jupiter	30	Saturn
4. Leo	6	Jupiter	11	Venus	18	Saturn	24	Mercury	30	Mars

185 Erroneously 3 in the place of 0.

186 Erroneously Mars instead of Venus.

5. Virgo	7	Mercury	16	Venus	21	Jupiter	26	Mars[187]	30	Saturn
6. Libra	6	Saturn	14	Mercury	21	Jupiter	28	Venus	30	Mars
7. Scorpio	7	Mars	11	Venus	19	Mercury	24	Jupiter	30	Saturn
8. Sagittarius	12	Jupiter	17	Venus	21	Mercury	25	Saturn	30	Mars
9. Capricorn	7	Mercury	14	Jupiter	22	Venus	26	Saturn	30	Mars
10. Aquarius	7	Mercury	13	Venus	20	Jupiter	25	Mars	30	Saturn
11. Pisces	12	Venus[188]	16	Jupiter	19	Mercury	28	Mars	30	Saturn

Ib. In column 13 there are twelve terms which appear to state the influences of the 12 houses of the zodiac on the native's life. These correspond, to a certain extent, to Sanskrit terms. In the following table the Arabic and Sanskrit terms are juxtaposed.

Table A002-5 Houses of the Zodiac

	Arabic Names of the houses of the zodiac	Terms in column 13	Meaning of the previous column	Sanskrit Name	Meaning of the Sanskrit Name
1	*al-ṭālīᶜ*	*al-ṭāliᶜ*	ascendant	*tanu*	body
2	*al-thānī*	*al-māl*	wealth	*dhana*	wealth
3	*al-thālith*	*al-akhwa*	brothers	*sahaja*	siblings
4	*al-rābiᶜ*	*al-ᶜāqiba*	followers?	*suhṛd*	friends
5	*al-khāmis*	*al-wālid*	son	*suta*	son
6	*al-sādis*	*al-marḍ*	sickness	*ripu*	enemy
7	*al-sābiᶜ*	*al-nasā'*	women (pl)	*jāyā*	wife
8	*al-thāmin*	*al-mawt*	death	*mṛtyu*	death
9	*al-tāsiᶜ*	*al-safar*	travel	*dharma*	religious life

[187] Erroneously Venus in the place of Mars.

[188] Erroneously Mars instead of Venus.

	Arabic Names of the houses of the zodiac	Terms in column 13	Meaning of the previous column	Sanskrit Name	Meaning of the Sanskrit Name
10	*al-ᶜāshir*	*al-sulṭān*	ruler	*karma/āspada*	authority
11	*al-ḥādīᶜ ashar*	*al-rakhā'*	welfare	*āya*	income
12	*al-thānīᶜ ashar*	*al-aᶜdā'*	enemy	*vyaya*	Expenditure

II. **The Table of Triplicities** is arranged immediately to the left of the centre at the top in 7 columns and 5 rows. The first row carries the label *muthallathāt nahārī laylī* (triplicities of the day [and] of the night). The characteristics or the elements to which the triplicities are assigned are written in the first column. Here the sequence of the names of the elements is not correctly maintained. Instead of fire, earth, air and water, the engraver wrote fire (*bār*?), air (*hawā*), water (*mā,* more correctly *mā'*) and earth (*arṣ,* correctly *arḍ*). The table contains only the names of the planetary regents. In the reproduction of the table below, the names of the signs are added in square brackets.

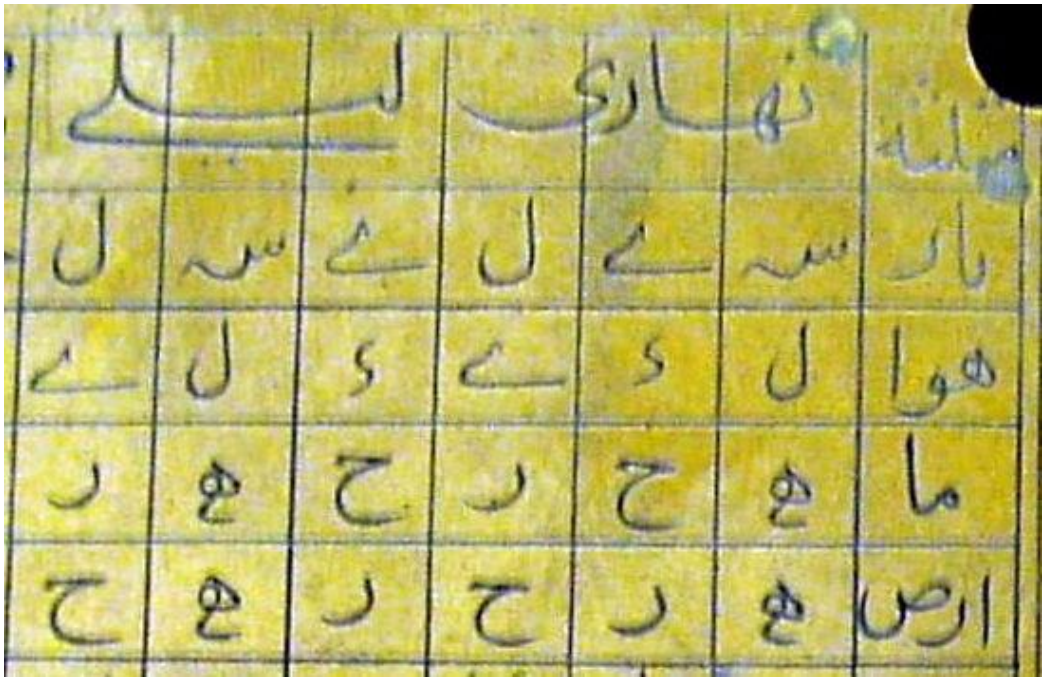


Figure A002.11 – Table of Triplicities (detail of figure A002.9)

Table A002-6 Triplicities

Muthallathāt **triplicities**	***Nahāri*** **of the day**			**Layīlī of the night**		
Fiery	[Aries] Sun	[Leo] Jupiter	[Sagittarius] Saturn	[Aries] Jupiter	[Leo] Sun	[Sagittarius] Saturn
Earthy[189]	[Taurus] Saturn	[Virgo] Mercury	[Capricorn] Jupiter	[Taurus] Mercury	[Virgo] Saturn	[Capricorn] Jupiter
Airy[190]	[Gemini] Venus	[Libra] Moon	[Aquarius] Mars	[Gemini] Moon	[Libra] Venus	[Aquarius] Mars
Watery[191]	[Cancer] Venus	[Scorpio] Mars	[Pisces] Moon	[Cancer] Mars	[Scorpio] Venus	[Pisces] Moon

III. Immediately below the tables of triplicities is a table with the intriguing title *farkh* (joy) in 7 columns and 8 rows.

189 Erroneously ‘air’ (*hawā*) instead of ‘earth’.

190 Erroneously ‘water’ (*mā’*) instead of ‘air’. In this and in the next row, Moon and Mars are interchanged in the regents of the day as well as in those of the night.

191 Erroneously ‘earth’ (*arḍ*) instead of ‘water’.

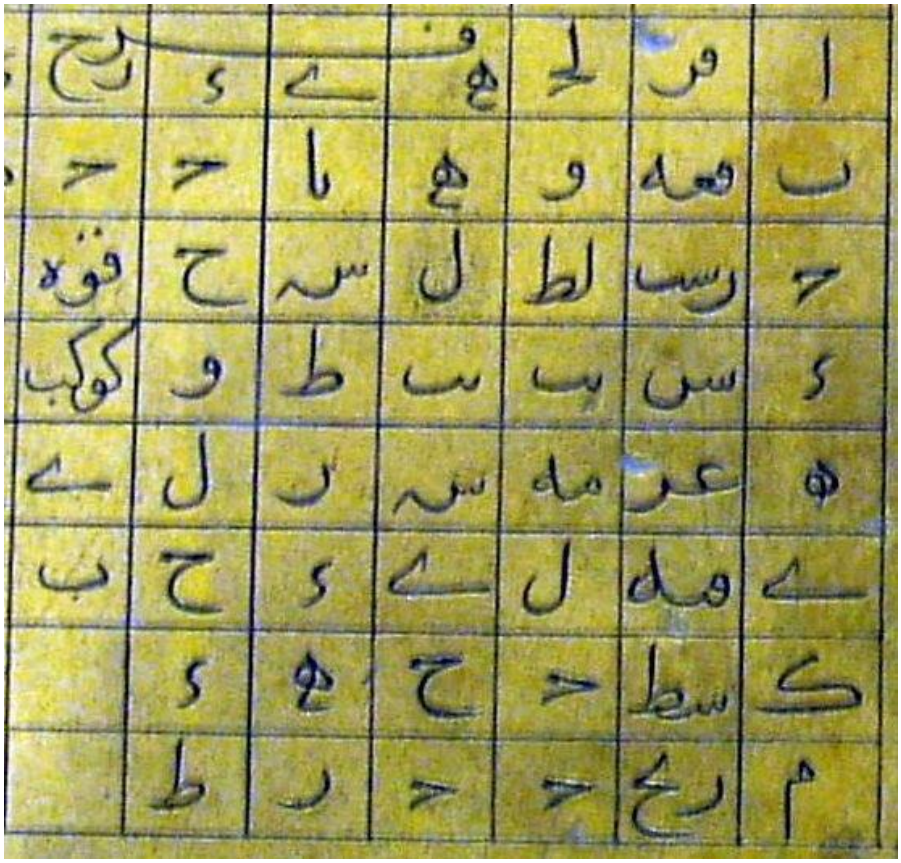


Figure A002.12 – Table of *farkh* (detail of Figure A002.9)

The first column on the right contains obviously the numbers 1, 2, 3, 4, 5, 10, 20, 40 in *Abjad* notation. In the rest of the cells, there are alphabetical symbols; it is difficult to decide whether these are mere numerical symbols or symbols for planets. The following table shows both possibilities. Such a table does not occur elsewhere; it is not clear what it signifies.

Table A002-7 Table of *farkh* as shown in Figure A002.12

1	86 / 106	13	0 / Venus	10 / Jupiter	4 / Mercury	7 / Moon
2	45	6	0 / Venus	11	3	3
3	260 / Moon / Sun	39	30 / Saturn	60 / Sun	8 / Jupiter	*quwwa* (strength)
4	60 / Sun	12	12	9	6	*kawkab* (planet)
5	77	45	60 / Sun	7 / Moon	30 / Saturn	10 / Jupiter
10	45	30	10 / Jupiter	4 / Mercury	8 / Jupiter	2
20	69	3	8 / Mars	0 / Venus	4 / Mercury	
40	218	3	3	7 / Moon	9	

IV Table of Faces of the Signs (*al-wujūh*)

The last four columns (or the first four when counted from the left) contain a table of decans with the title *wujūhāt* in 4 columns and 12 rows. The first three columns from the left show the planetary regents governing each of the three decans of a sign. The fourth column contains two sets of numbers in *abajd* notation. In the table below, these two sets are reproduced in two separate columns for the sake of clarity. One set has the serial numbers from 0 to 11 and carries the title *burj* (sign); these refer to the 12 signs and form the argument of the table. The second set is problematic. It carries the title *quwwa* (strength);[192] but strength is not usually assigned to the planets governing the decans of signs.

Table A002-8 Faces of the Signs

***burj* (sign)**	***Quwwa* (strength/ potency)**	***wujūhāt* (decans)**		
		10	20	30
0 Aries	8	Mars	Sun	Venus
1 Taurus	12	Mercury	Moon	Saturn
2 Gemini	5	Jupiter	Mars	Sun
3 Cancer	8	Venus	Mercury[193]	Moon
4 Leo	7	Saturn	Jupiter	Mars
5 Virgo	1	Sun	Venus	Mercury[194]
6 Libra	9	Moon	Saturn	Jupiter
7 Scorpio	3	Mars	Sun	Venus
8 Sagittarius	6	Mercury	Moon	Saturn

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192 Dr Martin Gansten informs me that this term became *kuttha* in Sanskrit texts on Tājika astrology which is derived from Arabic/Persian astrology; on these texts, cf. Pingree 1981, pp. 97-100.

193 Erroneously Jupiter instead of Mercury

194 Erroneously Jupiter instead of Mercury

9 Capricorn	11	Jupiter	Mars	Sun
10 Aquarius	10	Venus	Mercury	Moon
11 Pisces	2	Saturn	Jupiter	Mars

ALIDADE, PIN AND WEDGE

The alidade is nicely crafted with ornate terminals and an ornate centre piece. The right half is divided into 12 units, each of which corresponds to 5 divisions in the trigonometric quadrant on the back. The left half is engraved with declintaion arcs to match those in the upper right quadrant on the back. But neither half of the alidade is numbered. The eye-pieces have two holes each, one larger and the other smaller.

The horse is not flat; the head and neck are thicker and contoured. The eyes were originally filled with some red substance which is disappearing. On the neck, the mane is depicted by engraved lines. Plain-headed pin.

RULE IN THE FRONT

In the front is attached a rule with a pointed end and without any graduations. Indo-Persian astrolabes do not have rules. This one must have been added in recent times.



Figure A002.13 – Signature of the maker (photo by S. R. Sarma)

INSCRIPTION

Below the shadow squares is engraved in rather large letters the astrolabe maker's signature in double-outlines:

ṣanᶜat ustād allāhdād asṭurlābī lahūrī.

'Made by Master Allāhdād, the astrolabe-maker of Lahore.'

PROVENANCE

Ex-collection Chadenat; La Ferté-Barnard; coll. J. A. Billmeir, Elstead (Surrey).

BIBLIOGRAPHY

Maddison 1957, No. 159, pp. 20-21, pl. XVIII.

Anderson 1982, no. 126, p. 35, fig. 9.

Sarma 1994d.

A003⊙ ASTROLABE ATTRIBUTABLE TO ALLĀHDĀD

Late 16th century, Lahore

Diameter 208 mm

Oxford, Museum of the History of Science (#34611)

CCA 2530



Figure A003.1 – Front of the astrolabe (© Museum of the History of Science, Oxford)

This astrolabe, though not signed and dated, can be attributed to Allāhdād because of the similarity of workmanship between this astrolabe and the undated astrolabe by Allāhdād (A003) and because these two astrolabes contain Ibn Bāṣo's universal plate

for all latitudes. The retes are almost alike in their design and have exactly the same 36 star pointers. However, the gazetteer in this astrolabe appears to have been engraved by a different person, probably at a later point of time (see below under Gazetteer).

Components

Body with crown (d. 208, h. 267, t. 10), shackle and ring, rete (d. 198) for 36 stars, 6 plates (d. 198), alidade (l. 205), pin and wedge. The shackle and ring are crude replacements.

Front

The ring is plain with roundish cross-section, crudely soldered together. The shackle is also plain with a flat oval cross-section. The ring and shackle are clearly late replacements.

The profiles of the *kursī* consist of ogival bases with decorative holes, followed by three successive lobes. The finial is trifoliate. Leaving out a broad border, the rest of the *kursī* is elegantly reticulated. The limb is divided in 1° and numbered in 5s from 5 to 360.

Rete

The rete is thick in the middle and tapers slightly towards the circumference. The rings of the Tropic of Capricorn and ecliptic are held together by the equinoctial bar which is counter-changed at the centre. The spaces between the two rings and that inside the ecliptic ring are filled with a delicate tracery of tendrils terminating in tulip-like flowers. The tulips have two flared petals, one larger than the other; where the two petals branch off is a small hole pierced through the whole thickness. The holes are filled with black substance so that it shows at the back also. In the front the holes have a pleasing decorative function. The back is smooth and neatly polished with the black dots standing out.

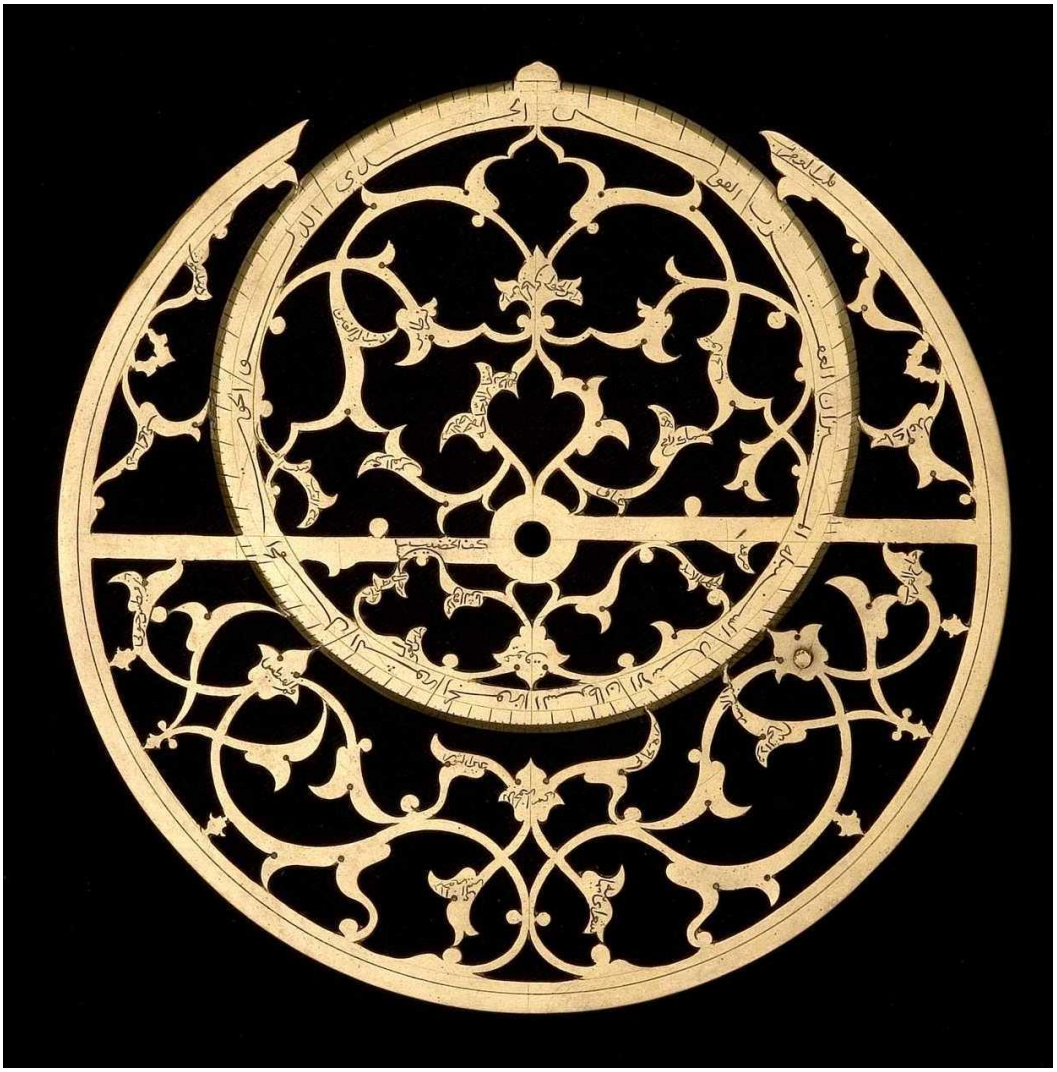


Figure A003.2 – Rete of the Astrolabe (© Museum of the History of Science, Oxford)

There is a small handle just outside the ecliptic ring in the segment of Virgo. A small triangular projection rising from the ecliptic ring at the zero point of Capricorn is the *al-murī* or the Capricorn index.

The ecliptic ring is divided into the 12 zodiac signs and labelled. Each sign is divided into 5 parts but these are not numbered. On the sloping edge of the ring, each of these parts is divided into 3 units, each of 2°.

There are 36 star pointers in the form of tulip petals. These are exactly the same as in the undated astrolabe by Allāhdād (A002).

Table A003-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab Qayṭus Janūbī*	β Ceti

	Star Name	Identification
2	*Batn al-Ḥūt*	β Andromedae
3	*Rijl al-musalsala*	γ Andromedae
4	*Fam al-Qayṭus*	γ Ceti
5	*Rās al-Ghūl*	β Persei
6	*Mirfak al-Thurayyā*	α Persei
7	*ᶜAyn al-Thawr*	α Tauri
8	*ᶜAyyūq*	α Aurigae
9	*Rijl al-Jawjā' al-Yusrā*	β Orionis
10	*Yad al-Jawjā' al-Yumnā*	α Orionis
11	*Shiᶜrā Yamānī*	α Canis Majoris
12	*Shiᶜrā Shāmī*	α Canis Minoris
13	*Fard al-Shujāᶜ*	α Hydrae
14	*Qalb al-Asad*	α Leonis
15	*Ẓahr al-Asad*	δ Leonis
16	*Ṣarfa*	β Leonis
17	*Janāḥ al-Ghurāb*	γ Corvi
18	*ᶜAnāq*	ζ Ursae Majoris
19	*Simāk Aᶜzal*	α Virginis
20	*Simāk Rāmiḥ*	α Bootis
21	*Nayyir Fakkah*	α Coronae Borealis
22	*ᶜUnuq al-Ḥayyā*	α Serpentis
23	*Qalb al-ᶜAqrab*	α Scorpii
24	*Rās al-Ḥawwā*	α Ophiuchi
25	*Rās al-Jāthī*	α Herculis

	Star Name	Identification
26	*Nasr Wāqiᶜ*	α Lyrae
27	*Minqār al-Dajājah*	β Cygni
28	*Nasr Ṭā'īr*	α Aquilae
29	*Dhanab al-Dulfīn*	ε Delphini
30	*Dhanab al-Dajājah*	α Cygni
31	*Dhanab al-Ḥūt*	γ Gruis
32	*Mankib al-Faras*	β Pegasi
33	*Matn al-Faras*	α Pegasi
34	*Dhanab al-Jadī*	δ Capricorni
35	*Janāḥ al-Faras*	γ Pegasi
36	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are six plates of varying thickness and colouration, serving nine different latitudes.

Table A003-2 Plates

	φ	Longest Day	(Locality)
1a	17;0°	13;2 hrs	
1b	36;10°	blank	
2a	21;40°	13;14	(Mecca)
2b	25;0°	13;25	(Medina)
3a	27;0°	13;44	(Agra)
3b	32;0°	14;8	(Lahore)

	φ	Longest Day	(Locality)
4a	30;0°195	13;18	
4b	40;0°	14;54	
5a	45;0°	15;30	
5b	Plate of horizons		
6a	Plate of ecliptic coordinates		
6b	Ibn Bāṣo's universal plate for all latitudes		

Interestingly, the two sides of plate 2 are devoted to Mecca and Medina, the holy cities of Islam. This juxtaposition was never repeated in any other Indian astrolabe. The two sides of plate 3 are devoted to Agra and Lahore, the two Mughal imperial cities. This practice was emulated by his descendants. There are no silver inlays on any plate here. Below the horizon are engraved *al-mashriq* and *al-maghrib* on the eastern and western sides respectively. In the centre are engraved the latitude (*al-arḍ*) and the duration of the longest day in two lines one below the other.

Altitude circles are for every 2°; on some plates the numbers form a semicircular arc, on others the characteristic round M shape. Azimuths are drawn for every 10° below the horizon. The style of their numbering varies from plate to plate. On some the numbers are engraved below and along the oblique horizon and below and along the circle of the Tropic of Cancer (e.g. 1b). On some other plates, there are two sets of numbers, one along the horizon and another at the northern end of azimuths in such a way that the numbers form two sides of an isosceles triangle. Yet on some other plates (e.g. 2b) one set is engraved in an arc above the equatorial circle and another set as in the previous case so that where the apex of the triangle touches the arc, one finds the number 90 in *Abjad* arranged four times in pleasing symmetry.

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[195] Instead of the zero sign, the engraver by mistake wrote the letter ayn (ع) which would have given the value of 70 in the minutes' place!



Figure A003.3 – Plate for 25°; note the the arrangement of the numbers of the azimuth circles; also the shape of zero (photo by S. R. Sarma)

On some other plates (3a) there are two sets, one in the form of an arc and another in the form of a truncated triangle.

There are two sets of hour lines on all latitude plates, for seasonal hours and for equal hours since sunset and before sunrise, both reaching up to the meridian, but both sets are numbered from the western horizon in elegant *Abjad* symbols.

5b Plate of horizons

Four sets of half horizons are engraved on the plate in the eastern fashion. Each set is labelled four times along the length of the half horizons. The half horizons for latitudes ranging from 4° to 66° are arranged at intervals of 8° in four batches in the following manner:

4	12	20	…	44	52	60
6	14	22	…	46	54	62
8	16	24	…	48	56	64
10	18	26	…	50	58	66

There are no declination scales, nor a label on the plate.

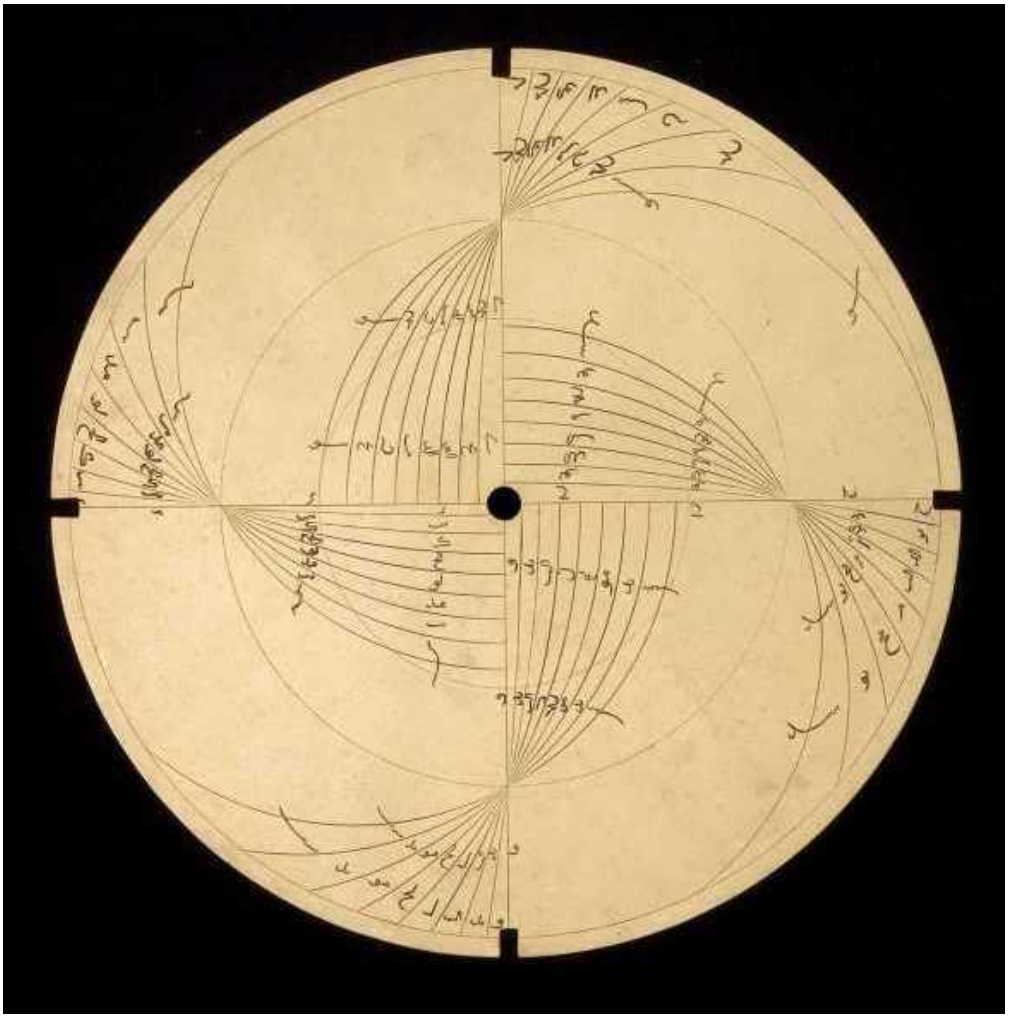


Figure A003.4 – Plate of horizons (© Museum of the History of Science, Oxford)

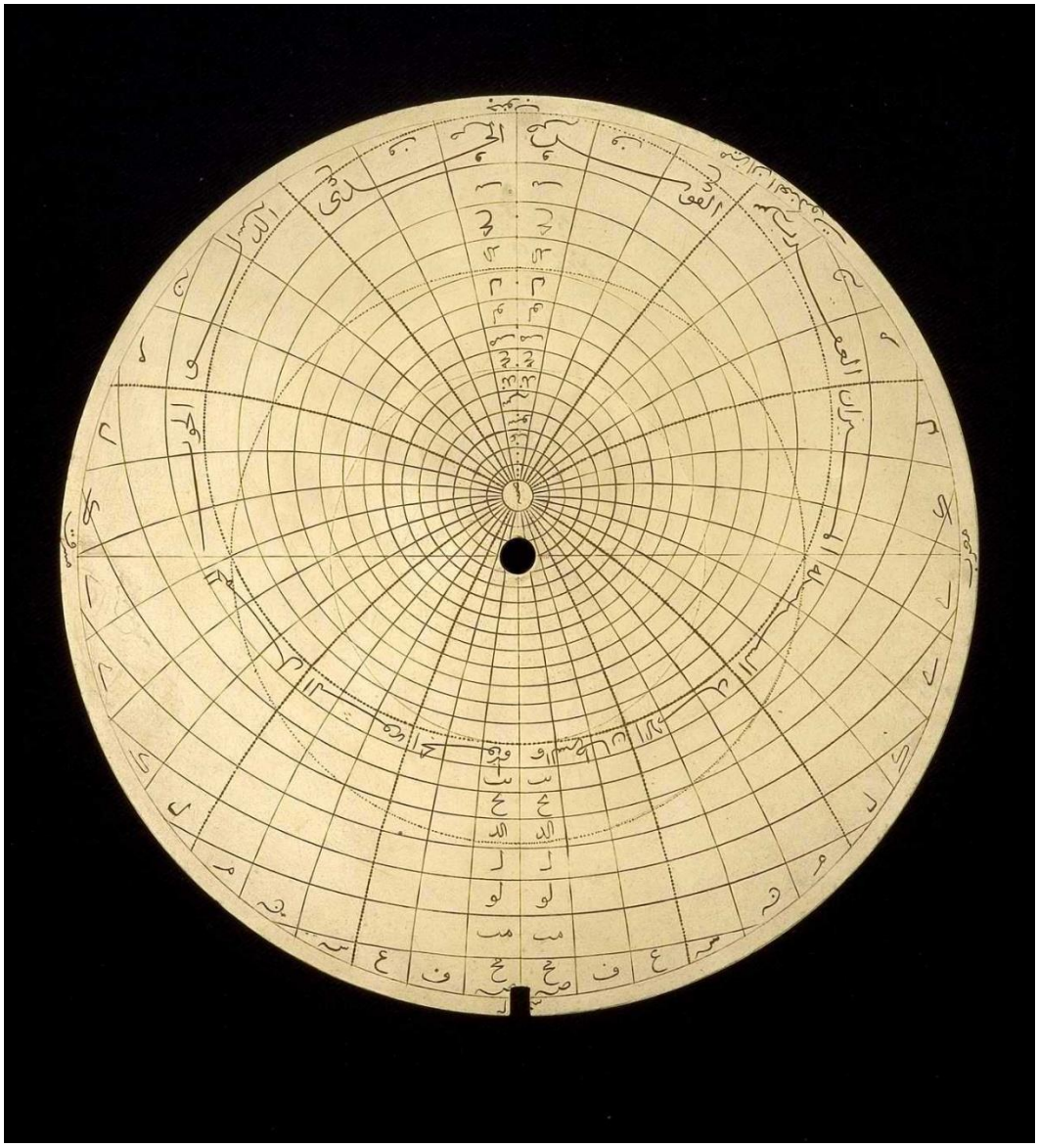


Figure A003.5 – Plate of ecliptic coordinates (© Museum of the History of Science, Oxford)

6a Plate of ecliptic coordinates

This plate is thicker and more yellowish than the other plates. On it are drawn first the equator and the two tropics. The equator and the Tropic of Cancer are drawn as dotted lines, the latter is rather faint. The ecliptic is also drawn as a dotted line and marked with the names of the 12 signs of the zodiac, starting at the vernal equinox and proceeding counter-clockwise.

Arcs of celestial longitudes radiating from the centre are drawn for every 10°. Every third of these, which constitutes the boundary of the signs, is dotted. The arcs are numbered along its entire circumference 10—90; 90—10; 10—90; 90—10.

Circles of celestial latitudes are drawn for every 6° as concentric circles around the zenith. These are numbered in two columns from the south point up to the centre from 6 to 90; again from the ecliptic circle up to the north point from 6 to 90.

Outside the Tropic of Capricorn the four cardinal points are marked and labelled *mashriq, maghrib, janūb and shamāl.*

In the south-west corner outside the line of the Tropic of Capricorn is the label *mīẓān al-ᶜankabūt.*

6b Universal plate for all latitudes

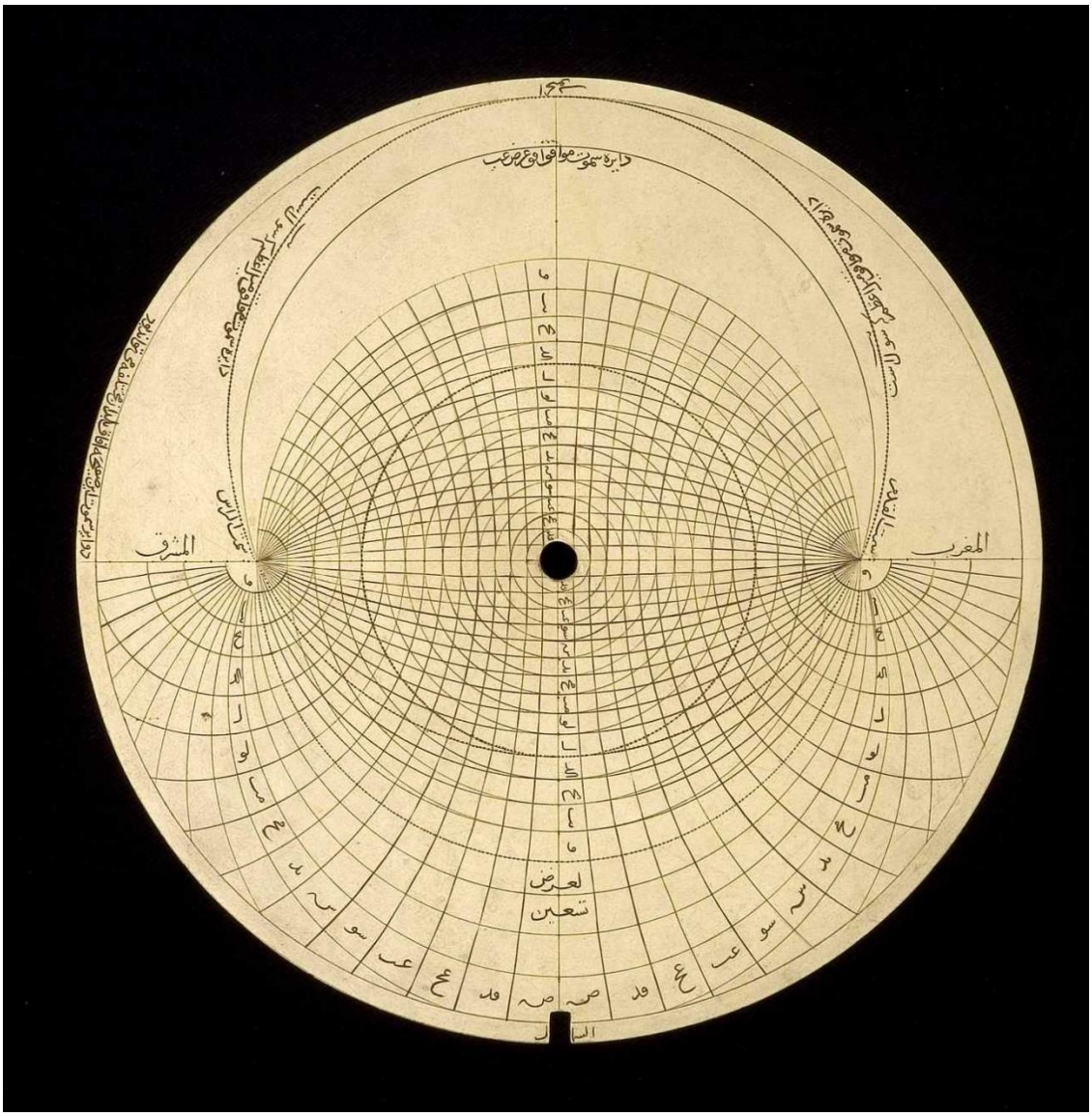


Figure A003.6 – Universal plate for all latitudes
(© Museum of the History of Science, Oxford)

As in the previous astrolabe (A002), here also on the reverse side of the plate of ecliptic coordinates is engraved the universal plate for all latitude (*al-ṣafīḥa al-jāmiᶜa*

li-jāmīᶜ al-ᶜurūḍ) which was designed by Ibn Bāṣo.[196] No lines are inlaid here with silver, but there are 11 labels at different places.

As on the obverse side, here also the cardinal directions are labelled. At the east and west points *al-mashriq* and *al-maghrib* respectively; and at the south and north points outside the peripheral circle *al-janūb* and *al-shamāl.*

As in A002, three families of circles are drawn here. First, the 30 arcs of great circles passing through the east and west points. These are horizons for each 6° of terrestrial latitudes from +90° to -90°. These are not numbered.

Then around the east and west points are drawn 15 arcs each at 6° intervals. These arcs divide horizons into equal parts. The numbers of these arcs start from the east and west points and proceed along lower periphery up to the meridian line.

Third, around the centre are drawn 14 concentric circles at 6° intervals; these constitute the altitude circles for the latitude of 90°. These circles are numbered along the vertical diameter both above and below the centre. Starting at 6 below, the numbering continues up to the centre and then from 90 at the centre it goes up to 6 at the top. The circle of 24° is emphasized by dots. The lower half of the outermost circle, which is the eqator, is dotted. Below this circle is written, across the meridian line, *al-ᶜarḍ tiṣīn* (the latitude of 90 [degrees]).

In A002, three semi-circles are traced between the equator and the outer circle of the plate. These semi-circles are not drawn here. But two circles which pass through the east and west points are extended into the southern half. One of these is drawn with its centre on the meridian at 36° to south of the centre of the plate. Where this circle intersects the meridian in the south is a label which reads *dā'ira samūt muwāfiq ufq ᶜarḍ 72* (circle of azimuths corresponding to the horizon of the latitude 72°).

Another circle is drawn with its centre on the meridian at 42° to south of the centre of the plate; it passes through the east and west points and extends into the southern half of the plate. This circle is completely dotted and carries four labels in the southern half. Where it emerges into the southern half after passing through the east point is written *samt al-rās* (azimuth of the head?). Where the circle emerges after passing through the

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196 On Ibn Bāṣo, see Calvo 2007; on the construction and use of the plate, see Calvo 2000.

west point is written *samt al-qadam* (azimuth of the foot?). A little above these labels, there is an identical label on both sides, which reads *dā'ira samūt muwāfiq mayl aᶜẓam karsū lāsat* (circle of azimuths corresponding to the maximum obliquity … ?); above this is written 12 in *Abjad* notation.

Finally, outside the circle of the Tropic of Capricorn, just above the east point is a long label *dawā'īr samūtā'īn ṣafīḥat afāq buldān* … (?).

Geographical Gazetteer

On the inner side of the mater, a geographical gazetteer is engraved in four concentric circles containing geographical data of 104 localities. Above the outer or first circle, compass directions are engraved at the east (*al-mashriq*), south (*al-janūb*) and west (*al-maghrib*) points. At the north point, the space is occupied by a plug to receive the notches cut in the plates.

In the first circle, two adjacent cells are filled with the name of a single locality so that the degrees and minutes of the latitudes etc. are written in separate cells. Mecca and Medina are mentioned without the honorifics. For each locality are given its name (*asmā' al-buldān*), latitude (*al-ᶜarḍ*), co-latitude (*tamām al-ᶜarḍ*), and longitude (*al-ṭūl*) in this order. This is perhaps the only astrolabe to list co-latitudes (90- φ), which can easily be calculated from the latitudes. Even so at least in five cases (nos. 56, 62, 76, 94, 95) there are errors, for the values of the latitude and co-latitude do not add up to 90! In fact, this gazetteer does not even follow the traditionally accepted parameters for the two holy cities of Islam, namely Mecca (Long. 67 as against 77;10) and Medina (Long 65;20, Lat. 24;20 as against Long. 75;20, Lat. 25;0).

Moreover, three types of symbols for zero are used in this astrolabe. On the plates are seen two different symbols which are, however, quite common.

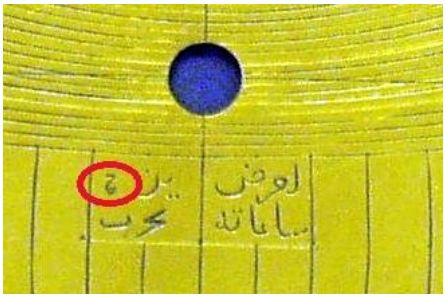


Figure A003.7 – Zero symbol on the plate for 17° (photo by S. R. Sarma)

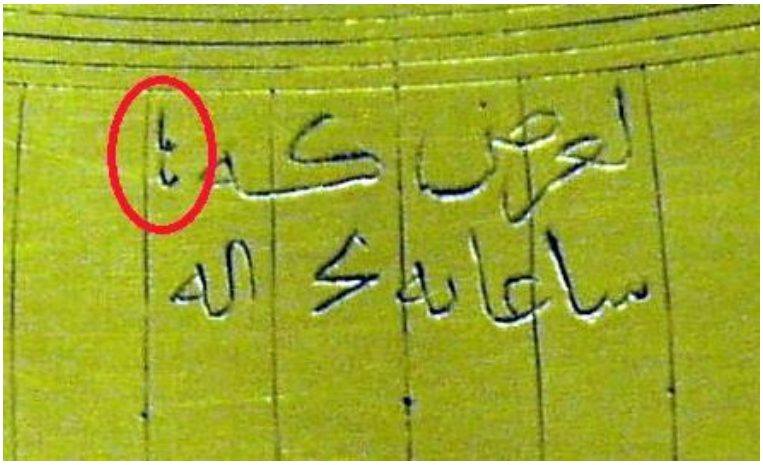


Figure A003.8 – Zero symbol on the plate for 25° (photo by S. R. Sarma)

But in the gazetteer, one encounters an entirely unusual symbol.



Figure A003.9 – Zero symbols in the gazetteer (photo by S. R. Sarm)

The quality of calligraphy in the gazetteer is not very good; the quality of engraving is also poor. Some dots seem to have been punched mechanically. In the inner ring, the *Abjad* symbols are scratched rather than engraved. The gazetteer was clearly engraved by a different hand.

The argument occupies the first two cells to the left of the vertical diameter, and the gazetteer is arranged counter-clockwise. In the following table, as in the other tables, we mention the name of the locality, longitude, latitude, and other parameters, in this order for the sake of consistency.

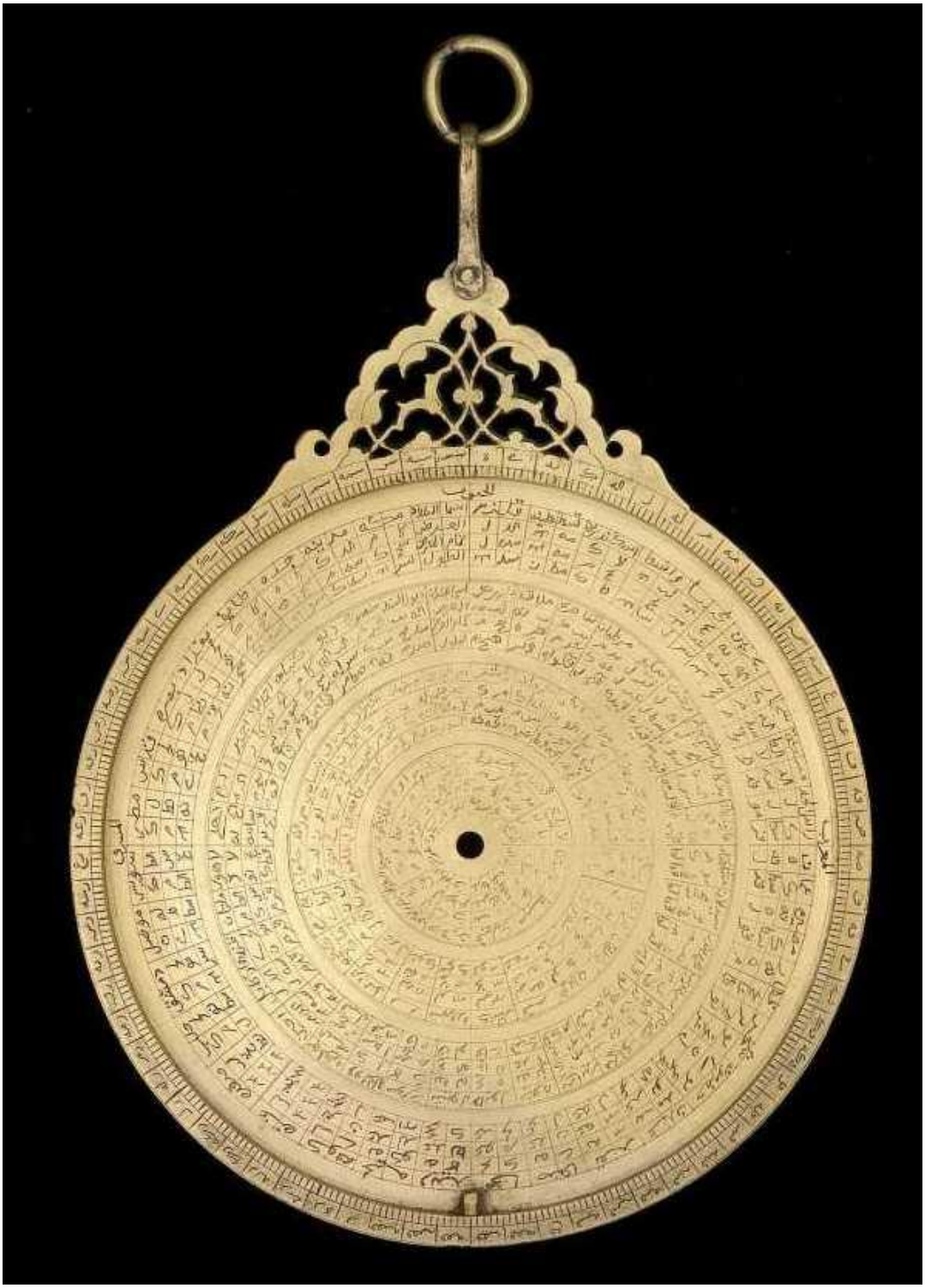


Figure A003.10 – Geographical gazetteer (© Museum of the History of Science, Oxford)

Table A003-3 Geographical Gazetteer

	Place Name	L	φ	Co-latitude
	(*asmā' al-buldān*)	(*al-ṭūl*)	(*al-ᶜarḍ*)	(*tamām al-ᶜarḍ*)

	Place Name	L	φ	Co-latitude
	First Circle			
1	Makka	67;0	21;40	68;20
2	Madīnah	65;20	24;20	65;40
3	Jadda	66;0	21;5	68;55
4	Tā'īf	65;20	21;20	68;40
5	Baghdād	63;55	33;30	56;30
6	Baṣra	83;40	30;20	59;40
7	Qadis	58;10	33;20	56;40
8	Miṣr	55;0	30;20	56;40
9	Sūs	58;29	29;20	60;40
10	Moṣul	58;29	35;50	54;10
11	Dimashq	67;0	33;20	56;40
12	Ḥalab	69;30	33;20	56;40
13	Ṣafada	59;0	32;0	58;0
14	Ghaza	58;0	32;0	58;0
15	Kūfa	68;30	32;10	57;50
16	Laḥya ?	72;0	15;26	74;14
17	Zabīd	73;20	15;21	74;39
18	Makhā	72;33	13;20	76;40
19	Ṣanaᶜā'	73;30	15;10	74;50
20	Taᶜizz	75;30	15;0	75;0
21	ᶜAdan	73;25	12;44	77;15
22	Hadhramūt	73;35	16;10	73;50
23	Shahar	77;36	16;17	73;43

	Place Name	L	φ	Co-latitude
24	Ẓafār	81;40	18;55	71;5
25	Maṣūrah	86;30	20;55	69;5
26	ᶜAmān	87;30	20;5	69;55
27	Rās al-Jad ?	87;46	20;30	69;30
28	Muskah	84;23	24;29	65;31
29	Suhār	83;40	25;20	64;40
30	Baḥrayn	83;0	25;15	64;45
31	Laḥsā	67;30	18;0	72;0
32	Wasit	61;0	32;0	58;0
33	Iskandariyya	51;20	31;20	58;40
34	Qasṭanṭaniyya	49;50	45;0	45;0
35	Qulzum	64;0	24;30	65;0
	Second Circle			
36	Daywal al-sind	95;0	25;12	64;48
37	Manṣūra	105;0	27;40	62;20
38	Diū ?	99;47	22;25	67;35
39	Kanbāyata	101;0	21;40	68;20
40	Aḥmadābād	108;40	23;15	66;45
41	Ajmīr	111;5	21;7	68;53
42	Akra	115;0	27;0	63;0
43	Dehlī	118;17	28;15	61;45
44	Lāhūr	109;20	31;4!	58.56
45	Multān	107;40	29;40	60;20
46	Qandahār	107;40	33.10	56;50

	Place Name	L	φ	Co-latitude
47	Kābul	104;40	34;30	65;30
48	Ujjayn	112;0	25;0	65;0
49	Nahlawara	112;30	22;0	68;0
50	Dawlatābad	107;0	20;30	69;30
51	Sūrat	101;0	21;20	68;40
52	Shīwar?	101;36	19;35	70;25
53	Dābūl	101;10	18;5	71;55
54	Jawah	102;10	15;56	74;4
55	Bījāpūr	120;0!	20;0	70;0
56	Manhlūr ?	102;35	12;55!	77;45!
57	Koshī	103;36	9;26	80;34
58	Sarandīb	130;0	10;0	80;0
59	Muḥammad Bandar	107;39	12;0	78;0
60	Siyalān	109;39	6;48	83;12
61	Mashalfitār	109;39	16;40	73;20
62	Mānīk Batan	112;9	19;18!	71;32!
63	Bankālā [Dhakā]	122;45	22;50	67;10
64	Nashtarjām	112;0	23;30	66;30
65	Rakhban?	117;4	20;30	69;30
66	Baykū	114;20	17;30	72;30
67	Martabān	123;30	14;40	75;20
68	Tanāṣarī ?	126;35	12;20	77;40
69	Malāqa	127;?	2;55	87;5

	Place Name	L	φ	Co-latitude
70	Shaharnū	118;0	32;0	58;0
	Third Circle			
71	Iṣfahān	77;40	34;50	55;10
72	Shīrāz	78;0	32;20	57;40
73	Sīrāf	79;0	29;50	60;10
74	Nīshābūr	81;45	36;20	53;40
75	Samarqand	89;30	36;50	53;10
76	Halwān	71;45	32;20!	56;40!
77	Najāra	96;19	39;10	50;50
78	Kanja	81;30	41;20	38;40
79	Ardabīl	74;30	38;0	52;0
80	Rayy	76;20	35;0	55;0
81	Suhraward	76;20	37;0	53;0
82	Kāshān	76;0	37;0	53;0
83	Qum	75;0	37;45	52;15
84	Hamadān	61;0	36;20	53;40
85	Ṭāliqān	75;17	36;10	53;50
86	Herāt	87;20	34;30	55;30
87	Balkh	71;0	36;41	53;[19]
88	Mārdayn	74;0	37;15	52;45
89	Tabrīz	87;0	38;0	52;0
90	Harmūz	73;0	28;19	61;41
91	Hāshah?	85;29	26;50	63;10
92	Kermān	94;0	29;20	60;40

	Place Name	L	φ	Co-latitude
93	Kāshghar	105;25	47;20	42;40
	Fourth Circle			
94	Barāwa	72;30	1;40!	83;20!
95	Maghaz Showa?	73;20	2;19!	87;45!
96	Saynū al-Ṭūbal	77;16	6;20	83;40
97	Bandar Kos	79;0	9;30	80;30
98	Hā Fūn	80	10;20	79;40
99	Qaylak	77;20	12;5	77;55
100	Meeṭ	75	11;20	78;40
101	Barbada	73;22	11;0	79;0
102	Zayla[c]	77;36	11;30	78;30
103	Qaṣār	67;6	14;20	75;40
104	Maṣū[c]	64;15	17;0	73;0

BACK

The degree scale on the rim is slightly wider (10 mm) than that at the front (8 mm). In the upper two quadrants, the scale is divided in 1° and 5° and labelled as 5—90; 90—5. The rim is empty in the lower half.

In the upper left is a trigonometric quadrant with 60 horizontal and 60 vertical equidistant parallels.

In the upper right is the solar quadrant with declination arcs drawn for each 30° of solar longitude or one zodiacal sign. The signs are labelled along the vertical and horizontal radii by their serial numbers from 0 to 11.

Under the horizontal diameter is written *al-mashriq* on the east and *al-maghrib* on the west. In the lower half are the shadow squares. On the left for the gnomon of 12 digits; the vertical and horizontal scales are divided in 12 units. In the vertical scale the

numbering begins at the horizontal diameter of the astrolabe, in the horizontal scale it begins at the centre. The label along the vertical scale reads *ẓill aṣābiᶜ maᶜkūs* (reverse shadow in digits), that under the horizontal scale simply *mustawī* (direct [shadow]).

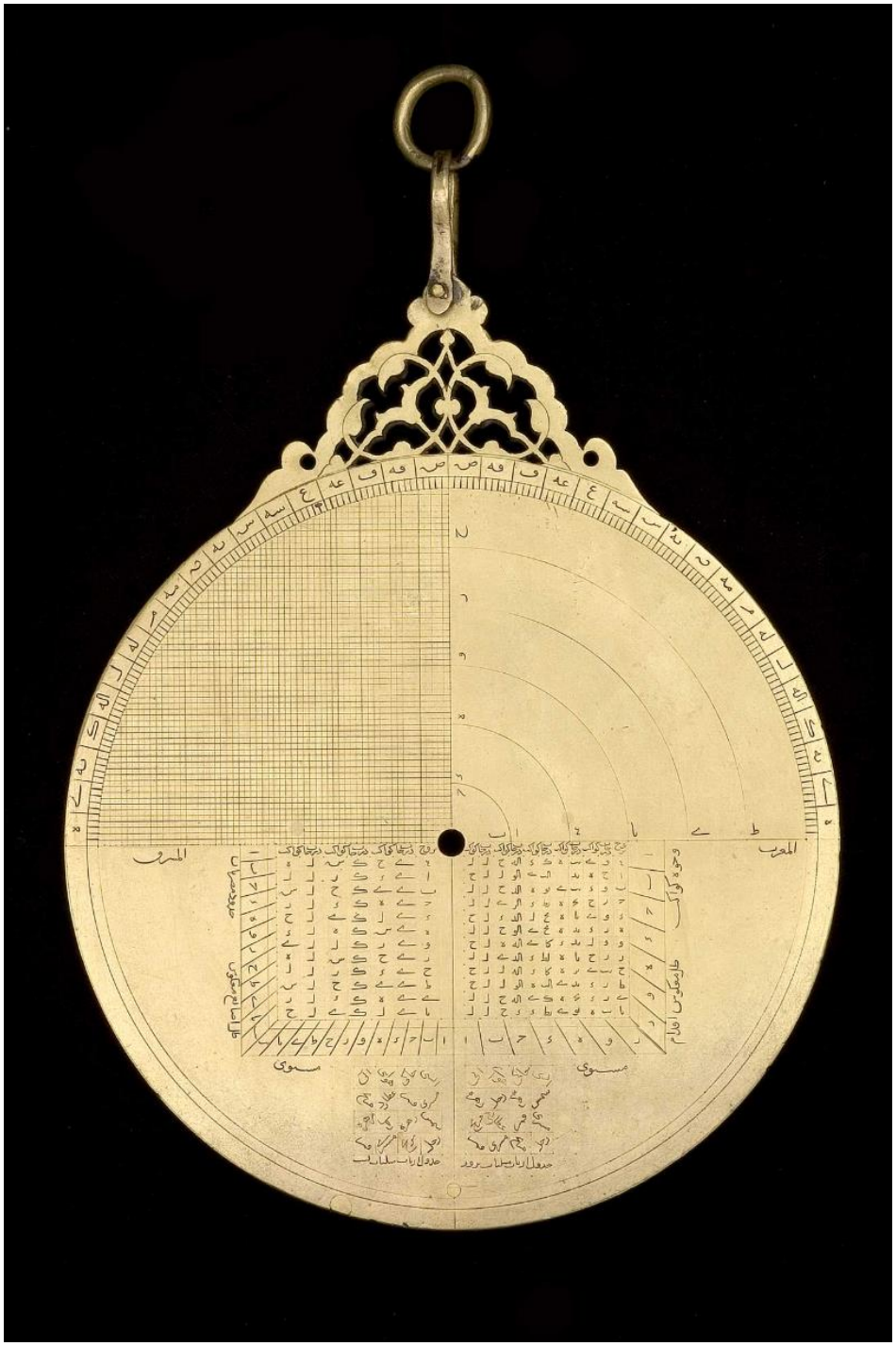


Figure A003.11 – Back of the astrolabe (© Museum of the History of Science, Oxford)

On the right is the square for 7 feet; here the scales are divided in 7 units and numbered in the same manner as on the left. The label along the vertical scale reads *ẓill maᶜkūs aqdām* (reverse shadow in feet) and that under the horizontal scale simply as *mustawī* (direct [shadow]).

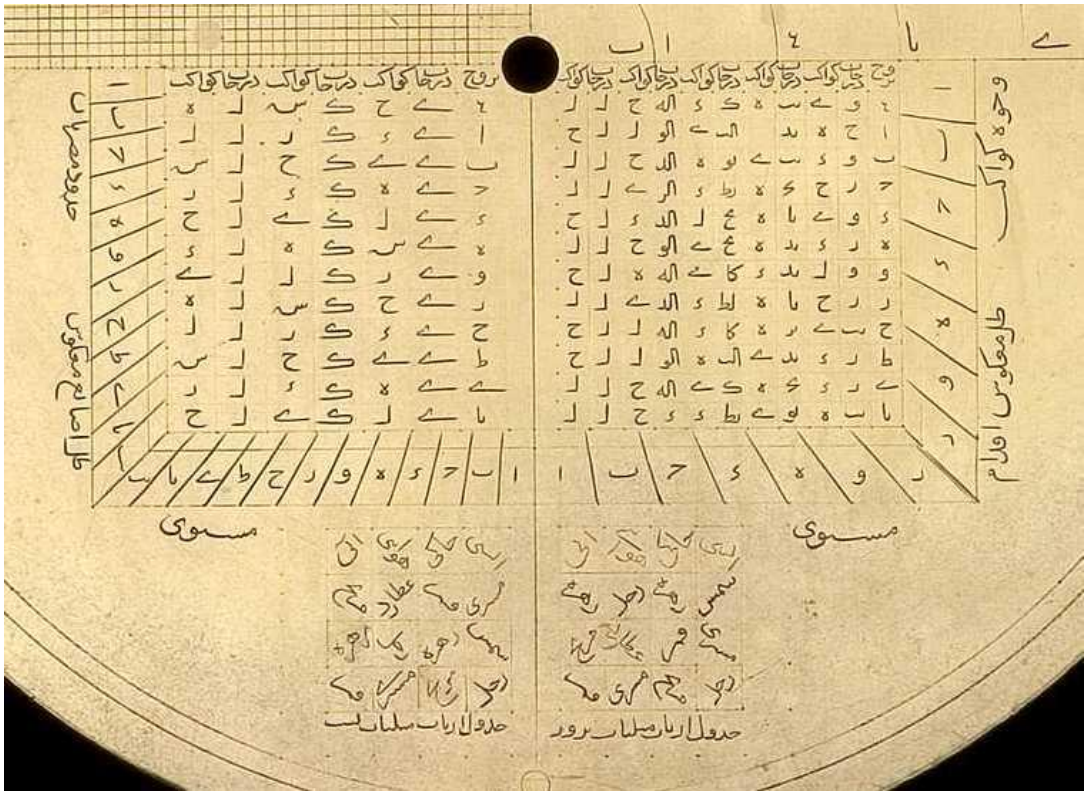


Figure A003.12 – Astrological tables on the back (detail of Figure A003.11)

Table of Decans or Faces of the Signs

Inside the squares are two astrological tables. On the left is a table with 7 columns and 13 rows which displays the regents of the decans.[197] The first column on the right carries the argument, viz., the names of the 12 signs through their serial numbers from 0 to 11. The following columns show alternately the degrees of decans in *Abjad* notation and the names of the presiding planets through the last letters of their names. In table below, we give the full names of the signs and planets, instead of the symbols.

Table A003-4 Faces of the Signs

	Degrees *darjāt*	**Planets** *kawākib*	**Degrees** *darjāt*	**Planets** *kawākib*	**Degrees** *darjāt*	**Planets** *kawākib*
0. Aries	10	Mars	20	Sun	30	Venus
1. Taurus	10	Mercury	20	Moon	30	Saturn
2. Gemini	10	Jupiter	20	Mars	30	Sun

197 Cf. Kaye 1918, p. 123.

	Degrees *darjāt*	Planets *kawākib*	Degrees *darjāt*	Planets *kawākib*	Degrees *darjāt*	Planets *kawākib*
3. Cancer	10	Venus	20	Mercury	30	Moon
4. Leo	10	Saturn	20	Jupiter	30	Mars
5. Virgo	10	Sun	20	Venus	30	Mercury
6. Libra	10	Moon	20	Saturn	30	Jupiter
7. Scorpio	10	Mars	20	Sun	30	Venus
8. Sagittarius	10	Mercury	20	Moon	30	Saturn
9. Capricorn	10	Jupiter	20	Mars	30	Sun
10. Aquarius	10	Venus	20	Mercury	30	Moon
11. Pisces	10	Saturn	20	Jupiter	30	Mars

Table of Limits

On the right is another astrological table, displaying the ‘limits’ or ‘terms’ in 11 columns and 13 rows. The first column on the right carries the argument, viz., the names of the 12 signs through their serial numbers. The following columns show alternately the degrees (*darjāt*) of limits in *Abjad* notation and the names of the presiding planets (*kawākib*) through the last letters of their names. In the table below, instead of the symbols, we shall give the full names of the signs and planets. Owing to the lack of space in the table, the argument *darjāt* (degrees) is substituted by *x*.

Table A003-5 Limits of the Signs

Signs *burūj*	*x*	Planets *kawākib*	*x*	Planets *kawākib*	*x*	Planets *kawākib*	*x*	Planets *kawākib*	*x*	Planets
0. Aries	6	Jupiter	12	Venus	20	Mercury	25	Mars	30	Saturn
1. Taurus	8	Venus	14	Mercury	22	Jupiter	26	Saturn	30	Mars
2. Gemini	6	Mercury	12	Jupiter	16	Venus	24	Mars	30	Saturn
3. Cancer	7	Mars	13	Venus	19	Mercury	27	Jupiter	30	Saturn

Signs ***burūj***	***x***	**Planets** ***kawākib***	***x***	**Planets** ***kawākib***	***x***	**Planets** ***kawākib***	***x***	**Planets** ***kawākib***	***x***	**Planets**
4. Leo	6	Jupiter	11	Venus	18	Saturn	24	Mercury	30	Mars
5. Virgo	7	Mercury	14	Venus	18	Jupiter	26	Mars	30	Saturn
6. Libra	6	Saturn	14	Mercury	21	Jupiter	25	Venus	30	Mars
7. Scorpio	7	Mars	11	Venus	19	Mercury	24	Jupiter	30	Saturn
8. Sagittarius	12	Jupiter	17	Venus	21	Mercury	25	Saturn	30	Mars
9. Capricorn	7	Mercury	14	Jupiter	22	Venus	26	Saturn	30	Mars
10. Aquarius	7	Mercury	13	Venus	20	Jupiter	25	Mars	30	Saturn
11. Pisces	12	Venus	16	Jupiter	19	Mercury	28[198]	Mars	30	Saturn

Strangely enough the labels designating these two tables are erroneously interchanged. The label on the left reads *ḥudūd miṣriyān* (limits according to the Egyptians); this labels actually pertains to the table on the right. The label on the right reads *wujūh kawākib* (faces of the signs or decans), but this belongs to the table on the left.[199]

198 There is an error here; instead of 28, it repeats the symbol of Mercury from the preceding cell.

199 On these tables, see Kaye 1918, pp. 120-126; Khareghat 1950, pp. 10-20.

Day Regents and Night Regents of Trigons[200]

Below the shadow squares are engraved two small tables on either side of the south-north diameter, presenting respectively the day regents and night regents of the trigons. In these tables the trigons themselves are not mentioned. These are mentioned here in the last row.

Table A003-6 Triplicities

Day Regents *Jadwal arbāb Muthallathāt* – (?)				**Night Regents** *Jadwal arbāb Muthallathāt* – (?)			
Fiery	Earthy	Airy	Watery	Fiery	Earthy	Airy	Watery
Jupiter *Mushtarī*	Moon *Qamar*	Mercury *ᶜUṭārad*	Mars *Mirrikh*	Sun *Shams*	Venus *Zuḥrah*	Saturn *Zuḥal*	Venus *Zuḥrah*
Sun *Shams*	Venus *Zuḥrah*	Saturn *Zuḥal*	Venus *Zuḥrah*	Jupiter *Mushtarī*	Moon *Qamar*	Mercury *ᶜUṭārad*	Mars *Mirrikh*
Saturn *Zuḥal*	Mars *Mirrikh*	Jupiter *Mushtarī*	Moon *Qamar*	Saturn *Zuḥal*	Mars *Mirrikh*	Jupiter *Mushtarī*	Moon *Qamar*
Aries	Taurus	Gemini	Cancer	Aries	Taurus	Gemini	Cancer
Leo	Virgo	Libra	Scorpio	Leo	Virgo	Libra	Scorpio
Sagittarius	Capricorn	Aquarius	Pisces	Sagittarius	Capricorn	Aquarius	Pisces

ALIDADE, PIN AND WEDGE

The alidade is a straight bar alidade with ornate ends and an ornate centre piece. To the ends are attached plain sighting plstes with a single hole in each. On the edge and the surface of the left half are engraved arcs which match with the declination arcs in the upper right quadrant. On the edge of the right half are divisions which correspond to 5 units in the trigonometric quadrant. These divisions are numbered in 5s. There is a broad-headed pin with a slot at the other end into which passes a wedge with the traditional horse head. The wedge may be a replacement.

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200 Cf. Kaye 1918, p. 125; Khareghat 1950, p. 22. The sequence of the regents in each column on the astrolabe varies from that given in these two sources. E.g. both Kaye and Khareghat enumerate the fiery day regents in this order: Sun, Jupiter, Saturn, whereas the astrolabe has the sequence Jupiter, Sun, Saturn. The same variation occurs in all columns.

A004⊙ ASTROLABE ATTRIBUTABLE TO ALLĀHDĀD AND ᶜĪSĀ[201]

Not dated, late 16th century, Lahore

Diameter 160 mm

London, National Maritime Museum, Greenwich (# AST0560)



Figure A004.1 – Front of the astrolabe (photo by S. R. Sarma)

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[201] The description is based on a brief personal examination in 1993, but mainly on Charette 2005a.

This astrolabe is neither signed and nor dated, yet there are some points of resemblance between this and the astrolabe made by Allāhdād in 1567: solid *kursī,* the unusual design of the rete, the incomplete gazetteer, and the calligraphy of the *Abjad* numbers on the limb. As in the undated astrolabe by Allāhdād (A002), there is a plate of horizons in western style here. Therefore, this astrolabe can be attributed to Allāhdād; it will be argued further that Allāhdād's son ʿĪsā may have engraved the back and some plate faces in this astrolabe.

COMPONENTS

Body with crown (d. 160, h. 202, t. 8), shackle and ring, rete (d. 140) for 13 stars, 5 plates, alidade. Pin and wedge are modern replacements.

FRONT

The ring is very large, but the shackle is rather small. The crown is high and solid, with almost flat lobes in the profiles and a trifoliate finial. The surface of the crown is plain, on which there is an inscription in a later hand: *bi-niʿmat Allāh,* 'by God's munificence'.

The limb is graduated in 1° and 5° and labelled in 5s from 5° to 360°.

RETE

The rete resembles to a great extent the rete in Allāhdād's astrolabe of 1567. In both the equatorial ring occurs in two disjointed segments, one inside the ecliptic ring and the other in the lower part. In the Hyderabad astrolabe, both the segments are of equal width; here the lower segment is much narrower. In both, the rings are held together by the equinoctial bar which is counter-changed at the centre. In the Hyderabad astrolabe, the solstitial bar runs from the south point to the centre; here it is fully shown, but without any counter change. In both the astrolabes, the star pointers are shaped like tiger's claws.

In the present rete, the ecliptic ring is divided into the 12 signs of the zodiac and labelled; each sign is divided into groups of 6° and numbered from 6 to 30 separately. The edge of the ecliptic circle is divided into 1°. There is a knob at the base of the star pointer α Canis Majoris to rotate the rete. A small triangular projection at the top of the ecliptic circle constitutes the Capricorn index.

There are 13 pointers on which the star names are engraved in starkly abridged form, and about six without labels. The named stars are as follows:

Table A004-1 Stars on the Rete

	Star Name	Identification
1	*Rijl Yusrā*	β Orionis
2	*Yad Yumnā*	α Orionis
3	*Yamānī*	α Canis Majoris
4	*Shāmī*	α Canis Minoris
5	*Fard*	α Hydrae
6	*Aᶜjal*	α Virginis
7	*Rāmiḥ*	α Bootis
8	*Fakkah*	α Coronae Borealis
9	*Jāthī*	α Herculis
10	*Wāqiᶜ*	α Lyrrae
11	*Ṭā'īr*	α Aquilae
12	*Dhanab* ?	ε Delphini
13	*Kh*(*al-Khaḍīb?*)	β Cassiopeiae

PLATES

There are 5 plates. On these only the latitude is mentioned, but not the duration of the longest day, although the arguments *ᶜarḍ* and *sāᶜāt* are engraved.

Table A004-2 Plates

	φ	(locality)
1a	21;40°	(Mecca)
1b	34;35°	(Bamyān)
2a	26°	

	φ	(locality)
2b	33°	
3a	35°	
3b	39;37°	(Samarqand)
4a	38°	
4b	Ecliptic coordinates	
5a	54° + 30°	double projection
5b	Plate of horizons (western style)	

On the latitude plates, altitude circles are drawn for every 3° and each fifth circle is dotted. Azimuth arcs are drawn for every 10° below the horizon. Plain lines for seasonal hours and dotted lines for equal hours since sunset and before sunrise are drawn.

According to Charette, plates 2b and 4a-b were engraved by a person different from the main engraver.

Geographical Gazetteer

On the inner surface of the mater is engraved a geographical gazetteer in two annular rings. According to the argument, the following data are planned to be provided: names of the localities (*al-bilād*), their longitudes (*al-ṭūl*), latitudes (*al-ᶜard*), *inḥirāf* (*al-inḥirāf*) and the duration of the longest day (*al-sāᶜāt*), but the cells corresponding to the last two items are left blank as in Allāhdād's astrolabe at Hyderabad (A001). The gazetteer is reproduced in the following table.[202]

[202] The table is from Charette 2005a; he does not reproduce place names as they are engraved, but only the modern equivalents.

Table A004-3 Geographical Gazetteer

	Place Name	L	φ
	Outer Circle		
1	Mecca	77;10	21;40
2	Medina	75;20	25;0
3	Jerusalem	66;30	31;50
4	Alexandria	61;54	30;58
5	Cairo	63;20	30;20
6	Damascus	70;0	33;15
7	Aleppo	72;10	35;50
8	Constantinople	59;50	45;0
9	Maragha	82;0	37;20
10	Tabriz	82;30	38;0
11	Ardabil	83;0	38;0
12	Shamakha	84;30	40;50
13	Kufa	79;30	31;30
14	Baghdad	80;0	33;25
15	Basra	84;0	30;0
16	Shiraz	88;0	29;36
17	Hamadan	83;0	35;10
18	Sawa	85;0	35;0
19	Qazwin	85;0	36;0
20	Isfahan	86;40	37;25
21	Kashan	86;0	34;0
22	Qum	85;40	34;15
23	Rayy	86;20	35;0

	Place Name	L	φ
24	Astarabad	89;35	36;50
25	Simnan	88;0	36;0
26	Damghan	88;55	36;20
27	Bistam	89;30	36;10
28	Sabzwar	91;30	36;5
29	Nishapur	92;30	36;21
30	Tus	92;30	37;0
31	Turshiz	92;0	35;0
32	Tabas-i Gilaki	92;0	33;0
33	Tun	92;30	34;30
34	Qayin	93;20	33;40
35	Heart	94;20	34;30
36	Badghis	94;30	35;20
37	Sarakhs	94;30	37;0
38	Marw	97;40	37;40
39	Faryab	99;0	37;45
40	Balkh	101;0	36;41
41	Bamiyan	102;0	34;35
42	Qabadhiyan	102;0	37;45
43	Talaqan	102;50	37;25
44	Andarab	103;15	34;0
45	Badakhshan	104;25	34;10
46	Bukhara	97;30	39;50
47	Samarqand	99;16	39;37

	Place Name	L	φ
48	Kish	99;30	39;30
49	Khojand	105;35	41;55
50	Kashghar	107;30	44;0
51	Khutan	107;0	42;0
52	Ghazna	104;20	33;35
53	Banjhir	104;40	35;0
54	Ribat-i Amir	105;0	34;0
55	Multan	107;35	29;40
56	Qandahar	106;40	33;0
57	Tibet	110;0	47;0
58	Kashmir	105;0	35;0
59	Delhi	113;35	28;39



Figure A004.2 – Back of the astrolabe (photo by S. R. Sarma)

BACK

In the upper half, the altitude scales on the rim are divided in 1° and in 5° and numbered in 5s as 5—90; 90—5.

In the upper left is a trigonometric quadrant with 60 equidistant horizontal and vertical parallels, with every fifth line highlighted with dots.

In the upper right quadrant, there are once again 30 equidistant horizontal parallels. There are also 5 declination arcs; the six zones created by these arcs represent six pairs of the zodiacal signs. The signs are labelled along the vertical and horizontal radii by their serial numbers from 0 to 11.

Upon these declination arcs is superimposed a sigmoid curve of the meridian altitude of the sun for the latitude of 32°, i.e., the latitude of Lahore; it carries the label *khaṭṭ niṣf al-nahār ʿarḍ l-b* (‘line of the meridian altitude, [for] latitude 32°’).

The rim of the lower half carries the cotangent scales in feet and digits. Inside the rim in the lower left quadrant are engraved the Sanskrit names of the lunar mansions in two quarter circles and the Sanskrit names of the zodiac signs in two more quarter circles. These Sanskrit names are written in Arabic/Persian transliteration. Above these quarter circles is the label *manāzil bi-zabān-i hind* (the lunar mansions in the language of India).

In the right quadrant, the Arabic names of the lunar mansions are engraved in two quarter circles. Inside these quarter circles is a third quarter circle on which there is a scale of 90° with subdivisions for every 30°, 5° and 1°, along which the Arabic names of the zodiacal signs and their serial numbers from 0-11 are engraved.

The Sanskrit names of the lunar mansions as engraved on the astrolabe and the correct forms are reproduced below, both in Roman transliteration.

Table A004-4 Sanskrit Names of the Lunar Mansions

	Astrolabe	Sanskrit
1	*ashnī*	*aśvinī*
2	*bahranī*	*bharaṇī*
3	*kartikā*	*kṛttikā*
4	*rohnī*	*rohiṇī*
5	*margsar*	*mṛgaśirā*
6	*āddrā*	*ārdrā*
7	*punarbas*	*punarvasu*
8	*pugah*	*puṣya*
9	*ashlekhā*	*aśleṣā*
10	*maghā*	*maghā*
11	*purbā bahalkanī*	*pūrvā phālgunī*

	Astrolabe	Sanskrit
12	*utrā bahalkanī*	*uttarā phālgunī*
13	*hasat*	*hasta*
14	*jitrā*	*citrā*
15	*swātī*	*svātī*
16	*visākhā*	*viśākhā*
17	*anrādhā*	*anurādhā*
18	*jyeshthā*	*jyeṣṭhā*
19	*mūlā*	*mūla*
20	*pūrbākhārā*	*pūrvāṣāḍhā*
21	*utrākhārā*	*uttarāṣāḍhā*
22	*sarwan*	*śravaṇa*
23	*abhaj*	*abhijit*
24	*dhanishtā*	*dhaniṣṭhā*
25	*satbhikah*	*śatabhiṣā*
26	*pūrbā bahadbadā*	*pūrvā bhādrapadā*
27	*utrā bahadbadā*	*uttarā bhādrapadā*
28	*rewthī*	*Revatī*

The Sanskrit names of the zodiac signs as engraved on the astrolabe and the correct forms are reproduced below, both in Roman transliteration.

Table A004-5 Sanskrit Names of the Zodiac Signs

	Astrolabe	Sanskrit
1	*mekah*	*meṣa*
2	*barkah*	*vṛṣa*

	Astrolabe	Sanskrit
3	*mithun*	*mithuna*
4	*karkah*	*karka*
5	*simka*	*siṃha*
6	*kanyān*	*kanyā*
7	*tul*	*tulā*
8	*barcihka*	*vṛścika*
9	*dhan*	*dhanuḥ*
10	*makar*	*makara*
11	*kumbh*	*kumbha*
12	*mīn*	*Mina*

Charette considers the Sanskrit names in Arabic/Persian transliteration 'a unique epigraphical source' and refers to similar lists in al-Bīrūnī's treatise on India and in the *Āᶜīn-i Akbarī*[203] and adds that 'it is interesting to note an almost exact correspondence between the spelling on our astrolabe and in the *Āᶜīn-i Akbarī.*'

Between these quarter circles and the east-west diameter of the astrolabe are engraved the two shadow squares. The shadow square on the left is smaller than the shadow square on the right. This is most unusual. Charette explains that the difference in size arose because these squares were drawn after the quarter circles were drawn containing the names of the zodiac signs and lunar mansions.

The shadow square on the left is divided into 7 and that on the right into 12. Inside the corner on the left is the label *ẓill sullam aqdām* (shadow scale in feet). Along the vertical scale is the label *ẓill aqdām maᶜkūs* (umbra versa in feet) and along the horizontal scale *ẓill aqdām mustawī* (umbra recta in feet).

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[203] Zodiacal signs: Abū al-Faḍl 3, pp. 14-15; Bīrūnī 1910, i. 220.
Lunar Mansions: Abū al-Faḍl 3, pp. 24-25; Bīrūnī 1910, i. 218.

Inside the corner on the right is the label *ẓill sullam aṣābiʿ* (shadow scale in digits). Along the vertical scale *ẓill aṣābiʿ maʿkūs* (umbra versa in digits) and along the horizontal scale *ẓill aṣābiʿ mustawī* (umbra recta in digits).

ALIDADE, PIN AND WEDGE

The alidade is a straight bar alidade with pointed ends and a plain centre-piece. The edge of one half of the alidade is marked with 60 divisions to match with the divisions on the trigonometric quadrant on the back. It may be a replacement. The pin and the wedge (a bent metal piece) are clearly recent replacements.

Charette notes that the rete and crown of this astrolabe are similar to those of the astrolabe at Hyderabad, that the calligraphy of the *Abjad* numerals on the limb is 'exactly identical' in both the astrolabes and that the gazetteers of both the astrolabes are partially completed. It may also be added that these are only two astrolabes produced in India which contain a western type plate of horizons. Therefore, it is quite possible that the present astrolabe also was made by Allāhdād.

Charette notes that while the main engraver engraved the limb and the gazetteer, the back displays the hand of another engraver. Likewise, while the plate faces 1, 2a, 3 and 5 were engraved by the main engraver, the other engraver engraved the plate faces 2b and 4ab. So these two persons must be contemporary. In particular, the two sides of plate 2 must have been engraved at the same time and those who did the engravings must be contemporary. If we assume that Allāhdād fabricated the astrolabe and engraved the limb, the gazetteer and the places faces 1, 2a, 3 and 5, the other person who engraved the rest must have been his son ʿĪsā. This assumption gains strength when we consider that the sigmoid graph of the sun's meridian altitude for the latitude 32° of Lahore which appears on the back of the present astrolabe can be seen also in ʿĪsā's two astrolabes of 1601 and 1604.[204] In sum, this astrolabe can be considered a joint work by Allāhdād and his son ʿĪsā towards the end of the sixteenth century.

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[204] The label on the astrolabes of 1601 and 1604 mentions the latitude 31;50°. The third extant astrolabe by ʿĪsā, which is undated, does not have this graph. But from this time on it became another hallmark of the Lahore astrolabes. In the astrolabes by Qā'im Muḥammad, Muḥammad Muqīm and Ḍiyā' al-Dīn Muḥammad, it was extended to the Mughal imperial cities of Agra, Lahore and Delhi.

PROVENANCE

The astrolabe was presented to the museum by Sir James Caird in May 1936.

BIBLIOGRAPHY

Charette 2005a.

ᶜĪSĀ

Allāhdād's son ᶜĪsa (*fl.* 1601-1604)[205] is known through three astrolabes; a fourth can be attributed to him on stylistic grounds. He may also have engraved parts of an unsigned astrolabe which is attributable to his father (A004). Though of varying sizes, the four astrolabes listed above present a uniform appearance with a solid and multi-lobed *kursī*. More important, in these astrolabes ᶜĪsā introduces for the first time several features which were emulated by his descendants and which become the characteristic features of the Lahore astrolabes.

(i) The sigmoid graph on the back for the meridian altitude of the sun throughout the year. ᶜĪsā draws it for the latitude of Lahore which is the seat of his family. It occurs in A005 (*khaṭṭ zawal*), A006 (*khaṭṭ nisf al-nahār*) and also in A004 (*khaṭṭ niṣf al-nahār*). His son Muḥammad Muqīm usually draws two curves for 29° and 32° which are the latitudes of the two Mughal imperial cities Agra and Lahore, while the nephew Ḍiyā' al-Dīn Muḥammad adds a third graph for 29°, the latitude of Delhi.

(ii) ᶜĪsā engraves the projections for 27° and 32° on the two faces of the same plate.

(iii) Likewise he employs the two sides of the same plate for the ecliptic coordinates and horizons. In the plate of horizons, he introduces the scales of declinations along the two diameters.

(iv) He introduces a combined projection for the latitudes 90°and 0° on one of the plates and a similar composite projection of the latitudes 72° and 18° on another plate.

(v) His gazetteers provide only the longitudes and latitudes and ignores the other parameters.

(vi) He reduces the astrological data on the back to the minimum and shows just the correspondences between the twelve signs of the zodiac and the twenty-eight lunar mansions in two concentric semicircles.

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[205] He is usually referred to as Mullā (learned man) by his descendants, but occasionally also as Hāfiẓ, i.e., one who has memorized the entire *Qurᶜān* (e.g. A064).

Thus cĪsā lays the real foundation for what are typically the Lahore astrolabes. The kursī is not yet standardized in his oeuvre, nor the design of the rete. Just as Allāhdād was experimenting with two styles of rete, cĪsā too appears to be trying different styles. The unusual style of rete seen in A006 and in A008 was one such experiment which was not continued later on. The same is the case with the decorative arches in the degree scales and in the gazetteer in A008. This too was not continued in the subsequent astrolabes.

A005⊙ ASTROLABE BY ʿĪSĀ, 1009 AH (AD 1601)[206]

Diameter 170 mm

Chicago, Adler Planetarium & Astronomy Museum (# N-69)

CCA 3823; Répertore 1



Figure A005.1 – Front of the astrolabe (accession no. N-69)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

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[206] Entry based on Pingree 2009, no. 13, pp. 52-57.

COMPONENTS

Body with crown (d. 170, h. 213, t. 11), shackle, ring, rete for 46 stars, 5 plates (3 original and two replacements), un-inscribed alidade (one sight is missing). Modern bolt and nut.

FRONT

High solid *kursī* with a plain surface; profiles consist of an ogee at the base, followed by two lobes and a trifoliate finial. The trifoliate pattern is repeated in the shackle; seen from the side, it has a trifoliate shape, and the bases through which the pin passes are also given the trifoliate shape.

The scale on the limb is graduated for 1°, 5° and numbered in 5s clockwise from 5 to 360.

RETE

The rings of the Tropic of Capricorn and ecliptic are held together by the equinoctial bar which is counter-changed at the centre. The space between the two rings and that inside the ecliptic is filled by a floral tracery from which emerge star pointers, some shaped like leaves and some others like tiger's claws. The ecliptic ring is divided into the signs of the zodiac and labelled accordingly. Each sign is divided into units of 6° and numbered 6, 12, 18, 24, 30. Each of these units is further subdivided into parts of 2°.

There are 46 named star pointers. Pingree remarks; 'The names of stars are very badly preserved; some I have been unable to read or to identify.' Pingree's star list is rearranged below by the increasing right ascension, but the identifications are as proposed by Pingree.

Table A005-1 Stars on the Rete

	Star Name	Identification
01	*Baṭn al-Ḥūt*	β Andromedae
02	*Rās al-Ghūl*	β Persei
03	*Tālī Masāf al-Nahr*	θ Eridani
04	*ʿAyn al-Thawr*	α Tauri

	Star Name	Identification
05	*ʿAyyūq*	α Aurigae
06	*Rijl al-Yusrā*	β Orionis
07	*[Yad] al-Jawjā' Yusrā*	γ Orionis
08	*Yad al-Jawjā' Yumnā*	α Orionis
09	*Rijl al-Jawjā' Yumnā*	κ Orionis
10	*Shiʿrā Yamānī*	α Canis Majoris
11	*---al Furūdaẏn*	ζ Canis Majoris
12	*Shiʿrā Shāmī*	α Canis Minoris
13	*Ṭaraf al-Sufīna*	ρ Puppis
14	*Fard al-Shujāʿ*	α Hydrae
15	*Mankhar Shujāʿ*	σ Hydrae
16	*Qalb al-Asad*	α Leonis
17	*Ẓahr al-Dubb*	α Ursae Majoris
18	*Qāʿidat al-Bāṭiẏa*	α Crateris
19	*Ẓahr al-Asad*	δ Leonis
20	*Zubānā* (?) *al-Asad*	ε (?) Leonis
21	*Janāḥ al-Ghurāb*	γ Corvi
22	*Simāk Aʿzal*	α Virginis
23	*Al-Mutaqaddim*	ε Virginis
24	*Simāk Rāmiḥ*	α Bootis
25	*Kiffa Janūbī*	α Librae
26	*Kiffa Shamālī*	β Librae
27	*Nayyir al-Fakkah*	α Coronae Borealis
28	*Yad al-Ḥawwā*	δ Ophiuchi

	Star Name	Identification
29	*Qalb al-ʿAqrab*	α Scorpii
30	*Rās al-Ḥawwā*	α Ophiuchi
31	*Rukbat al-Ḥawwā*	ζ Ophiuchi
32	*ʿAyn al-Tinnīn*	α Draconis
33	*Al-Nasr al-Wāqiʿ*	α Lyrae
34	*ʿIṣābat al-Rāmī*	ρ Sagittarii
35	*Minqār al-Dajājah*	β Cygni
36	*Nasr Ṭā'ir*	α Aquilae
37	*Dhanb al-Dulfīn*	ε Delphini
38	*Fam al-Faras*	ε Pegasi
39	*Dhanab al-Jady*	δ Capricorni
40	*Sāq Sākib al-Mā'*	δ Aquarii
41	*Mankib al-Faras*	β Pegasi
42	*Janāḥ al-Faras*	γ Pegasi
43	*Surrat al-Faras*	δ Pegasi
44	*Kaff al-Khaḍīb*	β Cassiopeiae
45	*Muqaddam*	?
46	*…al-janūbiyya*	δ Aquarii ?

PLATES

There are five plates with notches at the north point to fit into the corresponding tab in the mater. Pingree says that two of these plates are ‘extraneous’ and ‘uninscribed’. The three genuine plates serve the following latitudes.

Table A005-2 Plates

	φ	Longest Day
1a	22°	13;22 hours
1b	25°	13;25 hours
2a	27°	13;46 hours
2b	32°	14;8 hours
3a	Plate of ecliptic coordinates	
3b	Plate of horizons	

On plates 1 and 2, altitude circles are drawn for every 3° and numbered on both sides of the meridian. The catalogue says that there are 'no azimuths', but azimuth curves can clearly be seen in the photos on p. 57, drawn below the horizon for every 10° and numbered in different styles. There are lines for seasonal hours and equal hours drawn from the western and eastern horizons up to the meridian.

The plate of ecliptic coordinates carries the label *ṣafīhat mīzān al-ᶜankabūt.* On the plate of horizons, there are four sets of half-horizons for latitudes ranging from 9° to 81° at intervals of 3°. These are numbered at both ends. Along the radial edges there are declination scales, numbered 6, 12, 18, 24. There is no label mentioning the name of this tablet.

It may be noted that plate 2 is devoted to 27° and 32° which are roughly the latitudes of the two Mughal imperial cities Agra and Lahore. Since this time onwards, this plate and plate 3 (with the plate of ecliptic coordinates on one side and the plate of horizons on the other) became an essential feature of the Lahore astrolabes. Moreover, this is the first astrolabe where declination scales are drawn on the plate of horizons.



Figure A005.2 – Geographical Gazetteer (accession no. N-69)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Geographical Gazetteer

A geographical gazetteer is engraved in two circles on the inner surface of the mater, providing the names (*asmāʾ al-buldān*), longitudes (*al-ṭūl*) and latitudes (*al-ʿarḍ*) of 80 localities, which are ‘arranged more or less by region.’ Unlike his father, ʿĪsā does

not attempt to provide other parameters like the *inḥirāf*. The entries are read counter-clockwise from right to left. The symbol for zero is much smaller than the other *Abjad* letters and is placed higher than the rest.

Table A005-3 Geographical Gazetteer

	Place Name	L	φ	Identification
	Outer Circle			
1	Makka Mubārak	77;10	21;40	Mecca
2	Madīnat Rusūl	75;20	25;0	Medina
3	Iskandariyya	61;54	30;58	Alexandria
4	Miṣr	63;20	30;20	Cairo
5	Yaman	77;0	14;30	Ṣanaʿā’
6	Ṭāʿif	77;30	21;20	Tā’if
7	Bayt al-Maqdis	66;30	31;50	Jerusalem
8	Dimashq	70;0	33;15	Damascus
9	Anṭākiyya	71;26	35;30	Antiochus
10	Ḥalab	72;10	35;50	Aleppo
11	Qusṭanṭiyya	59;50	45;0	Istanbul
12	Anīth Madīnat al-Ḥikmā’	65;40	37;20	Athens
13	Mawṣil	77;0	34;30	Mosul
14	Ardabīl	82;30	38;0	Ardabil
15	Marāgha	82;0	37;33	Maragha
16	Tabrīz	82;0	38;0	Tabrīz
17	Bulghār	90;0	49;30	(Bulgars)
18	Kūfa	79;30	31;30	Kufa
19	Baṣra	84;0	30;0	Basra

	Place Name	L	φ	Identification
20	Baghdād	80;30	33;25	Baghdad
21	ʿAskar Mukram	54;30	31;15	Band Qir
22	Kāzirūn	87;0	29;55	Kazerun
23	Sābūr	86;55	30;0	Shapur
24	Shīrāz	88;0	29;36	Shiraz
25	Yazd	89;0	32;30	Yazd
26	Hamadān	83;0	35;10	Hamadan
27	Qazwīn	85;0	36;55	Qazwin
28	Iṣfahān	86;40	32;25	Esfahan
29	Kāshān	86;0	34;0	Kashan
30	Rayy	86;20	35;0	Shahr Rayy
31	Ṭāliqān	85;45	36;10	Taliq-an
32	Astarābād	89;30	36;50	Gotgan
33	Jurjān	92;0	36;50	Jurjan
34	Basṭām	89;30	36;10	Bastam
35	Sabzwar	91;30	36;5	Sabzevar
36	Nīshābūr	92;30	36;21	Neyshabur
37	Ṭūs	94;30	37;0	Tus
38	Harat	94;33	34;30	Herat
39	Sarakhs	94;30	37;0	Sarakhs
40	Fāriyāb	99;0	36;45	Dowlatabad
41	Balkh	101;1	36;41	Wazirabad
42	Badakhshān	104;24	37;10	Faizabad

	Place Name	L	φ	Identification
43	Khuwārizm	94;30	42;17	Kunya-Urgench
44	Bukhārā	97;30	39;50	Bukhara
45	Samarqand	99;16	37;37	Samarqand
46	Khujand	105;30	41;55	Leninabad
47	Kāshghar	106;30	44;0	Kashghar
48	Hurmuz	92;0	25;0	Hormoz
49	Kābul	104;40	34;30	Kabul
50	Mansūra Qaṣba Sind	105;0	27;40	Mansura
51	Sawmnāt	106;0	17;0	Somnath
52	Mūltān	107;35	29;40	Multan
53	Qandahār	106;40	33;0	Qandahar
54	Lahāwar	109;20	31;50	Lahore
55	Qannawj	115;50	26;35	Kannauj
	Inner Circle			
56	Bānārasī	117;20	26;50	Varanasi
57	Sarandīb	130;0	10;0	Sri Lanka
58	Tubbat	110;0	40;0	Lhasa
59	Kashmīr	103;0	35;0	Srinagar
60	Dihlī	114;48	28;17	Delhi
61	Akra	114	27;13	Agra
62	Kawāliyār	115	26;29	Gwalior
63	Ajmīr	111;50	24;0	Ajmer
64	Sulṭān Kūt	109;4	33;0	Sultankot

	Place Name	L	φ	Identification
65[207]	Baran	114;0	28;48	Buland Shahar
66[208]	Siyālkūt	109;4	33;0	Sialkot
65	Kawl	114;19	28;4	Aligarh
66	Sunnām	110;25	30;30	Sunam
67	Pānīpat	113;20	28;52	Panipat
68	Tānīsar	112;35	30;10	Thanesar
69	Budāūn	114;39	27;32	Budaun
70	Sanbhal	115;0	28;4	Sambhal
71	Kura	117;6	26;36	Manikpur
72	Aḥmadābād	108;40	23;15	Ahmedabad
73	Chānpānīr	108;45	22;30	Champaner
74	Kanbāyat	109;40	22;20	Cambay
75	Bījābūr	105;30	17;20	Bijapur
76	Ujjayn	102;0	22;30	Ujjain
77	Amarkūt	105	25	Umarkot
78	Jawnpūr	119;6	26;36	Jaunpur
79	Mānikpūr	118;6	26;49	Garhi Manikpur
80	Hānsī	102;25	29;15	Hansi

207 Not included in Pingree's list by mistake.

208 Not included in Pingree's list by mistake.



Figure A005.3 – Back of the astrolabe (accession no. N-69)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

BACK

On the back, the altitude scales on the rim of the upper half are divided in 5°, 1°, 0;30° and numbered in 5s as 5—90; 90—5.

In the upper left quadrant are drawn 60 horizontal parallels, with each fifth line highlighted with dots, to provide the cosines for each of the 60 parts of the Radius.

In the upper right quadrant are drawn the declination circles; these are labelled along the two radii with the serial numbers of the zodiac signs. On this quadrant are plotted 6 curves for unequal hours which are numbered serially and a sigmoid graph for the meridian altitude of the sun for the latitude of 31;50° (i.e. for Lahore) which carries the label *khaṭṭ zawal ᶜarḍ l.a.n.* (line of noon; latitude 31;50).

In the lower half are shadow squares, on the left for 7 feet and on the right for 12 digits. The vertical and horizontal scales are divided accordingly. In the inner corner on the left is engraved *ẓill sullam aqdām* (scale of shadows in feet). In the inner corner on the right is engraved *ẓill sullam aṣābīᶜ* (scale of shadows in digits). The vertical and horizontal scales on both sides carry the following labels:
Vertical scale on the left: *zill aqdām maᶜkūs* (umbra versa in feet),
Horizontal scale on the left: *zill aqdām mustawī* (umbra recta in feet),
Horizontal scale on the right: *zill aṣābīᶜ mustawī* (umbra recta in digits),
Vertical scale on the right: *zill aṣābīᶜ maᶜkūs* (umbra versa in digits).

The rim of the lower half carries the corresponding cotangent scales in feet (*zill aqdām*) and in digits (*zill aṣābīᶜ*). Inside these scales are inscribed the names of the zodiac signs and the corresponding lunar mansions in two semi-circular rows.

ALIDADE

Uninscribed, one of the sights is missing.

INSCRIPTION

Just above the semi-circular rows displaying the zodiac signs and the lunar mansions, there are three lines of inscription which read:

sanah 1009
ṣanaᶜahu aḍaᶜaf al-ᶜibād ᶜīsā wald allāhdād
asṭurlābī lāhūrī humāyūnī tā'rīkh shaḥr dhū 'l-ḥijja.
'[In] the year 1009,
made [by] the weakest of the servants [of God], ᶜĪsā the son of Allāhdād of Lahore,
the astrolabe-maker to [Emperor] Humāyūn, [on the] date [? in the] month Dhū'l-ḥijja.'

Here only the month is mentioned, but not the date. The month *Dhū'l-ḥjja* in AH 1009 lasted from 2 June to 30 June 1601, during which period the astrolabe was made.

BIBLIOGRAPHY

Pingree 2009, no. 13, pp. 52-57.

A006⊙ ASTROLABE BY ʿĪSĀ, 1013 AH (AD 1604-5)[209]

Diameter 120 mm

Chicago, Adler Planetarium & Astronomy Museum (#A-79)

CCA1076= CCA 3824[210]; Répertoire 2



Figure A006.1 – Front of the astrolabe (accession no. A-79)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

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209 Entry baed on Pingree 2009, no. 14, pp. 58-63.

210 By mistake CCA lists it twice, but both are identical.

The rete in this astrolabe has an unusual design where the two circles of the Tropic of Capricorn and the ecliptic are held together by the equinoctial bar without any counter change. Below the ecliptic, two semicircular rings are attached to the ring of the Capricorn symmetrically on either side of the meridian to serve as the bases for the star pointers. Pingree calls this rete 'a late addition', implying that it is not original. However, the discovery of another astrolabe with exactly the same type of rete, which will be described presently (A008), suggests that same type of rete could not have been added as replacement in two different astrolabes. On the contrary, this unusual rete may have been one of the designs with which ʿĪsā has been experimenting. At the beginning of the seventeenth century, the style of the Lahore astrolabes was still in a state of development and has not yet been standardized. Just as the patriarch Allāhdād was experimenting with two styles of rete, his son ʿĪsā too must be trying different styles of retes. The unusual style of rete seen here and in A007 was one such experiment which was not continued later on.

COMPONENTS

Body with crown (d. 120, h. 150, t. 10), shackle and ring, rete for 23 stars, 8 plates, un-inscribed alidade, pin, wedge.

FRONT

Plain ring with a circular cross-section; the shackle trifoliate but with plain bases. The *kursī* is solid with plain surfaces, with lobed and scalloped profiles and a trifoliate finial. The degree scale on the limb is divided in 1° and 5° and numbered in 5s from 5 to 360.

RETE

The 23 star pointers are shaped, in most cases, like daggers with handles. The ecliptic ring is divided into the 12 zodiac signs and labelled with their names; each sign is subdivided into units of 6°, but not numbered.

The star names are engraved on the pointers very clearly, but they are drastically abbreviated to fit in the limited space available. In the following table, the stars are rearranged in the order of increasing right ascension, starting from the vernal equinox.

Table A006-1 Stars on the Rete

	Star name	Identification
01	*Dhanab Qayṭus*	β Ceti[211]
02	*Fam Qayṭus*	γ Ceti
03	*ᶜAyn al-Thawr*	α Tauri
04	*ᶜAyyūq*	α Aurigae
05	*Rijl al-Jawjā'*	β Orionis
06	*Yad al-Jawzā'*	α Orionis
07	*Yamānī*	α Canis Majoris
08	*Shāmī*	α Canis Minoris
09	*Fard al-Shujāᶜ*	α Hydrae
10	*Qalb al-Asad*	α Leonis
11	*Simāk Aᶜzal*	α Virginis
12	*Rāmiḥ*	α Bootis
13	*Nayyir al-Fakkah*	α Coronae Borealis
14	*Ḥayyah*	α Serpentis
15	*Qalb al-ᶜAqrab*	α Scorpii
16	*Ḥawwā*	α Ophiuchi
17	*Wāqiᶜ*	α Lyrae
18	*Ṭā'ir*	α Aquilae
19	*Ridf*	α Cygni
20	*Fam*	ε Pegasi
21	*Sāq Sākib al-Mā'*	δ Aquarii

[211] Pingree 2009, p. 60, identifies this star as ι Ceti, but as it is situated in the sign of Aries, it should be β Ceti (*Dhanab Qayṭus Janūbī*) and not ι Ceti (*Dhanab Qaytus Shamālī*).

	Star name	Identification
22	*Mankib*	β Pegasi
23	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

The astrolabe is equipped with 8 plates. According to Pingree, only three of (numbered 1, 2, 3 below) these are original and the rest are replacements. Pingree does not adduce any reason why he considers the plates 4-8 replacements. No substantial stylistic difference can be seen between the two sets. Moreover, the plate of ecliptic coordinates and plates carrying double projections for 90° and 0° occur also in ʿĪsā's undated astrolabe (A009). All the plates have notches at the north point to fit into the corresponding tab in the body.

Table A006-2 Plates

	φ	Longest day
1a	28°	13 hours
1b	29°	13 hours
2a	31°	14 hours
2b	33°	14 hours
3a	34°	14 hours
3b	35°	14 hours
4a	27°	13;27 hours
4b	32°	14;18 hours
5a	36°	14;30 hours
5b	Plate of ecliptic coordinates	
6a	40°	14;54 hours
6b	45°	15;30 hours

	φ	Longest day
7a	Plate of horizons 1	
7b	Plate of horizons 2	
8a	Double projection for 0° and 90°	
8b	Double projection for 18° and 72°	

On plates 1-3, altitude circles are drawn for every 3°, but there are no azimuth arcs. These plates carry lines for seasonal hours and for equal hours drawn from the western horizon and numbered from 1 to 12. On plate 3, the lines for equal hours are dotted. On these plates the duration of the longst day is giving in hours only, omitting the minutes.

Plates 4ab, 5a, 6ab have altitude circles for every 6°. Plates 4ab and 5b have azimuths arcs drawn above and below the horizon for every 10°; on plate 6, these are drawn only below the horizon. Plates 4 and 6 carry lines for seasonal hours and dotted lines for equal hours drawn from the western and eastern horizons up to the meridian and numbered from 1 to 12. On plate 5a, plain lines are drawn for equal hours and dotted lines for equal hours from the western horizon.

Plate of ecliptic coordinates

On plate 5b is engraved the plate of ecliptic coordinates. The label *mīzān al-ʿankabūt* is engraved at the bottom, once each on either side of the meridian line. The ecliptic circle is divided into 12 signs and labelled with their names. Altitude circles are drawn for every 6°. Inside the ecliptic circle, there are numbered, along the meridian, from 6 up to 90, starting at the top and reaching up to the centre of the plate; between circles of the ecliptic and of the equator as 6, 12, 18 and between the circles of the equator and Capricorn as 6, 12, 18, 24. Azimuth circles are also drawn for 6° and numbered from 6 to 30, separately in each zodiac sign.

Two plates of horizons

On both sides of plate 7, half horizons are engraved for each degree of latitude from 3° to 66°. These are arranged in four sets on each side; on one side are horizons

for latitudes bearing odd number of degrees and on the other face for latitudes with even degrees. The horizons are numbered at both ends; there are declination scales along the four radii. In each set the horizons are arranged at intervals of 8° of latitude as shown below.

Table A006-3

Plate 7a							
4	12	20	28	36	44	52	60
6	14	22	30	38	46	54	62
8	16	24	32	40	48	56	64
10	18	26	34	42	50	58	66

Table A006-4

Plate 7b							
3	11	19	27	35	43	51	59
5	13	21	29	37	45	53	61
7	15	23	31	39	47	55	63
9	17	25	33	41	49	57	65

Plate for the Latitudes 0° and 90°

Plate 8a carries projections for the two latitudes of 0° and 90°.[212] This is the first time such projections were attempted to serve didactic purposes. The upper half shows projections for the latitude 0° and the lower half for 90°. On this plate are drawn the

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[212] Pingree 2009, p. 59, says: 'The last tympan bears on one side a projection for a latitude of 90°;' but it is a combined projection for 90° and 0°.

vertical and horizontal diameters and the concentric circles of the two tropics and the equator. The equator is represented by a dotted circle.

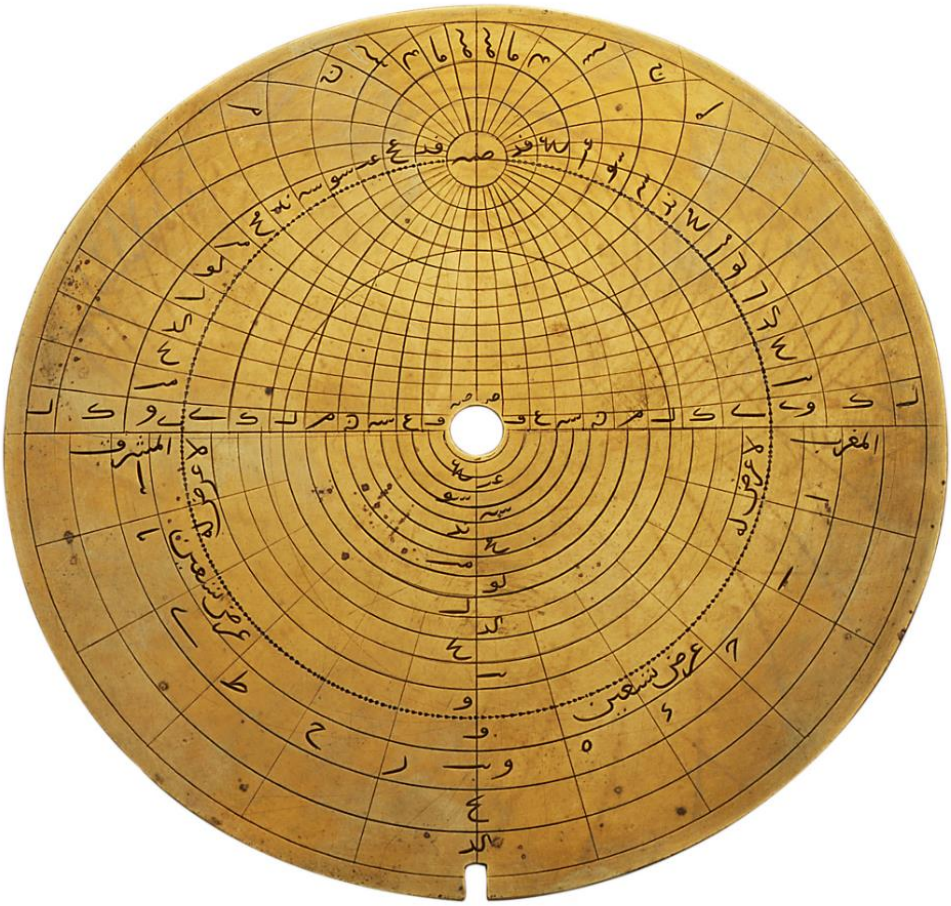


Figure A006.2 – Plate for latitudes 0° and 90° (accession no. A-79)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

The upper half carries projections for latitude of 0°, i.e. the equator. Here the zenith lies on the equatorial circle and the horizon becomes a line of diameter. Altitude circles are marked above the horizon for every 6° and numbered along the equatorial circle on both sides of the meridian. Azimuth circles, radiating from the zenith, are drawn for every 10° and numbered above the line of horizon from 10 to 90 inside the circle of equator and once again outside the circle of equator, starting above the line of horizon and continuing up to the top of the plate.

In the lower half are the projections for the latitude of 90°, i.e., the North Pole. Here the altitude circles, drawn for every 6°, merge with the declination circles and the

azimuth circles, drawn for every 10°, merge with the hour lines. Because, 'at the pole the altitude of an object is equal to its declination and its hour angle is the hour line'. [213]

Here the altitude circles are numbered along the meridian; once inside the equatorial circle from 0 to 90, starting from the equatorial circle up to the centre of the plate; and again outside the equatorial circle from 6 to 24 reaching up to the circle of Capricorn. The azimuth circles / hour lines are numbered from 1 to 12, from the western horizon to the eastern, along one of the altitude circles.

Under the western horizon is written *al-maghrib* and under the eastern horizon *al-mashriq.* Immediately below the dotted circle of equator is written *ʿarḍ tisʿīn* (latitude 90) on both sides of the meridian. Just inside the dotted circle of equator and below the line of horizon is written *lā ʿarḍ lahu* (no latitude) again on both the sides of the meridian.

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213 Morrison 2007, p. 65.

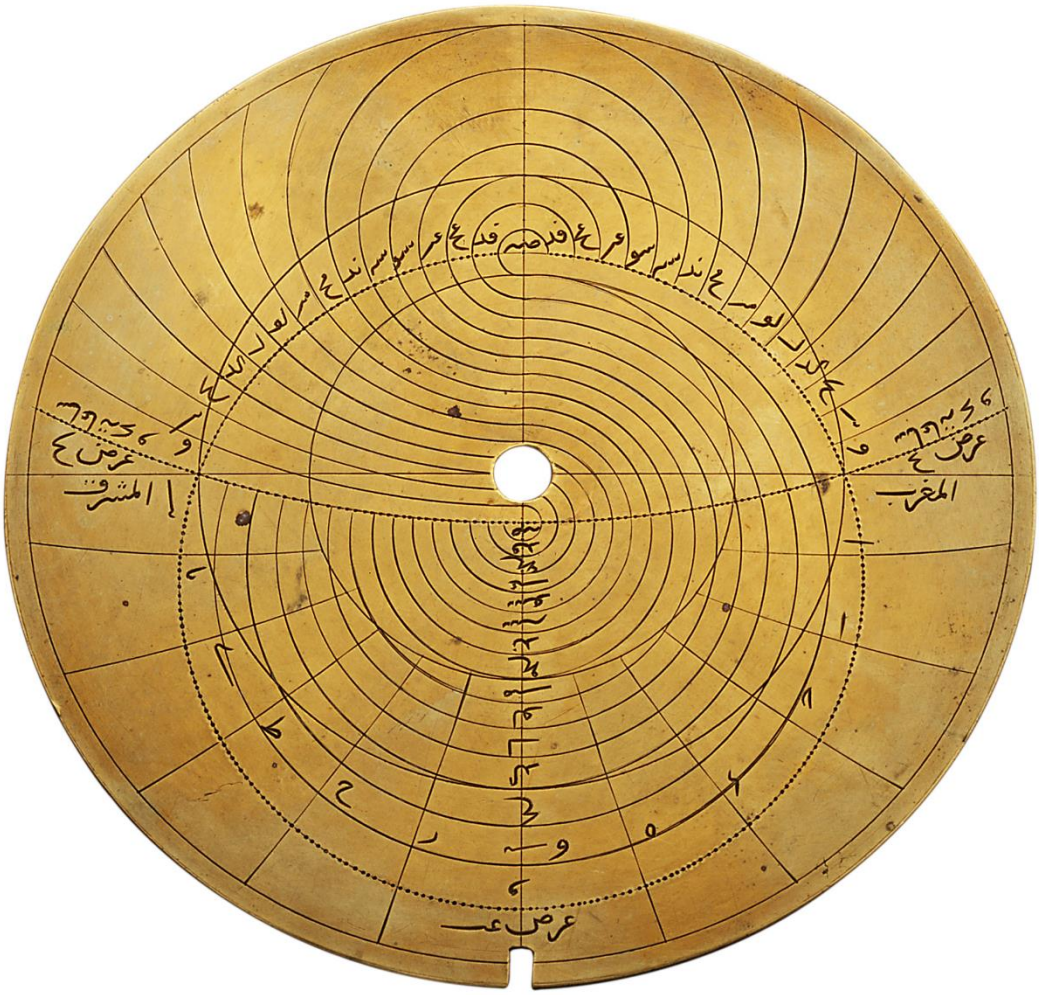


Figure A006.3 – Plate for Latitudes 18° and 72° (accession no. A-79)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Plate for the Latitudes 72° and 18°

Plate 8b has a combined projection for the latitudes 18° and 72°, resulting in S-shaped curves.[214] This is again the first attempt at the combined projection. On this plate are drawn the vertical and horizontal diameters, concentric circles of the tropics and the equator; furthermore, a dotted curve of the oblique horizon at latitude 18° and a dotted circle of the prime vertical. In the upper half, the altitude circles are drawn for every 6° and numbered along the dotted circle of the prime vertical on both sides of the meridian

214 Pingree 2009, p. 59, remarks that 'this is similar to a projection on tympan belonging to an astrolabe in the Benaki Museum in Athens (Inv.No. 13178)', but such projections occur in several Lahore astrolabes and also in Rāghavajit's Sanskrit astrolabe of 1669 (C008).

line. In the lower half also the altitude circles are drawn for every 6° and numbered from the prime vertical to the centre of the plate from 6 to 90 along the line of the meridian.

Just below the prime vertical at the north point is the label *ᶜarḍ 72* (latitude 72). Under the straight horizon in the east is the label *al-mashriq* and in the west *al-maghrib*. Between the straight horizon and the oblique horizon is written *ᶜarḍ 18* (latitude 18) both in the east and west. And just above the oblique horizon is the label *sāᶜāt 13;6* (13;6 hours) both in the east and in the west. This is the duration of the longest day at latitude 18°.

Geographical Gazetteer

On the inner surface of the mater, a geographical gazetteer is engraved in two concentric circles, providing the names (*asmā' al-buldān*), longitudes (*al-ṭūl*) and latitudes (*al-ᶜarḍ*) of 70 places. But very few towns from the Indian subcontinent are included here; Multan (67), Lahore (69) and Kashmir (70) are mentioned, but not Agra or Delhi. In each circle, the data is arranged from the right to the left proceeding counter-clockwise. As in the previous astrolabe, here also the symbol for zero is much smaller than the other letters.



Figure A006.4 – Geographical Gazetteer (accession no. A-79)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Table A006-5 Geographical Gazetteer

Place Name	L	φ	Identification
Outer Circle			

	Place Name	L	φ	Identification
01	Makka Mubārak	77;10	21;40	Mecca
02	Madīnat Rasūl	75;29	25;00	Medina
03	Tā'if	77;30	21;20	Tā'if
04	Tihāma	82;30	23;0	Yamāma
05	Hajar Baḥrayn	83;0	25;15	Manāmah
06	Dimashq	70;0	33;15	Damascus
07	Baʿalbak	70;15	33;15	Baʿalbaek
08	Ḥimṣ	70;15	34;0	Homs
09	Ḥalab	72;10	35;50	Aleppo
10	Ṭarsūs	68;40	36;42	Tarsus
11	Rūmiyya Kubrā	45;27	41;50	Roma
12	Madīnat al-Ḥukumā'	65;40	37;20	Athens
13	Qusṭanṭiyya	59;50	45;00	Istanbul
14	Mawṣil	77;0	34;30	Mosul
15	Nakhjawān	81;15	38;0	Nakhichevan
16	Marāgha	82;0	37;20	Marāgheh
17	Tabrīz	82;0	38;0	Tabriz
18	Ardabīl	82;30	38;0	Ardabil
19	Mūqān	83;0	38;0	
20	Bāb al-Abwāb	85;0	43;0	Darbent
21	Bulghār	90;0	59;30	(Bulgars)
22	Kūfa	79;30	31;30	Kufah
23	Madā'in	72;0	33;10	Ctesiphon

	Place Name	L	φ	Identification
24	Baghdād	80;30	33;25	Baghdad
25	Wasiṭ	81;30	30;20	Wasit
26	Baṣra	84;0	30;0	Basra
27	ʿAbbādān	84;30	30;0	Abadan
28	Kāzīrūn	86;0	39;15	Kazerun
29	Shīrāz	88;0	29;36	Shiraz
30	Iṣṭakhr	88;30	30;0	Takhṭ-e Jamshīd
31	Yazd	89;0	32;30	Yazd
32	Shahrūr	82;20	32;30	Shahrazur
33	Nihāwand Mā al-Baṣra	83;15	34;30	Nahavand
34	Zankān	83;40	36;30	Zanjan
35	Hamadān	83;0	35;10	Hamadan
36	Sāwa	85;0	35;0	Sāveh
37	Karaj	84;45	30;0	Karaj
38	Qazwīn	85;0	36;55	Qazwin
39	Iṣfahān	86;40	32;25	Esfahan
40	Kāshān	86;0	34;0	Kashan
41	Qumm	86;40	34;45	Qom
42	Rayy	86;20	35;0	Shahr Rey
43	Ṭāliqān	85;41	36;10	Taliq-an
44	Hawsam az-Jīlān	85;10	37;0	
45	Astarābād	89;30	36;50	Gorgān
46	Jurjān	90;0	37;50	Jurjān

	Place Name	L	φ	Identification
47	Simnān	88;0	36;0	Semnan
	Inner Circle			
48	Basṭām	81;30	36;10	Bastam
49	Sabzwar	91;30	36;5	Sabzevar
50	Nīshābūr	92;30	36;21	Neyshabur
51	Ṭūs	94;30	37;0	Tus
52	Qāyin	93;13	33;40	Qāyen
53	Zūzan	93;30	35;20	Zuzan
54	Harāt	94;13	34;30	Heart
55	Sarakhs	94;30	36;0	Sarakhs
56	Marw	97;0	37	Mary
57	Balkh	101;0	36;41	Wazirabad
58	Badakhshān	104;24	37;10	Faizabad
59	Bukhārā	97;30	39;50	Bukhara
60	Samarqand	99;16	39;37	Samarqand
61	Kābul	104;40	34;30	Kabul
62	Kāshghar	106;30	44;0	Kashgar
63	Khutan	107;0	42;0	Khotan
64	Hurmūz	92;0	25;0	Hormoz
65	Khabīṣ	93;0	31;0	Shadab
66	Daybul Hiyya Tāttah	102;7	25;10	Tatta
67	Multān	107;35	29;40	Multan
68	Qandahār	106;40	33;0	Kandahar
69	Lahāwar	109;20	31;50	Lahore

	Place Name	L	φ	Identification
70	Kashmīr	108;0	35;0	Srinagar

BACK

The rim of the two upper quadrants carries the altitude scales, divided in 1° and 5° and numbered 5—90; 90—5.

The upper left quadrant bears a trigonometric quadrant with 60 horizontal equidistant parallels, each fifth dotted, showing cosines for each of the 60 parts of the Radius.

In the upper right quadrant, there are declination arcs which divide the quadrant into 6 zones, one for each pair of opposite signs of zodiac, which are numbered along the radii. On this quadrant are plotted 6 curves for unequal hours which are numbered serially and the sigmoid graph for the meridian altitude of the sun for the latitude of 31;50° (i.e. for Lahore) with the label *khaṭṭ niṣf al-nahār ʿarḍ 31;50* (line of midday; latitude 31;50).



Figure A006.5 – Back View of the Astrolabe (accession no. A-79)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

In the lower half are shadow squares, on the left for 7 feet and on the right for 12 digits. The scales are divided and the divisions numbered accordingly.

In the inner corner on the left is engraved *sullam aqdām* (scale in feet). The vertical scale on the left is labelled as *aqdām maʿkūs* (reverse [shadow] in feet) and the horizontal scale *aqdām mustawī* (direct [shadows] in feet).

In the inner corner on the right is engraved *sullam aṣābīʿ* (scale in digits). The vertical scale on the right is labelled as *aṣābīʿ maʿkūs* (reverse [shadow] in digits) and the horizontal scale *aṣābīʿ mustawī* (direct [shadows] in digits]).

The rim of the lower half carries the corresponding scales of cotangents; on the left for 7 feet with the label *ẓill aqdām* (shadows in feet) and the end and on the right for 12 digits with the label *ẓill aṣābīʿ* (shallows in digits).

Below the shadow squares and adjacent to the circular cotangent scale are two semicircles bearing the names of the zodiac signs and the corresponding lunar mansions.

Alidade

The alidade is not graduated. One half of the wedge is curved terminating in a large circle; the other half is straight with the end tapering to a point.

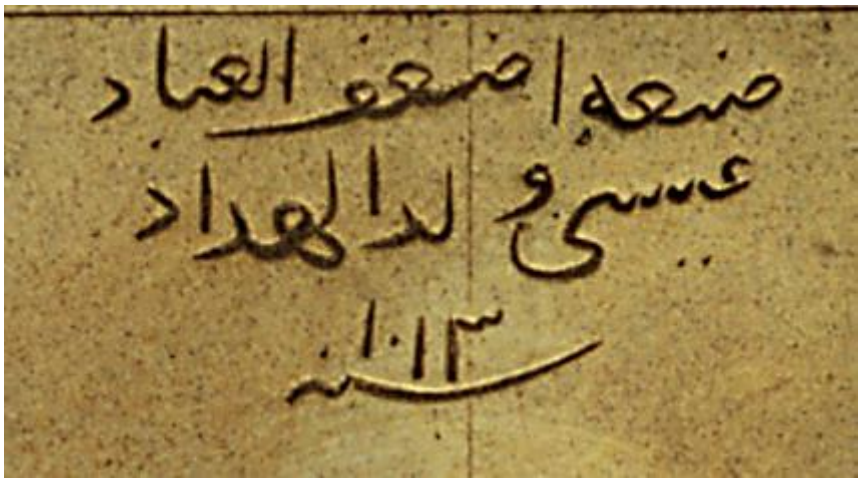


Figure A006.6 – Signature of the astrolabe maker (detail of Figure A006.5)

Inscription

Inside the shadow squares, at the centre, is engraved upside down the following inscription in three lines:

ṣanaʿahu aḍʿaf al-ʿibād

ʿīsā wald allāhdād

sanah 1013.

‘Made [by] the weakest of the servants [of God], ʿĪsā the son of Allāhdād, in the year 1013.’ The year corresponds to AD 1604-5.

Bibliography

Pingree 2009, no. 14, pp. 58-63.

A007⊙ ASTROLABE, UNDATED, BY ʿĪSĀ[215]

Not dated, ca. 1600, Lahore

Diameter 262 mm

UK, Ely, Cambs, PC

CCA 68 = CCA 3825[216]; Répertoire 3



Figure A007.1 – Front of the astrolabe (photo courtesy the owner)

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215 Entry based mainly on the photos kindly provided by the owner.

216 By mistake, CCA lists it twice, both are identical.

COMPONENTS

Body with crown (d. 262, h. 337, t. 14), shackle and ring, rete, 5 plates, alidade, washer, pin and wedge.

FRONT

The ring, shackle and the *kursī* are almost like those in the previous two astrolabes. The *kursī,* lobed with a trifoliate finial, has a plain unadorned surface.

The degree scale on the limb is graduated for 0;30°, 1°, 5° and numbered clockwise in 5s from 5 to 360.

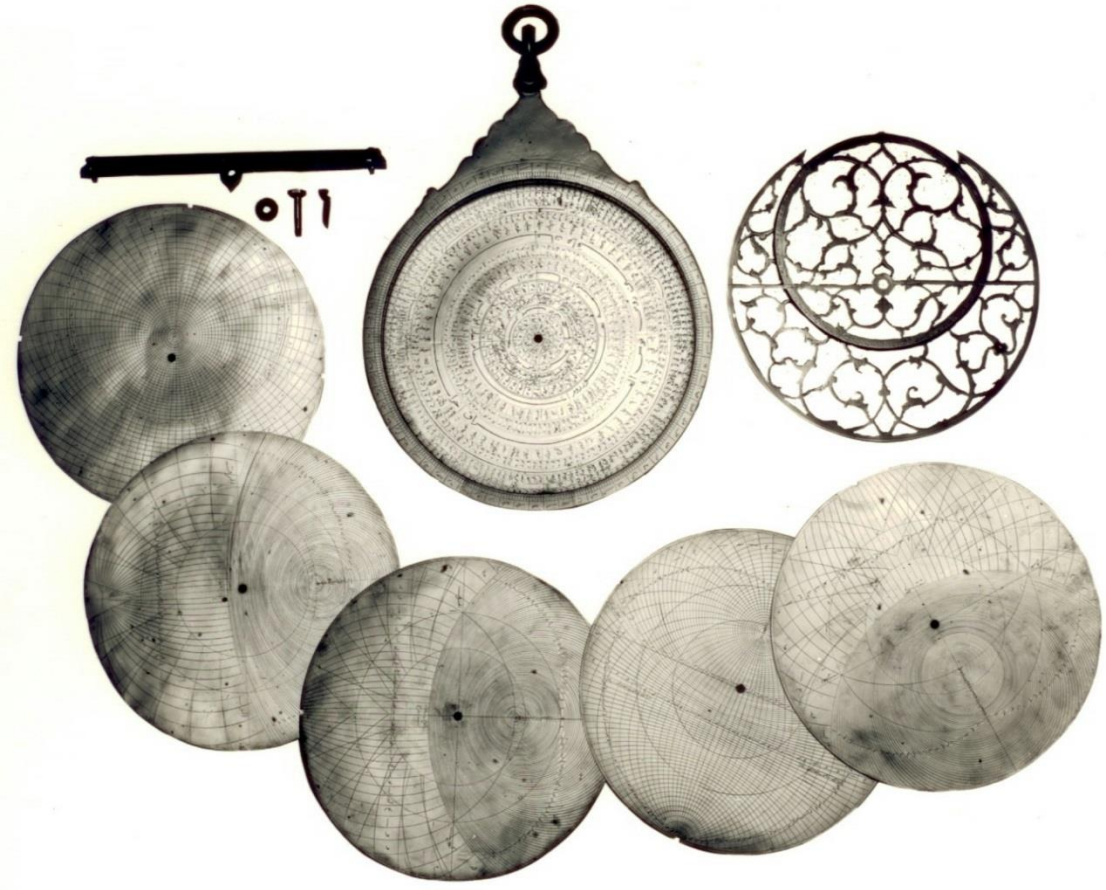


Figure A007.2 – All components of the cstrolabe (photo courtesy the owner)

RETE

The two narrow rings of the Tropic of Capricorn and the ecliptic are held together by a narrow equinoctial bar which has a counter-change at the centre. The space between the two rings and that inside the ecliptic ring is filled by an almost symmetrical floriate tracery. The ecliptic ring is divided into the 12 signs of the zodiac and labelled; each sign is divided in units of 6° each and numbered as 6, 12, 18, 24, 30 in counter-clockwise

direction. There is a handle to rotate the rete. There are some 59 star pointers. Their names cannot be completely deciphered from the available photos.

Plates

There are 5 plates serving the latitudes 18° and 29°; 27° and 32°; 37° and 40°; 0° and 24°+30°; Plate of ecliptic coordinates and plate of horizons. The plates have notches at the north point to fit into the corresponding tab in the body. Altitude circles are drawn for every degree and numbered. Azimuths are drawn below the horizon for every 10°. Lines are drawn for seasonal hours and equal hours since the sunset and before the sunrise.

Geographical Gazetteer

On the inner surface of the mater is engraved a geographical gazetteer in four concentric circles. The table contains the names, latitudes and longitudes of some 176 localities, arranged according to regions. The names of the regions are engraved with long circular flourishes in the spaces between the circles. The gazetteer could not be deciphered from the available photo.

Back

The rim of the two upper quadrants is divided in 0;30°, 1° and 5° and labelled as 5—90; 90—5.

In the upper left quadrant is a trigonometric quadrant with 60 horizontal parallels. The upper right quadrant is divided by the declination arcs into 6 zones, one each for an opposite pair of zodiac signs which are indicated by serial numbers along the two radii. On this quadrant are drawn six curves for the unequal hours. There is no sigmoid graph of the midday altitude of the sun as in his two other astrolabes.

In the lower half are two small shadow squares, on the left for 7 feet and on the right for 12 digits. The scales are divided and numbered accordingly. The scales carry appropriate labels.

The rim on the lower half bears the cotangent scales. Inside these scales, the names of the zodiac signs and the names of the corresponding lunar mansions are engraved in two semi-circular rows as in the previous two astrolabes.

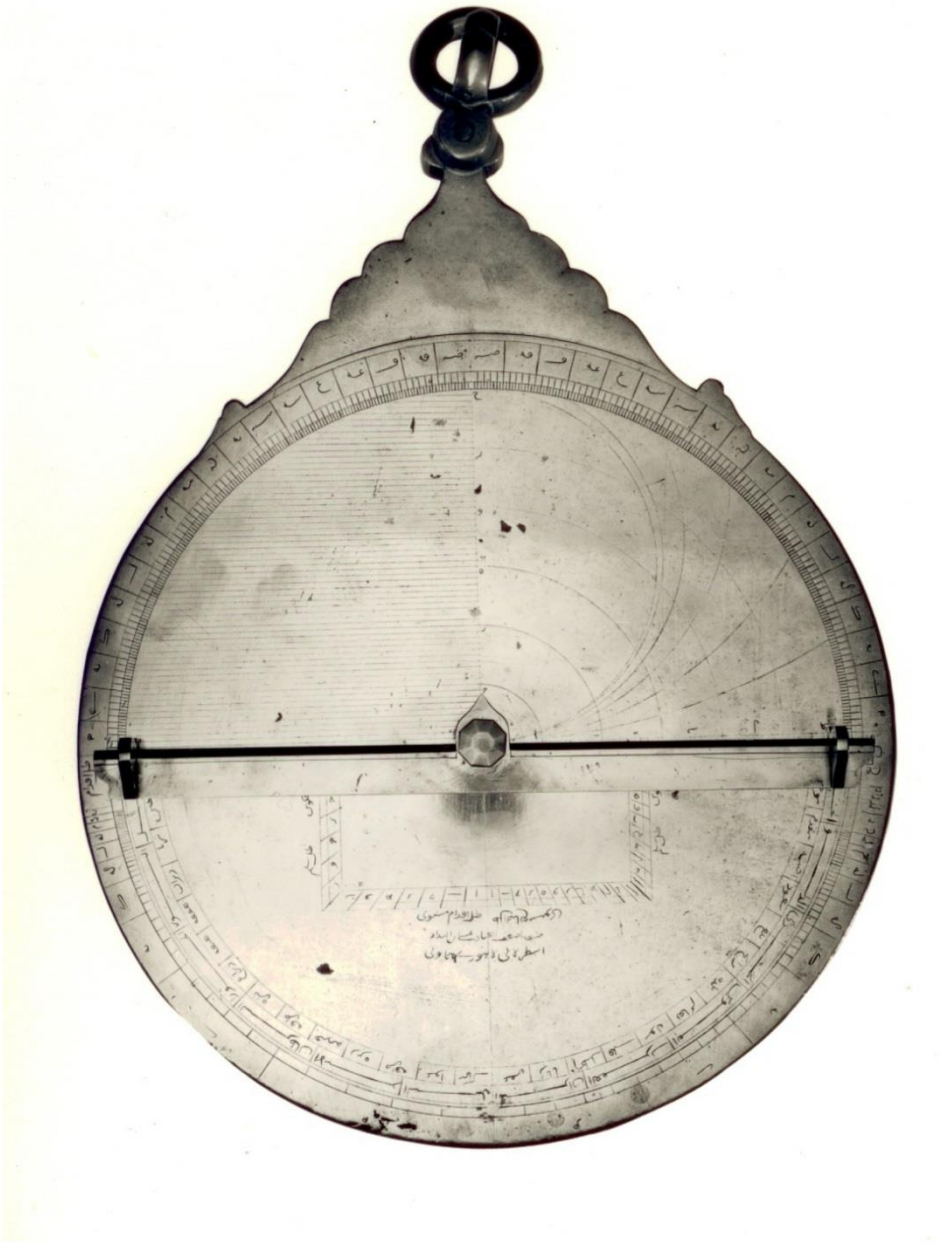


Figure A007.3 – Back of the astrolabe (photo courtesy the Owner)

ALIDADE

The alidade is a straight bar alidade with two sights but no graduations on it. There is a pin with an octagonal head, a washer and a wedge with horse's head

INSCRIPTION

Below the shadow squares is the signature of the astrolabe maker in two lines:

ṣanaʿahu aḍaʿaf al-ʿibād ʿīsā ibn allāhdād

asṭurlābī lāhūrī humāyūnī

'Made by the weakest of the servants [of God], ʿĪsā, the son of Allāhdād of Lahore, the astrolabe maker [to the Emperor] Humāyūn.'

PROVENANCE

Sotheby's London, 2 May 1977, Lot 257.

BIBLIOGRAPHY

Gunther 1932, no. 68

Wynter & Turner 1975, pp. 16-18, figs. 9, 10 and 11.

A008 ASTROLABE ATTRIBUTABLE TO ʿĪSĀ

Not dated, 17th century

Diameter 119 mm

PLU



Figure A008.1 – Front of the astrolabe (photo courtesy Museum of the History of Science, Oxford)

In the archives of the Museum of the History of Science at Oxford, there are two photos of the front and back of the astrolabe, and photocopies of all the components, plus a typed note signed by Francis Maddison on 10.xii.85.[217]

It has a very close resemblance to the astrolabe of 1604 by ᶜĪsā (A006). The size is the same. The *kursī,* the degree scale on the front and the entire configuration on the back is also the same. The unusual design of the rete is the same. In both the astrolabes, the gazetteer covers the same set of 70 localities in the same order and with the same coordinates.

There are also certain differences. In A006, the ecliptic ring in the rete is divided into 6° but not numbered; here it is divided in 2° and 6° and numbered in 6s from 6 to 30, separately in each sign. In this astrolabe, the labels in the degree scales on the front and at the back and the place names in the gazetteer are enclosed in arches. A006 contains 8 plates, but this one only 6 plates. It is not known whether there was space for 8 plates in the present astrolabe and two are missing. Finally, although the contents of the gazetteers are the same, the gazetteer in the present astrolabe displays a totally different calligraphy. It is difficult to decide whether it was made by ᶜĪsā himself at the beginning of the seventeenth century or whether it is an exact copy fabricated at a later period. I am inclined to the first possibility. At the beginning of the seventeenth century, the style of the Lahore astrolabes has not yet been standardized. Just as the patriarch Allāhdād was experimenting with two styles of rete, his son ᶜĪsā too must be trying different styles of retes.

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217 At the top of the note is written by hand ‘Sotheby’. Obviously the astrolabe was sent by Sotheby’s to Maddison for his evaluation which reads as follows:‘Indo-Persian Astrolabe; not signed, dated, on the back of the suspension bracket, ‘The hijrî year 1135 [= A. D. 1722/3]’; brass, diam. 119 mm, thickness 10 mm.‘Rete for 18 named stars and 6 unnamed star-pointers. 5 plates [sic! the photocopies show 6 plates]: for latitudes 18°, 29°; 31°, 33°; 36°, plate of ecliptic coordinates; 2 plates of horizons; a composite plate of special projections. In the mater there is a gazetteer of the longitudes and latitudes of 69 places (plus one place-name without coordinates). On the back is a sine quadrant; a graph of the meridian altitude of the sun for latitude 31° (?Lahore); a shadow-square; an astrological table; and scales of cotangents. The horse, pin, and washer appear to be original.
‘An attractive and well-made astrolabe continuing the tradition of plain but complete astrolabes of the well-known seventeenth-century makers of Lahore. Somewhat massive for its size, there is a pleasing arch decoration around the gazetteer and degree scales.’
FRM/10:xii:’85.
The astrolabe came up for auction at Sotheby’s on 25 March 1986; see catalogue of this date, lot 101. The description reproduces Maddison’s second paragraph verbatim.

The unusual style of rete seen in A006 and in the present astrolabe was one experiment which was not continued later on. The same is the case with the decorative arches in the degree scales and in the gazetteer. This too was not continued in subsequent astrolabes. The geographical gazetteer in the present astrolabe must have been engraved by an assistant in ᶜĪsā's workshop, hence the difference in calligraphy.

COMPONENTS

Body with *kursī* (d. 119, t. 10), shackle, ring, rete, alidade, pin and horse.

FRONT

The *kursī* is solid with lobed profiles. On back of the *kursī* is a carelessly scratched inscription *asṭurlāb 1135 hijrī* ((= AD 1722-23). This must have been added by one of the owners.

The limb is divided in 1° and 5° and numbered from 5 to 360. These numbers are enclosed inside arches.

RETE

As mentioned above, the rete is exactly like the rete in the astrolabe by ᶜĪsā of 1604 (A006) and contains the same 23 named star-pointers.

Table A008-1 Stars on the Rete

	Star name	Identification
01	*Dhanab Qayṭus*	β Ceti
02	*Fam Qayṭus*	γ Ceti
03	*ᶜAyn al-Thawr*	α Tauri
04	*ᶜAyyūq*	α Aurigae
05	*Rijl al-Jawjā'*	β Orionis
06	*Yad al-Jawzā'*	α Orionis
07	*Yamānī*	α Canis Majoris
08	*Shāmī*	α Canis Minoris
09	*Fard al-Shujāᶜ*	α Hydrae

	Star name	Identification
10	*Qalb al-Asad*	α Leonis
11	*Simāk Aᶜzal*	α Virginis
12	*Rāmiḥ*	α Bootis
13	*Nayyir al-fakkah*	α Coronae Borealis
14	*Ḥayyah*	α Serpentis
15	*Qalb al-ᶜAqrab*	α Scorpii
16	*Ḥawwā*	α Ophiuchi
17	*Wāqiᶜ*	α Lyrae
18	*Ṭā'ir*	α Aquilae
19	*Ridf*	α Cygni
20	*Fam*	ε Pegasi
21	*Sāq Sākib al-Mā'*	δ Aquarii
22	*Mankib*	β Pegasi
23	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are six plates.

Table A008-2 Plates

	φ	Longest Day
1a	18°	13 hours
1b	29°	13 hours
2a	31°	14 hours
2b	33°	14 hours
3a	36?	? hours

	φ	Longest Day
3b	40°	14 hours
4a	34?	14 hours
4b	Plate of ecliptic coordinates	
5a	Double projection for 0° + 90°	
5b	Triple projection for 0°+ 90°+ 72°	
6a	Plate of horizons 1	
6b	Plate of horizons 2	

GEOGRAPHICAL GAZETTEER

The geographical gazetteer engraved on the inner side of the mater provides the names, longitudes and latitudes of 70 localities. Here also the place names are enclosed in arches as on the limb. The gazetteer is nearly identical to the gazetteer in A006, except minor differences in nos. 30 and 33.

Table A008-3 Geographical Gazetteer

	Place Name	L	φ
	Outer Circle		
01	Makka Mubārak	77;10	21;40
02	Madīnat Rasūl	75;29	25;00
03	Tā'if	77;30	21;20
04	Yamāma	82;30	23;0
05	Hajar Baḥrayn	83;0	25;15
06	Dimashq	70;0	33;15
07	Baʿalbak	70;15	33;15

	Place Name	L	φ
08	Ḥimṣ	70;15	34;0
09	Ḥalab	72;10	35;50
10	Ṭarsūs	68;40	36;42
11	Rūmiyya Kubrā	45;27	41;50
12	Madīnat al-Ḥukumā’	65;40	37;20
13	Qusṭanṭiyya	59;50	45;00
14	Mawṣil	77;0	34;30
15	Nakhjawān	81;15	38;0
16	Marāgha	82;0	37;20
17	Tabrīz	82;0	38;0
18	Ardabīl	82;30	38;0
19	Mūqān	83;0	38;0
20	Bāb al-Abwāb	85;0	43;0
21	Bulghār	90;0	59;30
22	Kūfa	79;30	31;30
23	Madā’in	72;0	33;10
24	Baghdād	80;30	33;25
25	Wasiṭ	81;30	30;20
26	Baṣra	84;0	30;0
27	ᶜAbbādān	84;30	30;0
28	Kāzīrūn	86;0	39;15
29	Shīrāz	88;0	29;36

	Place Name	L	φ
30	Iṣṭakhr	88;0[218]	30;0
31	Yazd	89;0	32;30
32	Shahrūr	82;20	32;30
33	Nihāwand[219]	83;15	34;30
34	Zankān	83;40	36;30
35	Hamadān	83;0	35;10
36	Sāwa	85;0	35;0
37	Karaj	84;45	30;0
38	Qazwīn	85;0	36;55
39	Iṣfahān	86;40	32;25
40	Kāshān	86;0	34;0
41	Qumm	86;40	34;45
42	Rayy	86;20	35;0
43	Ṭāliqān	85;41	36;10
44	Hawsam az-Jīlān	85;10	37;0
45	Astarābād	89;30	36;50
46	Jurjān	90;0	37;50
47	Simnān	88;0	36;0
	Inner Circle		
48	Basṭām	81;30	36;10
49	Sabzwar	91;30	36;5
50	Nīshābūr	92;30	36;21

218 A006 has the value 88;30.

219 A006 has Nihāwand Māh al-Baṣrah.

	Place Name	L	φ
51	Ṭūs	94;30	37;0
52	Qā'in	93;13	33;40
53	Zūzan	93;30	35;20
54	Harāt	94;13	34;30
55	Sarakhs	94;30	36;0
56	Marw	97;0	37
57	Balkh	101;0	36;41
58	Badakhshān	104;24	37;10
59	Bukhārā	97;30	39;50
60	Samarqand	99;16	39;37
61	Kābul	104;40	34;30
62	Kāshghar	106;30	44;0
63	Khutan	107;0	42;0
64	Hurmūz	92;0	25;0
65	Khabīṣ	93;0	31;0
66	Daybul Hiyya Tāttah	102;7	25;10
67	Multān	107;35	29;40
68	Qandahar	106;40	33;0
69	Lahāwar	109;20	31;50
70	Kashmīr	108;0	35;0

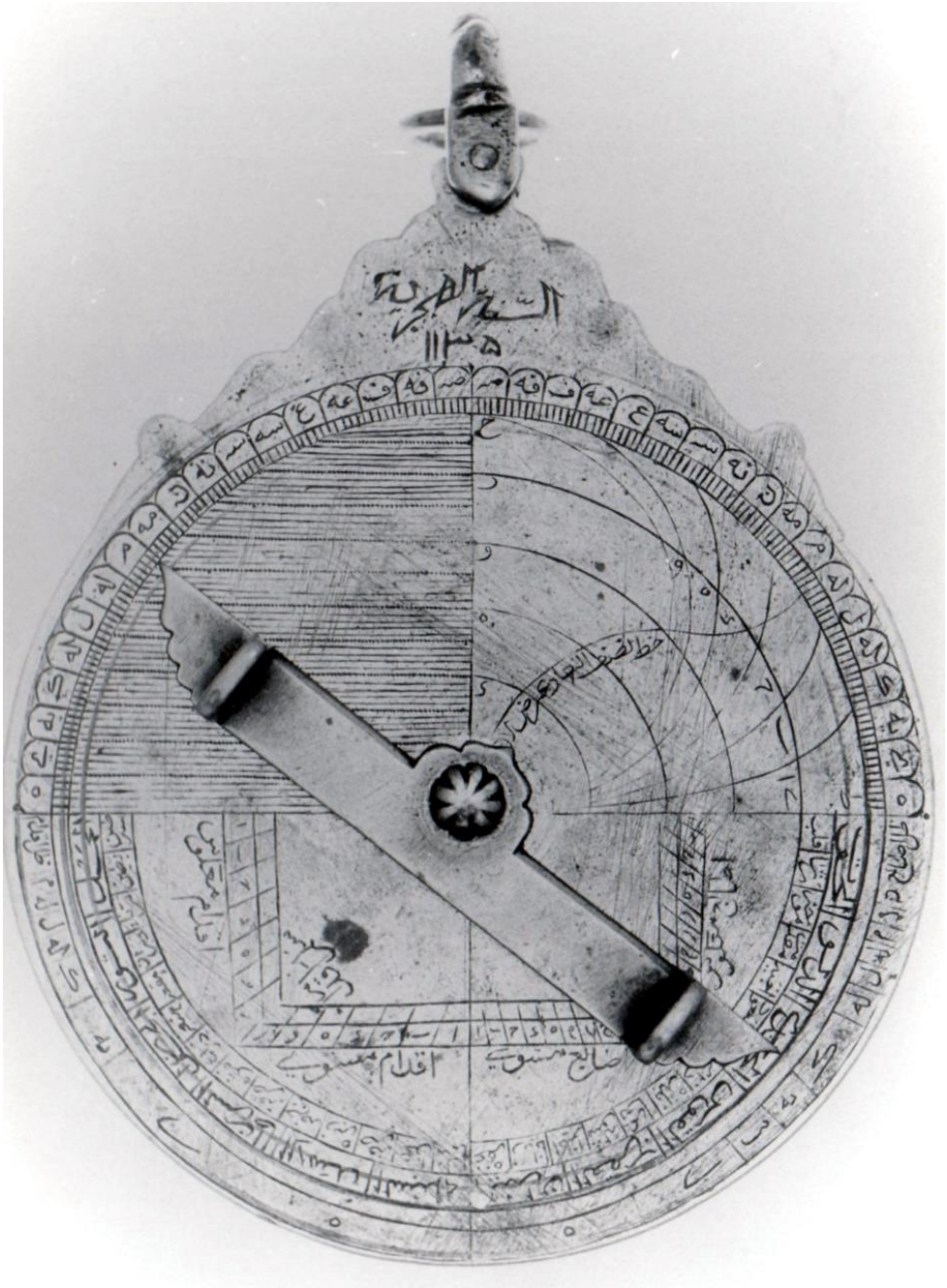


Figure A008.2 – Back of the astrolabe
(photo courtesy Museum of the History of Science, Oxford)

BACK

The rim on the upper half on the back carries altitude scales, divided in 1° and 5° and numbered 6---90; 90---6. As on the limb, here also the numbers are enclosed in arches. The trigonometric quadrant on the upper left is filled with 60 horizontal parallels which show cosines for each of the 60 parts of the Radius. Here every fifth line is dotted.

In the upper right quadrant, declination arcs divide the quadrant into 6 segments, one for each pair of opposite signs of zodiac, which are numbered along the radii. Here

6 curves are drawn for unequal hours which are numbered serially and a sigmoid graph for the meridian altitude of the sun for a latitude of 31;50° (i.e. for Lahore) with the label *khaṭṭ niṣf al-nahār ᶜarḍ l.a.n.* (line of midday; latitude 31;50).

In the lower half are shadow squares, on the left for 7 feet and on the right for 12 digits. The scales are divided and the divisions numbered accordingly. The labels are as in the previous astrolabe.

On the rim of the lower half are cotangent scales. These are followed by two semi-circular rows bearing the names of the zodiac signs and the corresponding lunar mansions.

ALIDADE

The alidade is not graduated.

BIBLOGRAPHY

Sotheby's auction catalogue, 25 March 1986, lot 101.

QĀ'IM MUḤAMMAD

Qā'im Muḥammad (*fl.* 1624-1635), the elder son of ᶜĪsā, is known through four astrolabes; three others can be attributed to him. He also produced one astrolabe jointly with his younger Muḥammad Muqīm. There is yet another astrolabe in Hannover (A009) which is said to have been produced by the sons of ᶜĪsā (*ibnī ᶜīsā ibn allāhdād*), but it is uncertain whether the inscription is authentic. Qā'im is the first member of the family to produce celestial globes as well, four of which survive today[220] Until this time, celestial globes were produced first as two hollow spheres and then joined together. Qā'im Muḥammad produced them as single hollow spheres by applying the *cire perdue* or lost wax method which had been employed in India for long time in casting bronze statues.

Qā'im's astrolabes and celestial globes carry dates between 1624 and 1637. Thus the period of his activity falls in the reigns of the Mughal emperors Jahāngīr (r. 1605-1627) and Shāh Jahān (r. 1628-1658). On some of his instruments, Qā'im mentions the time of production in the regnal years of Jahāngīr or of Shāh Jahān, in addition to or in lieu of the Hijrī years.

Qā'im enjoyed the patronage of high dignitaries of the Mughal court. In 1622, he made a celestial globe for Nawāb I'tiqād Khān, who was a brother of Nūr Jahān Begum, the queen of Jahāngīr. Five years later, in 1627 he created a fabulous astrolabe for Nawāb Khwājah Abū al-Ḥasan who held many important positions under Jahāngīr, such as the Subahdār of Deccan and the General Paymaster of the Household; only the rete of this astrolabe survives in Patna (A011).

The Lahore astrolabes became more or less standardized in the work of ᶜĪsā. Qā'im made further refinement in the design of the *kursī* and rete, and also introduced certain innovations.

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[220] These four globes are
F001 Celestial Globe by Qā'im 1032/1622-23, d. 188 UK, Blackburn
F002 Celestial Globe by Qā'im 1035/1625-26, d. ? Paris, PC
F003 Celestial Globe by Qā'im J 22/1626-27, d. 156 London, V&A
F004 Celestial Globe by Qā'im 1046/1637-38, d. 173 Patna.
Full descriptions of these globes will appear in section F.

Although four of his astrolabes are known to exist, no details are available about A010 and A012 and in A011 only the rete is extant. Therefore, his work has to evaluated on the basis of the single complete astrolabe A013. Here the rete contains as many as 58 named star pointers. On the latitude plates, in addition to the lines for seasonal and equal hours, there are also, for the first time, lines for the traditional Indian time units of *ghaṭīs* of 24 minutes. In the 7 plates, 5 plate faces carry double projections of two latitudes. The gazetteer is arranged according to the Ptolemaic climates, but commences with the second climate so that the holy cities Mecca and Medina occupy the first places. The rete carries, for the first time, *zawraqī* or ship horizons and there is a special plate to be used with these *zawraqī* horizons.

There are two innovations in this astrolabe which are unique to this astrolabe and are not found in any other astrolabe produced in India. The first is the circle for the visibility of the star *Suhayl* (Canopus) traced on many plates. Second, the back contains a series of completely circular scales including an eccentrically placed *Rūmī* or Syro-Macedonian calendar.

Except these two, the other features mentioned above occur in three unsigned astrolabes A014, A015 and A016, and for this reason these astrolabes can be attributed to Qā'im Muḥammad. In A014, lines for *ghaṭīs* are drawn on many plates; what is new here is that on many plates the maximum duration of daylight is expressed in *ghaṭīs*. Also in common with A013 is the gazetteer commencing with the second climate. A015 is much larger and displays superior workmanship; yet in technical aspects it is exactly like A014 with the same gazetteer and with the plates serving the same latitudes. The third unsigned astrolabe A016 displays splendid workmanship like Qā'im's A011. In its rete, the names of the zodiac signs are cut in silhouette along the rim of the ecliptic almost in the same manner as in A011. It also carries *zawraqī* horizons as in A013.

A009⊙ ASTROLABE BY THE TWO SONS OF ᶜĪSĀ, 1018 AH (AD 1609-10)

Diameter 84

Hannover, Kestner-Museum (#1914, 61)

CCA 69; Répertoire lists this astrolabe as Muḥammad Muqīm 1



Figure A009.1 – Front and back of the astrolabe (from Frank & Meyerhof 1925)

This small and rather crude astrolabe was the subject of a very learned and valuable monograph entitled *Ein Astrolab aus dem indischen Mughulreiche* by Josef Frank and Max Meyerhof.[221] The inscription on the *kursī* states that the astrolabe was made by the two sons of ᶜĪsā, the son of Allāhdād (*ibnī ᶜīsā ibn allāhdād*) in 1018 AH (= AD 1609-10) at Lahore. Since Qā'im Muḥammad and Muḥammad Muqīm, the two sons of ᶜĪsā, made a name for themselves as accomplished instrument makers, one is tempted to conclude that the present astrolabe must be a juvenile work by them. But such a conclusion is problematic as there are several layers of engravings on this astrolabe.

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221 Frank & Meyerhof 1925.

Components

Body with *kursī* (d. 84, h. 110, t. 8), shackle and ring, rete (d. 72) for 20 stars, 5 plates, pin; the alidade and wedge can be seen in the photos accompanying the monograph of 1925 by Frank and Meyerhof; but they were not there when I examined the astrolabe in 1996.



Figure A009.2 – All the components of the astrolabe (photo by S. R. Sarma)

Front

Small flattish ring, shackle of trifoliate shape, high solid *kursī* with three lobes on each side and a trifoliate finial. The front and back surfaces of the *kursī* are filled with inscriptions.

The degree scale on the limb is divided in 1° and 5°. The groups of 5° are numbered from 5° to 90° separately for each quadrant in clockwise direction. At the bottom, there is a lug on the meridian at the north point to hold the plates in position.

Rete

The rete is rather crude. The equatorial ring is almost completely represented here unlike in the majority of the Lahore astrolabes. The three rings of the Capricorn, equator and ecliptic are held together by the equinoctial bar which has one counter change at the centre and by the solstitial bar also with one counter change at the centre. Guide-lines

can be discerned at the back of the rete. The ecliptic ring is divided into 12 signs and labelled. Each sign is further subdivided into five units of 6° each, but not numbered. There are 20 star pointers which are listed below.[222]

Table A009-1 Stars on the Rete

	Star Name	Identification
01	*Baṭn Ḥūt*	β Andromedae
02	*Fam al-Qayṭus*	γ Ceti
03	*Rijl Jawjā' al-Yusrā*	β Orionis
04	*Shiʿrā Yamānī*	α Canis Majoris
05	*Muqaddam Zira ʿayn*	α Geminorum
06	*Rās Taw'am*	β Geminorum
07	*Fard Shujāʿ*	α Hydrae
08	*Qāʿidat al-Bāṭiya*	α Crateris
09	*Simāk-i Aʿzal*	α Virginis
10	*Simāk Rāmiḥ*	α Bootis
11	*Nayyir Fakkah*	α Coronae Borealis
12	*Qalb al-ʿAqrab*	α Scorpii
13	*Rās al-Jāthī*	α Herculis
14	*Nasr Wāqiʿ*	α Lyrae
15	*Nasr Ṭā'ir*	α Aquilae
16	*Dhanab al-Dajājah*	α Cygni
17	*Dhanab al-Jadī*	δ Capricorni
18	*Sāq*	δ Aquarii

222 Frank & Meyerhof 1925, pp. 40-41; see also the corrections suggested by Kunitzsch 1959, p. 62, n. 1.

	Star Name	Identification
19	*Dhanab Qayṭus Shamālī*	ι Ceti
20	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are five plates serving the latitudes between 18° and 39;37°.

Table A009-2

	φ	Longest Day	(Locality)
1a	21;40°	13;18 hours	(Mecca)
1b	35	14;25	
2a	39;37	—	(Bukhara?)
2b	24	13;31	
3a	27	13;44	
3b	32	14;8	
4a	18	13;6	
4b	Double projection of 0° and 90°		
5a	Plate of ecliptic coordinates		
5b	Plate of horizons		

On all latitude faces (1a to 4a) altitude circles are drawn for every 6° and labelled on both sides; azimuth arcs are traced below the horizon for every 10° and labelled. Plain lines for seasonal hours and dotted lines for equal hours counted from the western and eastern horizons. Plates 4b, 5a and 5b are as in other astrolabes.

GEOGRAPHICAL GAZETTEER[223]

For engraving the gazetteer, the inner surface of the mater was divided into 4 annuli; eight diametricac lines divide these four rings to form 64 cells. However, many of the cells remain blank and the gazetteer is engraved, in a most eccentric manner, all over the astrolabe, on both sides of the *kursī*, on its rim, on the rim of the main body, on the back and so on. We reproduce the gazetteer below, according to the description by Frank & Meyerhof, but add serial numbers to the names of the cities. Of these, 27 cities are engraved on the inner side of the mater. But here, latitudes and longitudes are engraved only for four cities. It is highly intriguing why the gazetteer is incomplete on the inner surface of the mater and why it is engraved so inelegantly all over the astrolabe. The 66 localities engraved at different places on this astrolabe with or without their geographical coordinates are listed below.

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223 Frank & Meyerhof 1925, pp. 34-40.



Figure A009.3 – Geographical gazetteer (photo by S. R. Sarma)

Table A009-3 Geographical Gazetteer

	Place Name	L	φ
(On the front of the *kursī* immediately below the makers' inscription)			
01	Lahāwar	109;20	31;50
(On the back of the *kursī*)			
02	Makka	77;0	21;40
03	Madīnah	75;20	25;0
04	Bayt al-Maqdis	66;30	31;50

	Place Name	L	φ
(On the edges of the *kursī*)			
05	Kūfa	79;30	31;30
06	Baṣra	84;0	30;0
07	Baghdād	82;0	33;25
08	ᶜAdan	76;0	11;0
09	Jaddah	76;0	21;0
10	Yaman	77;0	15;30
(On the edge of the main body)			
11	Aḥmadābād	108;40	23;15
12	Kambāyat	109;20	22;20
13	Sawmnāt	106;0	17;0 !
14	Tānīsar	112;25	30;10
15	Pānīpat	113;10	28;52
16	Ajmīr	111;5	24;00
17	Akra	117;0	26;38
18	Dihlī	113;20	28;12
19	Kawālyar	115;0	26;29
20	Kannawj	112;50	26;36
21	Karra	107(?);6	26;36
22	Banāras	117;20	26;15
23	Badā'ūn	114;19	27;37
24	Baran	114;0	28;45
25	Jawnpūr	119;6	26;36
26	Awah	118;6	27;21

	Place Name	L	φ
27	Sannām	110;0(?)	30;30
28	Sambhal	115;15	28;20
29	Hānsī	112;25	29;15
30	Kol	114;19	28;0
31	Gopāmau	116;38	26;45
32	Lāhūr	109;20	31;50
33	Mūltān	107;35	29;40
34	Dawlatābād	102;0	20;30
(On the back, along the arc of the upper right quadrant)			
35	Aḥmadnakar	107;0	19;0
36	Rājkhar	109;15	18;20
37	Burhānpur	---	---
38	Ujjayn	112;0	22;30
(On the inner side of the mater itself, in the grid with three annuli, are engraved just the names of some towns, but without their longitudes and latitudes.)			
	Outer circle		
39	Amarkūt		
40	Sulṭānkūt		
41	Ilāhābād		
42	Hanzah	6770	1215[224]

[224] Common Arabic/Persian numerals were added later, representing the inḥirāf and maximum day length, as Frank and Meyerhof assume. They reproduce these values as 6775 and 1215 in the text and as 65° 55’ and 12h 15 m in footnote 7. However, the astrolabe has 6770 and 1210, clearly distinguishing the zero from five.

	Place Name	L	φ
43	Sarangpur	6750	1440[225]
44	Sironj	6783	1450[226]
45	Narwar	6840	1520[227]
46	Kālinjar		
47	Shikarpūr ?		
48	Mungher		
49	Pandwā		
50	Sanārkāw		
51	Satkānw		
52	Khayrābād		
53	Sūrat		
54	Bījāpūr		
55	Kolkonda		
	Middle Circle		
56	Kābul		
57	Peshāwar		
58	Tabakpur		
59	Bandar		
60	Kalbarka		
61	Parenda		
62	Jawl (?)		

225 Frank & Meyerhof 1925 reproduce these wrongly as 6755 and 1140.

226 Not 1445 as Frank & Meyerhof 1925 write.

227 Frank & Meyerhof 1925 wrongly as 6845 and 1525.

	Place Name	L	φ
	Inner Circle		
63	Qandahār		
64	Harāt		
65	Mashhad		
66	Tahrān		

This gazetteer was not done by a single engraver, but by three as Frank and Meyerhof note. Nearly all the towns are from the Indian Subcontinent and that part of Afghanistan which was under Mughal rule. Remarkably enough there are very few towns from outside. These are engraved on the back and on the edges of the *kursī,* viz. Makka, Madīnah, Bayt al-Maqdis, Kūfa, Baṣra, Baghdād, ᶜAdan, Jadda and Yaman.



Figure A009.2 – Back of the astrolabe (photo by S. R. Sarma)

BACK

The rim of the two upper quadrants carries the altitude scales divided in 1° and 5° and labelled as 5—90; 90—5. The upper left contains a trigonometric quadrant with 30 horizontal parallels; each fifth is highlighted with dotted lines. The upper right quadrant is divided into 6 concentric zones to represent the six pairs of zodiac signs. Along the vertical and horizontal radii, the signs are labelled with their serial numbers. Superimposed on this grid is the graph for the midday solar altitude at the latitude 32°. This carries the label *khaṭṭ nisf al-nahār ᶜarḍ l-b,* 'line of midday, latitude 32°'.

In the lower left quadrant, two shadow squares are engraved one inside the other. That for 12 digits is outside. Under the horizontal scale is the label *zill aṣābīᶜ mustawī* (umbra recta in digits) and to the left of the vertical scale is the label *zill aṣābīᶜ maᶜkūs* (umbra versa in digits). The shadow square for 7 feet is inside. Within the square is the

label for the vertical scale *zill aqdām maᶜkūs* (umbra versa in feet). The label related to the horizontal scale is engraved in the lower right quadrant: *zill aqdām mustawī* (umbra recta in feet). The rim of the lower left quadrant carries the corresponding cotangent scales.

In the lower right quadrant are engraved the names of signs and the names of the corresponding lunar mansions in two batches.



Figure A009.3 – Inscription on the front of the *kursī* (photo by S. R. Sarma)

INSCRIPTION OF THE MAKERS[228]

On the front side of the kursī is engraved the following inscription in five lines:

sanᶜat
tamat bāydī aḍcafī al-cibād
ibnī cīsā ibn allāhdād
sanah 1018 fī balad dār al-khilāfat
lāhāwar. ṣānah allāh tac can afāt al-dahwar.

‘Made by the two hands of the weakest of the servants [of God], the two sons of cĪsā, the son of Allāhdād, in the year 1018 in the city of Lahore, the abode of the Caliph. May the Great God save them from vicissitudes of fate.’

The year 1018 AH corresponds to AD 1609-10.

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228 Frank & Meyerhof 1925, p. 34.

Conclusion

This astrolabe, though rather inelegantly produced, contains all the characteristic features of the Lahore astrolabes as they took shape in the oeuvre of ʿĪsā. Can the two sons of ʿĪsā ibn Allāhdād who produced this astrolabe be Qā'im Muḥammad and Muḥammad Muqīm? Qā'im's surviving astrolabes and celestial globes are dated between 1032/1622 and 1046/1637. Muqīm's extant astrolabes are dated between 1031/1621 and 1070/1659. If the two sons mentioned in the 1609 astrolabe are really Qā'im and Muqīm (and if the astrolabe is their early work), it is strange that there are no instruments by them from the period between 1609 and 1621. It is also possible that these two sons are not Qā'im and Muqīm but other sons who may not have produced any other instrument after this astrolabe. A third possibility is that the inscription was added later by somebody else.

Frank and Meyerhof are of the view that there are four different layers of engraving by different hands at different points of times. These layers are as follows: (1) The inscription on the front of the *kursī*. (2) The names of the 37 cities with their coordinates engraved on the edges of the astrolabe. (3) The names of the 27 cities engraved on the inner side of the mater. (4) The names of four cities with the *inḥirāf* and the maximum day length duration in common Arabic/Persian numerals engraved on the inner side of the mater. Therefore, it is not possible to determine whether the two sons of ʿĪsā who produced this astrolabe in 1609 are indeed the accomplished instrument makers Qā'im Muḥammad and Muḥammad Muqīm.

Bibliography

Frank & Meyerhof 1925.

A010 ASTROLABE BY QĀ'IM MUḤAMMAD, 1034 AH (AD 1624-25)

Diameter ?

PLU

CCA 1128; Répertoire 2

Sulaiman Nadvi, who made the very first survey in 1935 of the astrolabes and globes made by the members of the Allāhdād family, states as follows: [229]

There is one astrolabe made by Qâ'im Muḥammad in Calcutta which belongs to Qâzi Obeidu'l Bârî.* It bears the following inscription.

> *ᶜamal qā'im muḥammad ibn ᶜīsā ibn allahdād aṣṭurlābī humāyūnī 1034 h[ijrī]*
>
> 'The work of Qā'im Muḥammad, son of ᶜĪsā, son of Allahdād, the astrolabe maker of [Emperor] Humāyūni, 1034 Hijrī'.

On the other corner of this astrolabe is written the '21st year of Jahāngīr's accession.'

The *Hijrī* year 1034 lasted from 13 October 1624 to 1 Oct 1625. About the owner of the astrolabe Qâzi Obeidu'l Bârî, Nadvi adds in a footnote: 'He comes of an old family of Calcutta. I am indebted to Professor Maḥfuzu'l Haqq of the Presidency College, Calcutta, for my information concerning this astrolabe.'

Since then, there has been no trace of this astrolabe.

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[229] Nadvi 1935, p. 627.

A011⊙ ASTROLABE BY QĀ'IM MUḤAMMAD MADE FOR NAWĀB KHWĀJA ABŪ AL-ḤASAN, 1037 AH (AD 1627)

Diameter of the rete 326 mm

Patna, Khuda Bakhsh Oriental Public Library



Figure A011.1 – Full view of the rete (photo by S. R. Sarma)

Only the large rete with a unique calligraphic design survives of what must have been a yet larger and fabulous astrolabe. Among the one thousand and odd Islamic astrolabes that survive today in various museums throughout the world, there are occasional attempts to incorporate calligraphic designs into the *ʿankabūt.* But nowhere so completely and so regally as in the present specimen. It is a pity that only a part is available and not the whole astrolabe.



Figure A011.2 – Portrait of Khwājah Abū al-Ḥasan, Musée Guimet, Paris[230]

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230 The inscription below the portrait reads *shabīh khwājah abū'l ḥasan durust ikhlās-i camal hāshim* (True portait of Khwājā Abū al-Ḥasan painted sincerely by Hāshim).

The calligraphic design joining the star pointers states that the astrolabe was made in the reign of Jahāngīr for Nawāb Jumlah al-Mulkī Khwājah Abū al-Ḥasan. He held many important positions under Jahāngīr, such as the Subahdar of Deccan and the general paymaster of the household (*bakhshī-kul*).[231] *Jumlah al-Mulkī* is a title conferred on him.[232]



Figure A011.3 – Signature of the astrolabe maker on the reverse (photo by S. R. Sarma)

In the Lahore astrolabes, the maker's signature is generally on the back of the mater. Here, luckily, it is engraved on the back of the rete, on the lower part of the ecliptic ring[233] and reads

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231 He is frequently mentioned in Jahāngīr's Memoirs (see Jahangir, pp. 79, 80, 103, 172, 192, 202 appointed to Subahdar of Deccan, 219, 221, 256 made paymaster general, bakhshī-kul, 260, 282 promoted to a higher rank, 287, 318, 320).
There was another Abū al-Ḥasan who was related by marriage to both Jahāngīr and Shāh Jahān and was influential at the court of both the emperors. He was a brother of Nūr Jahān and thus brother-in-law of Emperor Jahāngīr; he was the father of Mumtāz Mahal and thus the father-in-law of the next emperor Shāh Jahān.
But in Jahāngīr's Memoirs, the former is always referred to Khwājah Abū al-Ḥasan whereas the latter under the title Āsaf Khān. In my earlier publications (Sarma 1994d, Sarma 1999c, Sarma 2011a), I wrongly identified the Abū al-Ḥasan mentioned in the present astrolabe as Nūr Jahān's brother.

232 In his mail of 28.11.2012, Professor Muzaffar Alam writes as follows:
'I could not locate the title 'Jumlah al-Mulki' for Khwaja Abu al-Hasan. I checked first with Athar Ali Sahib's "Apparatus", and also two monographs, one on nobility under Jahangir (Afzal Husain), another nobility under Shahjahan (Firdaus Anwar). Athar Sahib does not even list him under Jahangir!
'I understand that he is Khwaja Abu al-Hasan Turbati, an Iranian noble, who rose to become Mir Bakhshi under Jahangir, then appointed Diwan-i A'la after I'timad al-Daulah's death. He died in AH 1042 in Shahjahan's reign. Majalis-i Jahnagiri mentions him as 'Rukn al-Saltanat' (also 'Ma'asir al-Umara'), 'Madar al-Muhamm' and 'Diwan-i Kull'. A noble with such high positions and titles could well be called 'Jumlah al-Mulki'.'

233 He does so again in his astrolabe of 1635 (A013).

ṣanaᶜahu aqall al-ᶜibād qā'im muḥammad ibn ᶜīsā ibn allāhdād asturlābī lahūrī humāyūnī

'The work of the least of the servants [of God], Qā'im Muḥammad, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker of [Emperor] Humāyūn.'

The rete consists of the two rings of the Tropic of Capricorn and of the ecliptic, both held together by the equinoctial bar which is counter-changed at the two intersections with the ecliptic ring. The space between the two rings and that inside the ecliptic ring is filled with calligraphic design.

In keeping with the exalted status of the patron, the rete was lavishly produced. On some segments the surface is decorated by plain lines. To the left and right of the ecliptic ring, in the spaces above the equinoctial bar, there are cut-outs in the shapes of flowers, with circular depressions, which may have been originally encrusted with gems.



Figure A011.4 – Right part of the rete (photo by S. R. Sarma)

Note the flower with five petals at the periphery. Gems may have been embedded in the depressions of the petals. The second arc from the right is the ecliptic. From the middle of the arc of the eclptic runs the term *Jahāngīrī* in florid letters.

The outer ring of the Tropic of Capricorn is plain with two concentric circles engraved on it. The sloping edge of the equinoctial ring is divided in units of 2° and these are numbered on the upper surface, separately for each sign from 2 to 30. The

names of the signs are cut out in silhouette along the inner edge of the ecliptic ring. In the lower half can be seen the names *Ḥamal, Thawr, Jawjā', Saraṭān, Asad* and *Sunbulah* and in the upper half the names *Mīzān, ᶜAqrab, Qaws, Jadī, Dalw* and *Ḥūt* proceeding in anti-clockwise direction.

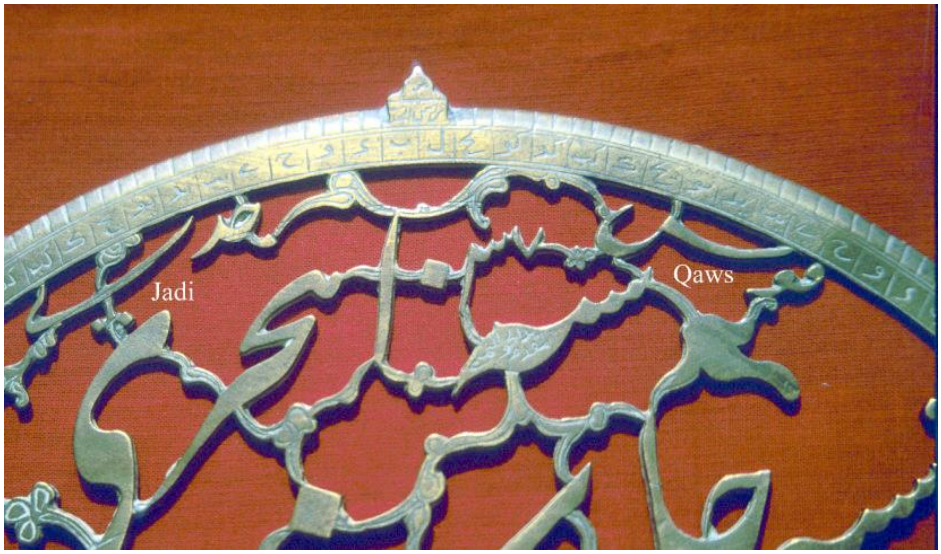


Figure A011.5 – Upper segment of the rete (photo by S. R. Sarma)

The arc above is that of the ecliptic. It is divided in 2° along the sloping edge, and numbered in 2s from 2 to 30, separately for each sign. The names of the signs are immediately below the ecliptic in cut out letters. On the right can be seen *Qaws* (Sagittarius) and on the left *Jadī* (Capricorn).

At the zero-point of Capricorn, there is a pointed projection on the ecliptic ring on which is inscribed *Rās al-jadī,* 'head of the Capricorn'. This point, generally known as *al-murī,* moves along the degree scale on the limb and indicates the position of the zodiac circle. There must have been a handle affixed to the equinoctial bar on its eastern segment between the Tropic of Capricorn and the Ecliptic. It is now lost, only a small hole remains where the handle must have been inserted.

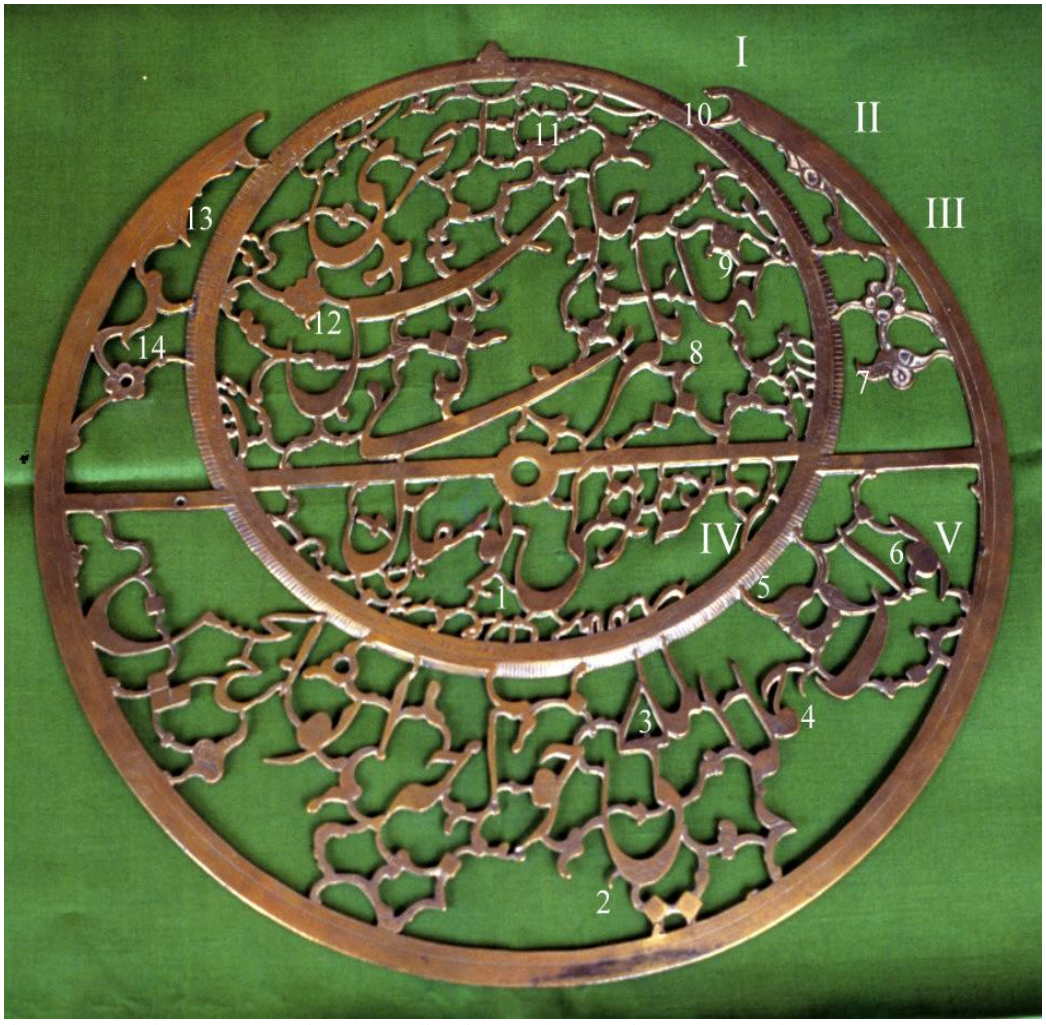


Figure A011.6 – The rete with the dedication and star pointers marked (photo by S. R. Sarma)

The calligraphic pattern joining the star pointers reads as follows in five lines:

I *sanah 1037 ḥijrī*

II *sanah julūs*

III *jahāngīrī 22*

IV *sanah turkī toshqān'īl*

V *nawāb jumlah al-mulkī khwājah abū al-ḥasan*

'The year 1037 Hijrī / the regnal year of Jahāngīr 22 / in the Turkish year of the rabbit'[234] / Nawab Jumlah al-Mulkī Khwājah Abu al-Ḥasan.'

The year AH 1037 lasted from 11 September 1627 to 29 August 1628 (Gregorian). Jahāngīr died during in the course of this year on 8 November 1627. Therefore, the

[234] Abū al-Faḍl 2, pp. 20-21: Turkish Era, the fourth year of the cycle is Tawishqān, the Hare.

astrolabe must have been completed between 11 September and 8 November 1627 shortly before Jahāngīr's death. There are 14 named star pointers in the rete which are listed below.

Table A011-1 Stars on the Rete

	Star Name	Identification
01	*Al-ᶜAyyūq*	α Aurigae
02	*Shiᶜrā Yamānī*	α Canis Majoris
03	*Shiᶜrā Shāmī*	α Canis Minoris
04	*Fard al-Shujāᶜ*	α Hydrae
05	*Qalb al-Asad*	α Leonis
06	*Qaᶜidat al-Bāṭiya*	α Crateris
07	*Simāk Aᶜzal*	α Virginis
08	*Simāk Rāmiḥ*	α Bootis
09	*Kiffa Shamālī*	β Librae
10	*Qalb al-ᶜAqrab*	α Scorpii
11	*Yad al-Ḥawwā al-Yumnā al-Muqaddam*	δ Ophiuchi
12	*Fam al-Faras*	ε Pegasi
13	*Dhanab al-jadī*	δ Capricorni
14	*Sāq Sākib al-Mā' al-Janūbī*	δ Aquarii

The rete is in good condition; in two cases, the star pointers appear to have come loose and are welded to the ecliptic ring.

BIBLIOGRAPHY

Sarma 1994d

Sarma 1999c

Sarma 2011a

A012 ASTROLABE BY QĀ'IM MUḤAMMAD, 1041 AH (AD 1631-32)

1631, Lahore

Diameter 120 mm

Baghdad, Museum of Arab Antiquities (# 9721)

CCA 3821; Répertoire 5

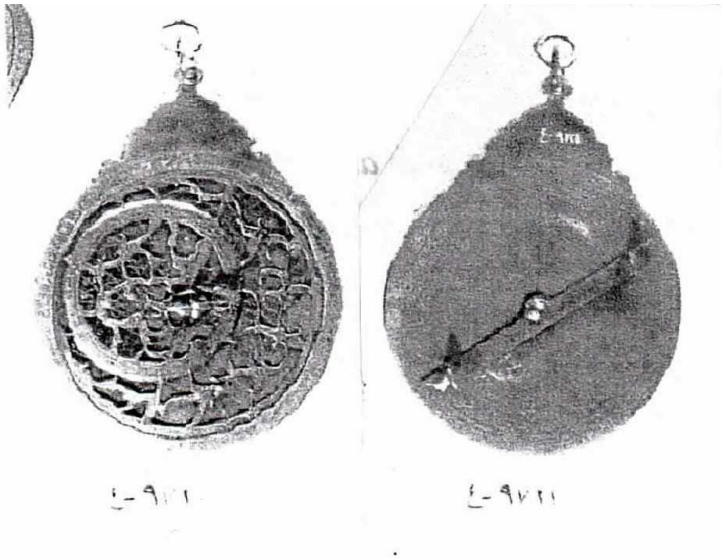


Figure A012.1 – Front and back of the astrolabe (photo from King 2005, p. 435)

The Répertoire mentions that the astrolabe carries the following inscription:

> *ṣanaᶜahu aqall al-ᶜibād qā'im muḥammad ibn ᶜīsā ibn allāhdād asṭurlābī lāhūrī humāyūnī sanah 1041 hijrī julūs shāh jahān sanah 5*
>
> 'Made by the least servant [of God], Qā'im Muḥammad, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn. The year 1041 Hijrī, the 5th regnal year of [Emperor] Shāh Jahān.'

According to Répertoire, the astrolabe has 6 plates, a geographical gazetteer engraved on the inner side of the mater, a sine graph, a solar quadrant and astrological tables on the back.

BIBILOGRAPHY

Faransīs & Naqshabandī 1957, pp. 28-32.

King 2005, pp. 434-435.

A013⊙ ASTROLABE BY QĀ'IM MUḤAMMAD, 1045 AH (AD 1635-36)[235]

Diameter 190.5 mm

Oxford, Museum of the History of Science (#42730)

CCA 71; Répertoire 6



Figure A013.1 – Front of the astrolabe (© Museum of the History of Science, Oxford)

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235 Gunther 1932, no. 71, pp. 191-197. Gunther misses the first part of the name and calls him merely as 'Mohammad ibn Isa'. In the second edition of Gunther, the front view of this astrolabe adorns the back of the dust jacket.

Like the astrolabe of 1627 (A011), this too is an ambitious astrolabe with many new features. The rete contains a very large number of star pointers and, for the first time, two *zawraqī* or ship horizons. In the 7 plates, 5 plate faces carry double projections. On the latitude plates, in addition to the lines for seasonal and equal hours, there are also, for the first time, lines for the traditional Indian time units of *ghaṭīs* of 24 minutes. On several plates can be seen a circle for the visibility of the star *Suhayl* (Canopus). No other Lahore astrolabe carries this circle. There is also plate to be used with the *zawraqī* horizons. The back also contains many unusual elements, such as a series of completely circular scales including an eccentrically placed *Rūmī* or Syro-Macedonian calendar.

COMPONENTS

Body with *kursī* (d. 190.5, h. 265, t. 14), shackle and ring, rete (d. 169) for 58 stars, 7 plates (d. 169), alidade (l. 178) and pin. The original wedge is lost.

FRONT

The body, rim and *kursī* are made in one piece. The inner surface of the mater within the rim (where is the geographical gazetteer is engraved) is not perfectly flat, but slopes down from the rim towards the centre. Consequently, some of the plates became curved by the weight of the other plates above them. At the north point, a plug to hold the plates in position is inserted from the back and hammered flush with the surface of the back.

The ring is quite small for this massive astrolabe. It has a diamond cross-section with sharp edges; the shackle has a trifoliate shape with trifoliate bases, also with a diamond cross-section and sharply defined edges. The *kursī* is very high, the profiles consisting of a series of five ascending lobes with a trifoliate finial; with finely cut fretwork, the surface is filled with decorative lines.

The degree scale on the limb is divided into 0;30°, 1° and 5°, and numbered in 5s clockwise from 5° to 360°.



Figure A013.2 – Rete of the astrolabe (photo by S. R. Sarma)

RETE

The rete is thick in the middle and tapers towards the circumference, which facilitates the rotation of the rete around the central pin.

The two rings of Capricorn and the ecliptic are held together by the equinoctial bar, with one counter change, asymmetrically at its intersection with the ecliptic ring in the west. A small ring for the pin to pass through is incorporated into the equinoctial bar. Above this small ring, there are two parallel arcs, constituting the 'ship' (*zawraq*) horizons, which will be discussed below.

The space between the two rings of Capricorn and ecliptic and that inside the ecliptic ring is filled with floral tracery; decorative lines are engraved at some places on the tracery. Because of these decorative lines, it more difficult to read the star names than would have been otherwise.

There are about 58 named star pointers, mainly shaped like tiger's claws. A partial, and somewhat faulty, list of these stars was published by Gunther;[236] Kunitzsch prepared a correct and more comprehensive list, but in the same sequence as given by Gunther.[237] In the following table, however, the stars are listed in the order of their increasing right ascension.

Table A013-1 Stars on the Rete

	Star Name	Identification
01	*Qarn al-Ḥamal*	γ or β Arietis
02	*Dhanab al-Qayṭus J[anūbī]*	β Ceti
03	*Baṭn al-Ḥūt*	β Andromedae
04	*Fam al-Qayṭus*	γ Ceti
05	*Ṣadr al-Qayṭus*	π Ceti
06	*Rās al-Ghūl*	β Persei
07	*Mirfaq al-Thurayyā*	α Persei
08	*Masāfat al-Nahr*	γ Eridani
09	*ᶜAyn al-Thawr*	α Tauri
10	*ᶜAyyūq*	α Aurigae
11	*Riǰl al-Jawzā' al-Yusrā*	β Orionis
12	*Yad al-Jawzā' Yusrā*	γ Orionis
13	*Yad al-Jawzā Yumnā*	α Orionis
14	*Riǰl al-jawzā' al-Yumnā*	κ Orionis
15	*Shiᶜrā Yamānī*	α Canis Majoris
16	*Shiᶜrā Shāmī*	α Canis Minoris

236 Gunther 1932, I, p. 192.

237 Kunitzsch 1959, pp. 62-64.

	Star Name	Identification
17	*Ṭarafat al-Safīna*	ρ Puppis
18	*Suhayl*[238]	α Carinae
19	*Mankhar Shujā*^{c}	σ Hydrae
20	*Qafzah al-Ūlā*	ν Ursae Majoris[239]
21	*Thāniya*	μ Ursae Majoris[240]
22	*Fard al-Shujā*^{c}	α Hydrae
23	*Thālith*	ι Ursae Majoris[241]
24	*Nathra Saḥābī*	ε Cancri
25	*Qalb al-Asad*	α Leonis
26	*Ẓahr al-Dubb al-Akbar*	α Ursae Majoris
27	*Qā*^{c}*idat al-Bāṭiya*	α Crateris
28	*Ẓahr al-Asad*	δ Leonis
29	*Al-Ṣarfa*	β Leonis
30	^{c}*Anāq*	ζ Ursae Majoris[242]
31	*Janāḥ al-Ghurāb*	γ Corvi
32	*Simāk A*^{c}*zal*	α Virginis
33	*Simāk Rāmiḥ*	α Bootis
34	*Kiffa Janūbī*	α Librae
35	*Kiffa Shamālī*	β Librae

238 The star *Suhayl* is no. 56 in in the list of Kunitzsch 1959, p. 64. But I cannot locate it on the rete at all!

239 Savage-Smith 1985, p. 136: *al-qafzah al-ūlā,* 'the first leap,' νξ UMa.

240 Savage-Smith 1985, p. 136: *al-qafzah al-thāniyah,* the second leap, λμ UMa.

241 Savage-Smith 1985, p. 136: *al-qafzah al-thālithah,* 'the third leap,' ικ UMa

242 Kunitzsch 1959 has γ Andromedae which is clearly a misprint.

	Star Name	Identification
36	*Nayyir al-Fakkah*	α Coronae Borealis
37	*ᶜUnuq al-Ḥayyah*	α Serpentis
38	*Qalb al-ᶜAqrab*	α Scorpii
39	*Rukbat al-Ḥawwā Yusrā*	ζ Ophiuchi
40	*Rās al-Jāthī*	α Herculis
41	*Rās al-Ḥawwā*	α Ophiuchi
42	*Yad al-Ḥawwā Yumnā*	ν Ophiuchi[243]
43	*Nasr Wāqiᶜ*	α Lyrae
44	*ᶜIṣābat al-Rāmiḥ*	ρ or υ Sagittarii
45	*Minqār al-Dajājah*	β Cygni
46	*Nasr Ṭā'ir*	α Aquilae
47	*Dhanab al-Dulfīn*	ε Delphini
48	*Dhanab al-Dajājah*	α Cygni
49	*Fam al-Faras*	ε Pegasi
50	*Janāḥ al-Faras*	γ Pegasi
51	*Dhanab al-Jadī*	δ Capricorni
52	*Mankib Sākib al-Mā'*	α Aquarii
53	*Sāq Sākib al-Mā' J[anūbī]*	δ Aquarii
54	*Dhanab al-Qayṭus S[hamālī]*	ι Ceti
55	*Mankib al-Faras*	β Pegasi
56	*Matn al-Faras*	α Pegasi

[243] Kunitzsch 1959 remarks that the instrument maker may have actually meant δ Oph which he ought to have labelled as … *yusrā.*

	Star Name	Identification
57	*Surrat al-Faras*	δ Pegasi
58	?	

Zawraqī horizons on the rete

The most notable feature of the rete are the two parallel arcs placed above the small ring at the centre. These look like the outlines of boats, their upright masts represented by the corresponding segments of the vertical meridian. Therefore, this projection is called *zawraq* (ship). The *zawraqī* astrolabe was invented by al-Bīrūnī's contemporary Abu Saʿīd Sijzī.

Astrolabes with this design may have been made and used at the time of its invention in the eleventh century and later, but no such astrolabes are extant today. All that exists now are a few Lahore astrolabes in which one or two *zawraqī* horizons are incorporated in the otherwise standard retes and which contain a special plate to be used along with the *zawraqī* horizons. The present astrolabe is the earliest specimen known to us.

Here the upper arc is fashioned like the ecliptic circle in the rete. It is divided into the first six signs of the zodiac and is labelled with their names from right to left. On the sloping edge, each sign is divided into five units. The function of this arc is not known. The lower arc carries the legends *ufq mujassam gharbī* (the horizon of the western solid) and *ufq mujassam sharqī* (the horizon of the eastern solid).[244] Obviously this arc is the proper *zawraqī* horizon, but the latitude is not mentioned. It is probably 42°. This horizon has to be used together with a special type of projection engraved on plate 7b which will be described below. In this plate, inside a miniature plate, a horizon is drawn for latitude 42°.

PLATES

There are seven plates with the following specifications:

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244 Rendered thus in Gunther 1932, p. 192.

Table A013-2 Plates

	φ	Longest day
1a	27°	13;4 hours
1b	32°	14;8 hours
2a	25°	13 hours
2b	30° + 36°	
3a	35°	15;27 hours
3b	22° + 40°	
4a	38°	14;38 hours
4b	18° + 44°	
5a	23;30°	13 hours
5b	20° + 70°	
6a	0° + 90°	
6b	Plate of horizons	
7a	Plate of ecliptic coordinates	
7b	Tablet to be used with the *zawraqī* horizons	

Six plate faces carry the projections for six different terrestrial latitudes from 23;30° to 38°. In particular, plate 1 carries projections for 27° and 32° on its two sides for the two Mughal imperial cities of Agra and Lahore. This became a standard feature in all the astrolabes by Muḥammad Muqīm and Ḍiyā' al-Dīn Muḥammad. The plate of horizons is engraved on 6a and the plate of ecliptic coordinates on 7a. Usually these are engraved on the two sides of the same plate in the Lahore astrolabes, in particular in the astrolabes made by Muḥammad Muqīm and his nephew Ḍiyā' al-Dīn Muḥammad.

On the six plate faces for the latitudes 23;30°, 25°, 27°, 32°, 35° and 38°, altitude circles are drawn for every 2° and every fifth line is highlighted by dots; azimuths arcs are drawn for every 30° above the horizon and for every 6° below the horizon. In the lower half, plain lines are drawn for seasonal hours and dotted lines for equal hours

which are counted from the western horizon. All the four types of lines are numbered in *Abjad.*

On plates 32°, 35°, 38° lines for *ghaṭīs* (of 24 minutes) are drawn from the western horizon and numbered in standard Arabic/Persian numerals from 1 to 35 or 36. This is a useful innovation because the *ghaṭī* was the traditional unit of time in India and was used for practical purposes for both Hindus and Muslims alike.[245] It would have been better if the *ghaṭī* lines were drawn also on the plate for 27° (Agra). Latitude 38° falls far north of the Indian subcontinent where the time unit of the *ghaṭī* was never used.

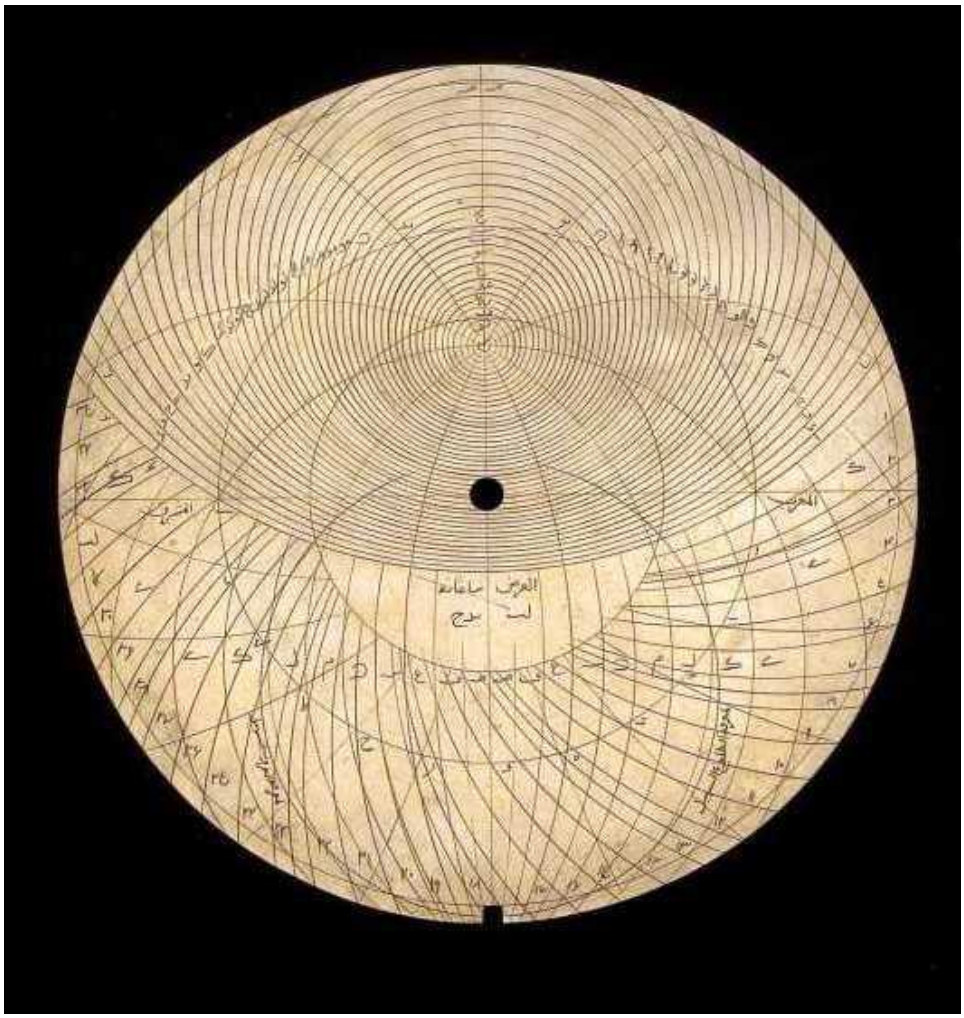


Figure A013.3 – Plate for Latitude 32°; notice the circle of the 'Visibility of Canopus' in the lower half (© Museum of the History of Science, Oxford)

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245 On the use of the time unit, see the section R on water clocks.

Circle of the Visibility of Canopus

Furthermore, on as many as 9 plate faces (viz., 1a, 1b, 2a, 2b, 3a, 4a, 4b, 5a, 7b) a dotted circle is drawn most of which occupies the lower half. No other Lahore astrolabe carries this circle.



Figure A013.4 – Labels on plate for 27° (photo by S. R. Sarma)

Following legends are engraved along the western and eastern sides respectively: *l'maᶜrifat al-ṭalūᶜ al-suhayl* (for the knowledge of the rising of Canopus) and *l'maᶜrifat al-gharūb al-suhayl* (for the knowledge of the setting of Canopus).



Figure A013.5 – Label on plate for 32° east (photo by S. R. Sarma)

North-South Projections on the plate for 23;30°

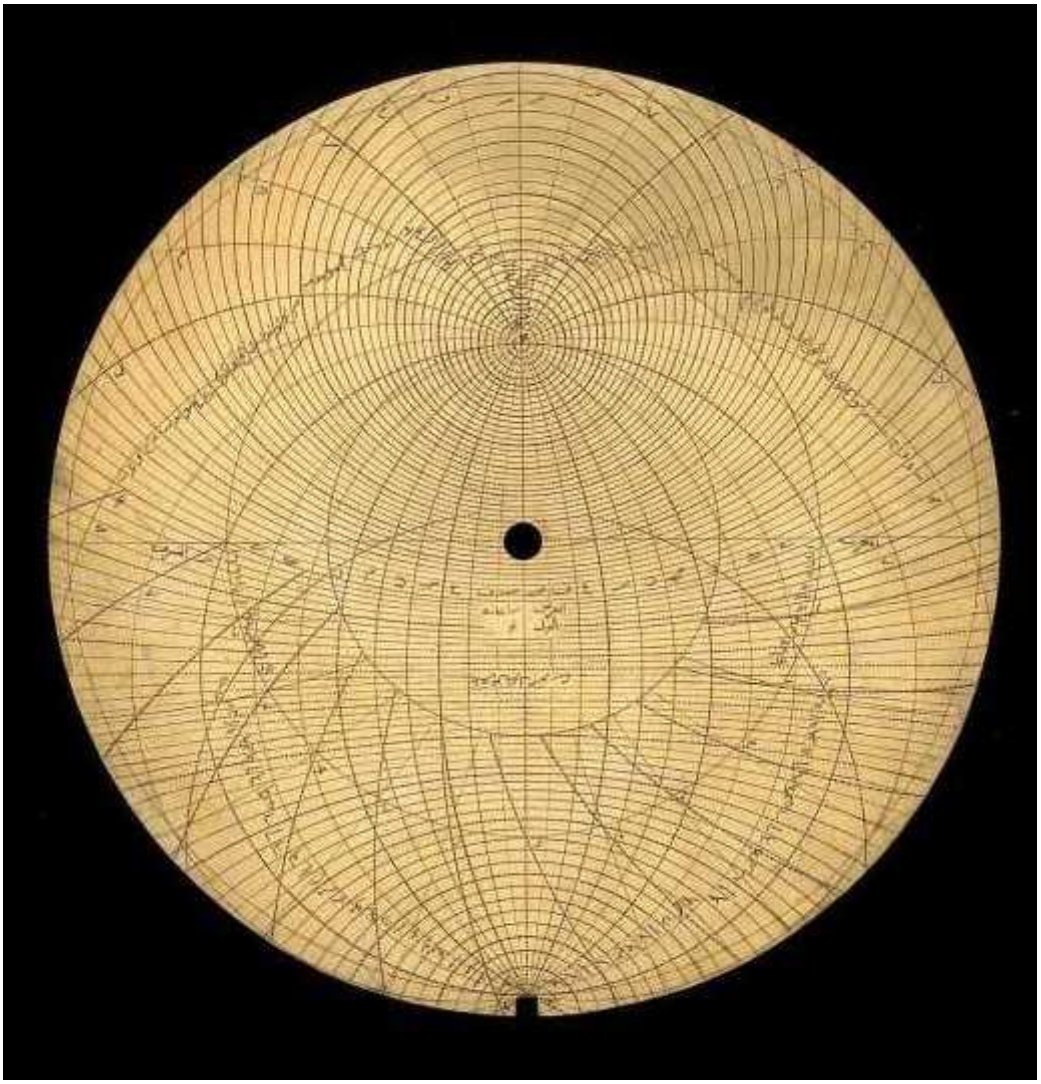


Figure A013.6 – Plate for 23;30° (© Museum of the History of Science, Oxford)

Plate 4a carries the projections for 23;30°. This is the traditional value of the latitude of Ujjain which is considered to be situated on the Tropic of Cancer. On this plate altitude circles are drawn for every 2°, azimuth arcs for every 6° above and below the horizon. There are lines for seasonal hours and dotted lines for equal hours counted from the western horizon, but no lines for *ghaṭīs*.

Interestingly in the lower half are drawn altitude circles for the southern projection. There is a label stating *ʿarḍ 23;30 janūbī* (latitude 23;30 south).

Most unusual is, however, that as many as five plate faces (viz., 2b, 3b, 4b, 5b, 6a) carry double projections. The double projection for the latitudes 0° and 90° occurs in other astrolabes also, but the rest are rare. These plates serve mainly didactic purposes,

but show the great skill of the astrolabe maker in drawing highly complicated projections.

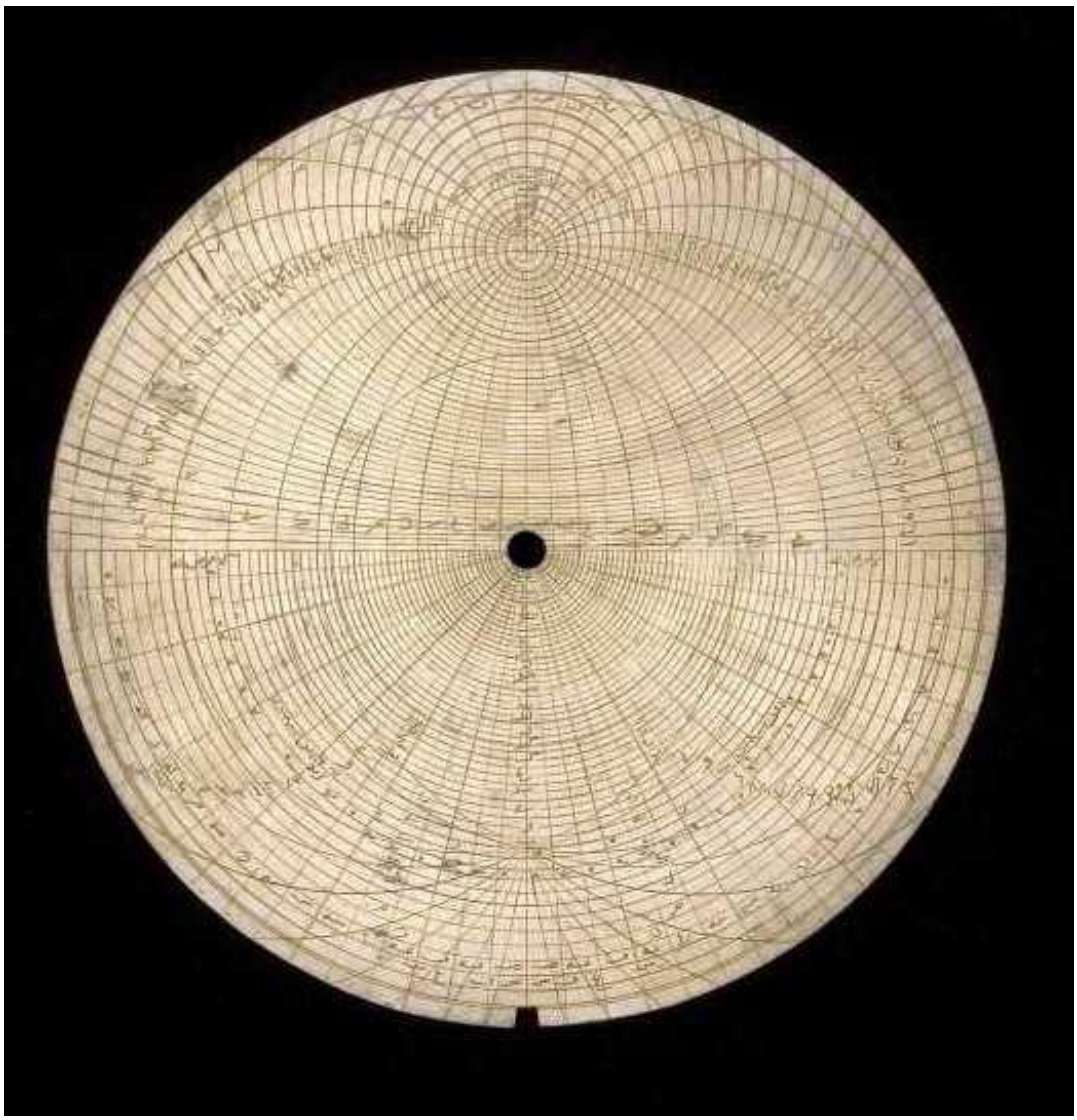


Figure A013.7 – Double Projection for the Latitudes 0° and 90
(© Museum of the History of Science, Oxford)

6a Plate of horizons

On the plate of horizons, half horizons are drawn in four batches at intervals of 6° in the following manner:

6	12	18	…	78	84	90
7	13	19	…	79	85	90
8	14	20	…	80	86	90
4	10	16	…	82	88	90

Strangely latitudes 3, 9, 15 … 81, 87, 90 are omitted. There are declination scales marked 6, 12, 18 and 23;30, the last value being that of the obliquity. There is no label on the plate.

7a. Plate of ecliptic coordinates

It is similar to that found in the previous astrolabes. It carries the label *mīzān al-ᶜankabūt.*

7b. Tablet to be used with the *Zawraqī* Horizons

This plate is specially designed for use in conjunction with the *zawraqī* horizons incorporated in the rete. Like the other plates, this one is also engraved with the vertical and horizontal diameters, and the three concentric circles of the Tropic of Capricorn, the celestial equator and the Tropic of Cancer. Under the horizontal diameter or the east-west bar is engraved *al-maghrib* and *al-mashriq* on the west and east respectively.

Two mutually intersecting oblique horizons are drawn across the plate. The arc with the convex side to the north is the oblique horizon for the latitude 32° and that with the convex side to the south is the horizon of the latitude 27°. Where the arcs intersect with the equinoctial colure, there are labels at the end of each horizon. Thus at the two ends of the horizon for 27° are engraved *ufq sharqīᶜarḍ 27* on the east, meaning 'eastern horizon latitude 27' and *ufq gharbī ᶜarḍ 27* on the west, meaning 'western horizon latitude 27'. Likewise, at the two ends of the horizon for 32° is engraved *ufq ᶜarḍ 32* both times.



Figure A013.8 – Plate to be used with *zawraqī* horizons
(© Museum of the History of Science, Oxford)

The twelve astrological houses are marked, once outside the equator and once inside the circle of Cancer, but with a difference. Outside the equator the division of the houses commences from the west point and proceeds counterclockwise, but inside the Cancer circle the division commences a little below the east-west line and proceeds counterclockwise. The names of the astrological houses are engraved in elongated letters so that the names occupy the full stretches of the corresponding houses. In Arabic, the first house is named *al-ṭālīᶜ,* 'the ascendant,' and the rest are called by the ordinal numbers: 1. *al-ṭālīᶜ,* 2. *al-thānī,* 3. *al-thālith,* 4. *al-rābiᶜ,* 5. *al-khāmis,* 6. *al-sādis,* 7. *al-sābiᶜ,* 8. *al-thāmin,* 9. *al-tāsiᶜ,* 10. *al-ᶜāshir,* 11. *al-ḥādī ᶜashar,* 12. *al-thānī ᶜashar.*

Each house, as marked outside the equator, is divided in 5 parts, and numbered as 6, 12, 18, 24, 30 in counter-clockwise direction. Arcs emanating from the centre of the plate (?) pass through these divisions.

Inside the circle of Cancer, there is a ring which is divided into the 12 astrological houses; these commence a little below the east-west line. These houses are divided into 10 parts each, but numbered in 6s as before with 6, 12, 18, 24, 30 in the counter-clockwise direction inside the equatorial circle. Arcs emanating from the centre of the plate (?) pass through these divisions of 10 parts. Thus, outside the circle of Cancer, these families of arcs produce a mesh.

Inside the ring of the astrological houses marked within the circle of Cancer is the miniature projection for the latitude 42° drawn upside down.[246] Here are two concentric rings (as they would be on the rim of an ordinary plate); the inner one is divided in 2° and the outer one in 6° and labelled in 6s from 6° to 360° starting at the south point of the miniature plate. The numbers proceed clockwise and because the space is extremely limited the hundreds' signs often omitted. There are the concentric circles of the equator and the Tropic of Cancer. The oblique horizon is marked by a dotted line, above which are drawn altitude circles for every 6° and numbered on both sides of the meridian. Azimuth arcs are drawn both above and below the horizon for every 30°. Lines for seasonal hours and dotted lines for equal hours counted from the western horizon are drawn. In the space between the oblique horizon and the circle of Cancer is inscribed *al-ᶜarḍ 42* (latitude 42 [degrees]) to the west of the meridian and *sāᶜāt 15* (longest day 15 [hours]) to the east of the meridian. Finally, the ecliptic circle is drawn touching the circle of Cancer in south and the circle of Capricorn in the north. This circle is divided into the 12 zodiac signs and labelled with their names. The names commence from the east point on the east west bar and proceed counter-clockwise. Each sign is further subdivided into 5 units.

The plate also carries, on the eastern part, a complete dotted 'circle of the visibility of Canopus' placed symmetrically on either side of the east-west line. Above the upper part is the inscription *l'maᶜrifat al-gharūb al-suhayl* (for the knowledge of the setting of

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246 It is not clear why the latitude 42° was chosen here.

Canopus) and below the lower part *l'ma^{c}rifat al-ṭalū^{c} al-suhayl* (for the knowledge of the rising of Canopus).

At the bottom of the plate is a long inscription bearing the designation of this special plate: *ṣafīhat maṭraḥ al-shu^{c}ā^{c} kahtrd* (?) *abī rayhān taswīyat al-buyūt khwānand,* (plate for finding the projection of the astrological rays according to (?) Abū Rayhān [al-Bīrūnī] [and] equalization of the astrological houses).[247]

GEOGRAPHICAL GAZETTEER

On the inner side of the mater is engraved a geographical gazetteer in three concentric circles. The gazetteer is read counter-clockwise from the upper vertical radius. The first cell in each row is filled with the argument: *al-bilād, al-ṭūs, al-^{c}arḍ.* The localities are arranged according to climates. But astrolabe maker commences with the second climate because he wishes to begin the gazetteer with the holy cities of Medina and Mecca which are situated in this climate. After a certain number of cities, the climate to which these belong is engraved across the three rows.[248]

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247 Gunther 1932, p. 194, describes it thus: 'a complicated plate in the centre of which is a miniature tablet for lat. 42°, hours 15. Across the bottom is written "A table of the projection of rays", which according to Albiruni is also called "equalization of houses" (=areola, Nallino, p. 324).'

248 Two years later, in 1637, his brother Muḥammad Muqīm arranged the gazetteer according to climates in a more elegant manner (A024); cf.

see also A014.

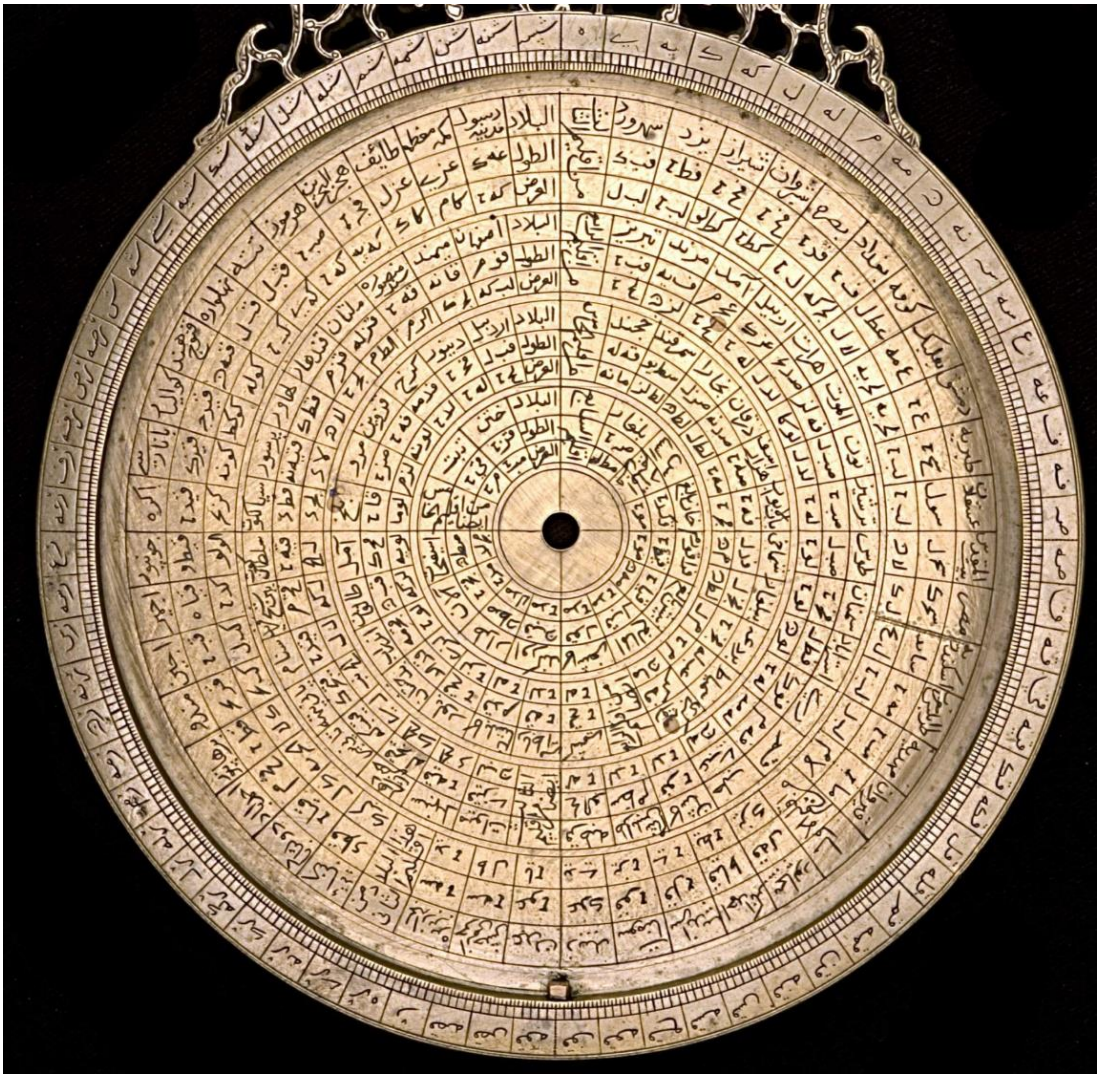


Figure A013.9 – Geographical gazetteer (© Museum of the History of Science, Oxford)

Table A013-3 Geographical Gazetteer

	Place Name (*al-bilād*)	**L (*al-ṭūl*)**	**φ (*al-ᶜarḍ*)**
	First Circle		
1	Madinat Rasūl	75;20	25;0
2	Makka Mubārak	77;10	21;40
3	Ṭāᶜif	77;30	21;20
4	Hajar al-Baḥrayn	83;0	25;15
5	Hurmūz	92;0	25;0
6	Tatta	102;30	25;10

	Place Name (***al-bilād***)	**L** (***al-ṭūl***)	**φ** (***al-ʿarḍ***)
7	Nahlawāra	102;30	22;0
8	Qannawj Hind	115;50	26;35
9	Kawāliyar	114;3	27;13
10	Bānārasī	114;0	26;36
11	Akra	114;0	27;13
12	Jawnpūr	119;6	26;36
13	Ajmīr	112;5	24;0
14	Ujjayn	112;0	22;30
15	Mandu	107;13	22;13
16	Burhānpūr	109;0	20;21
17	Aḥmadābād	108;40	23;15
18	Dawlatābād	111;0	20;30
19	Kanbāyat	109;4	22;20
haḍ al-bilād min iqlīm al-thānī (these [are] cities of the second climate)			
20	Bajja az Barbar	65;0	14;0
21	Jarmī az Habasha	65;0	9;30
22	Adan	76;0	11;0
23	Dabīl	74;20	14;10
24	Sawmnāt	107;0	17;0
25	Sarandīb	130;0	10;0
26	Aḥmadānakar	112;9	19;0
27	Bījāpūr	105;30!	17;20
min iqlīm al-awwal (of the first climate)			
28	Qīrwān	41;0	31;40

	Place Name (***al-bilād***)	**L** (***al-ṭūl***)	**φ** (***al-ᶜarḍ***)
29	Mahdiyya	42;0	32;30
30	Ṭarābulus Maghrib	45;0	32;0
31	Iskandariyya	61;14	30;18
32	Miṣr	63;20	30;20
33	Bayt al-Maqdis	63;30	31;50
34	ᶜAsqalān	66;30	32;0
35	Ṭībariya	68;0	32;0
36	Dimashq	70;0	33;15
37	Baᶜalbak	70;45	33;15
38	Kūfa	79;30	31;30
39	Baghdād	80;0	33;25
40	Baṣra	84;0	30;0
41	Shabzwān	88;0	29;0
42	Shīrāz	88;0	29;36
43	Yazd	89;0	32;0
44	Suhraward	82;20	32;30
min iqlīm al-thālith (of the third climate)			
	Second Circle		
45	Iṣfahān	86;40	32;25
46	Mīmand	101;55	33;20
47	Sind Mansūra	105;0	27;40
48	Mūltān	107;35	29;40
49	Qandahār	107;40	33;0
50	Lahāwar	109;20	31;50

	Place Name (***al-bilād***)	**L** (***al-ṭūl***)	**φ** (***al-ᶜarḍ***)
51	Parsūr	115;55	31;20
52	Siyālkot	109;4	33;4
53	Sulṭānkot	115;0	30;28
54	Pīnshaḥ Farīd?	118;40	30;25
55	Sanām	114;0	30;30
56	Pānīpaht	113;20	28;52
57	Tānīsīr	112;25	30;10
58	Ḥaẓrat Dehlī	113;35	28;30!
59	Sanbhal	115;0	28;4
60	Mewāt	117;10	32;50
ayḍān min iqlīm al-thālith (also of the third climate)[249]			
61	Qurṭaba	18;26	35;0
62	Ṭarabulus Shām	69;40	34;0
63	Kāshān	86;0	34;0
64	Ḥalab	72;10	35;50
65	Qūm	85;40	35;45
66	Rayy	86;20	35;0
67	Astarābād	89;30	36;50
68	Samnān	83;0	36;0
69	Ṭūs	92;30	36;0
70	Turshīz	92;0	35;0
71	Tūn	92;30	34;30

[249] There is no need of this label here; its purpose is served by the label at the end of the second circle.

	Place Name (***al-bilād***)	**L** (***al-ṭūl***)	**φ** (***al-ᶜarḍ***)
72	Alamūt	85;37	36;21
73	Herāt	94;13	34;30
74	Arbīl	77;20	35;0
75	Āmad	73;40	38;0
76	Marand	80;15	37;50
77	Tabrīz	82;0	38;0
min iqlīm al-thālith (of the third climate)			
	Third Circle		
78	Ardabīl	82;30	38;0
79	Dinawar	83;0	35;0
80	Karkh	84;45	34;0
81	Qazwīn	85;0	36;55
82	Marw	97;0	37;40
83	Balkh	101;0	36;41
84	Āmul	88;20	36;15
85	Ṭāliqān	102;50	37;25
86	Andarāb	103;45	36;0
87	Badakhshān	104;24	37;10
88	Balūr	108;0	37;0
89	Kābulistān	104;40	35;0
90	Ribāt Amīr	105;0	34;0
91	Kashmīr	108;0	35;00
min iqlīm al-rābiᶜ ayḍān (also of the fourth climate)			
92	Rūmiyya Kabrī	85;27	41;50

	Place Name (***al-bilād***)	**L** (***al-ṭūl***)	**φ** (***al-ᶜarḍ***)
93	Samyāṭ	72;35	40;0
94	Bardaᶜa	83;0	40;30
95	Babulghār	83;30	39;50
96	Shamākhī	84;30	40;50
97	Bāb al-Abwāb	85;0	43;0
98	Hazār Asf	95;0	45;0[250]
99	Darqān	94;55	39;30
100	Bukhārā	97;30	39;50
101	Samarqand	69;16!	39;37
102	Khujand	105;35	41;55
min iqlīm al-khāmis (of the fifth climate)			
	Fourth Circle		
103	Khutan	107;0	42;0
104	Tubbat	110;0	40;0
min iqlīm al-khāmis ayḍān (also of the fifth climate)			
105	Isfījāt	99;50	43;34
106	Ālān	103;0	44;0
107	Ṭarāz	99;50	44;0
108	Awazqand	102;50	44;0
109	Kāshghar	106;30	44;0
110	Al-Māligh	102;30	44;0
111	Bīshān Bāligh	111;0	45;50

[250] This latitude belongs actually to the sixth climate and not here!

	Place Name (***al-bilād***)	**L** (***al-ṭūl***)	**φ** (***al-ᶜarḍ***)
112	Qarāqūram	119;0	46;0
113	Khān Bāligh	124;0	46;0
min iqlīm al-sādis (of the sixth climate)			
114	Bulghār	90;0	49;3?
iqlīm al-sābiᶜ (the seventh climate)			

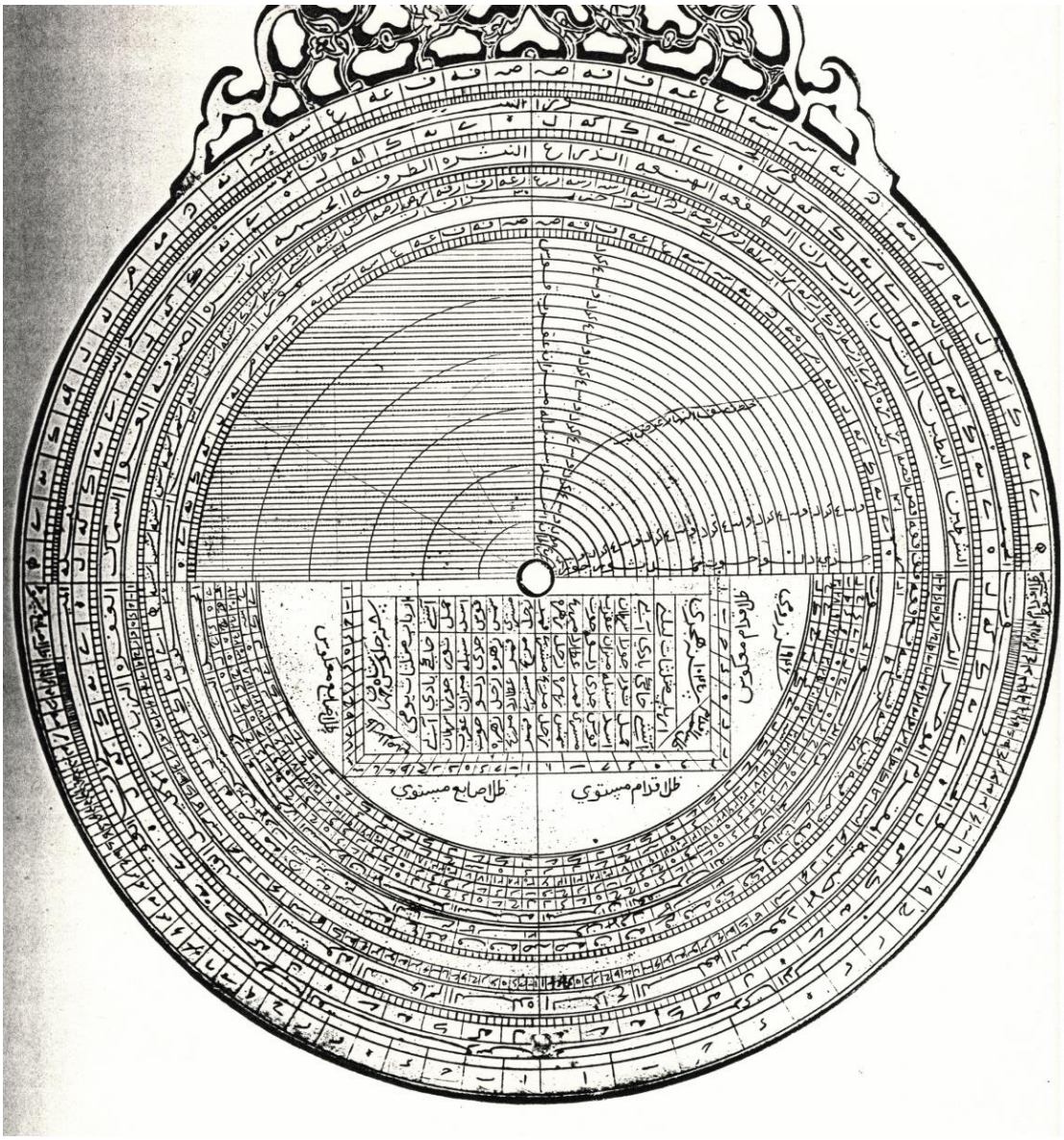


Figure A013.10 – Back of the astrolabe (from Gunther 1932, pl. XLVI)

BACK

On the back, the rim of the two upper quadrants carries a degree scale divided as in the front, but numbered as 5—90;90—5 for measuring the altitudes. The rim of the lower half has the two scales of cotangents for feet and digits in two rows. Inside these circular scales, there are eight concentric rings bearing the following scales:

1. Names of the zodiac signs starting from the west point and proceeding clockwise;
2. 1/6 parts of the signs numbered in *Abjad* as 5, 10, 15 … 30 separately for each sign;
3. Single degrees of arc;
4. Names of the 28 lunar mansions starting from the west point and proceeding clockwise;
5. A scale engraved only in the lower half, with *Abjad* numbers as 1, ... 22, 23;30, 30;23, 22 … 1 separately in each quadrant;

6-7-8. Then follows in the three rows a calendar of *Rūmī* (Syro-Macedonian or Byzantine) solar months which is placed eccentrically.[251] Blank spaces are left on either side of these eccentric rings for adjusting the space with the concentric rings.

Ring 6 is divided in single degrees. In ring 7, groups of 5° are labelled in *Abjad* from 5 to 360. The counting commences at 2 degrees below the horizontal diameter (= 2° Libra). Finally, in row 8 are the names of the *Rūmī* months above which are written the number of civil days in the standard Arabic numerals:

1. *Tishrīn al-Awwal 31* (October)
2. *Tishrīn al-Thānī 30* (November)
3. *Kānūn al-Awwal 31* (December)
4. *Kānūn al-Thānī 31* (January),
5. *Shubāṭ 28* (February)
6. *Ādhār 31* (March)
7. *Nīsān 30* (April)
8. *Ayyar 31* (May)
9. *Ḥuzayrān 30* (June)
10. *Tammūz 31* (July)

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[251] On calendar scales on the back, cf. Morrison 2007, pp. 111-114.

11. *Āb 31* (August)

12. *Aylūl 30* (September)

Then in the upper half, the altitude scales are repeated once more in 1° and 5° and numbered 5—90; 90—5 as on the rim.

Trigonometric Quadrant in the Upper left

In the upper left is the sexagesimal trigonometric quadrant with 60 horizontal parallels (to indicate cosines of every 1/60 part of the Radius); each fifth line is highlighted with dots. Attempts are made also to draw 12 vertical parallels but these are not completely engraved. Three radial lines are drawn at intervals of 30°. The declination arcs for each 30° of solar longitude drawn in the upper right quadrant are extended into this quadrant as well, which is somewhat unusual.

Solar Quadrant in the Upper Right

In the upper right quadrant, declination circles are drawn for every 6° of solar longitude, with every fifth circle being highlighted with dots. The names of the corresponding signs are engraved along the two radii. Starting at the centre along the vertical axis the names of *Saraṭān* (Cancer) to *Qaws* (Sagittarius) (i.e., from summer solstice to winter solstice) and starting from the periphery along the horizontal radius the names of *Jadī* (Capricorn) to *Thawr* (Taurus) (i.e., from winter solstice to summer solstice). The one-fifth part of each sign is numbered in lines somewhat deviating from the radii as 6, 12, 18, 24, 20 separately for each sign. Here was drawn a graph for the meridian altitude of the sun throughout the year with the label *khaṭṭ niṣf al-nahār bi ᶜarḍ 32* (line of midday at latitude 32°).

Shadow Squares

In the lower half are engraved two shadow squares, on the left for the gnomon of 12 digits and on the right for the gnomon of 7 feet. The vertical and horizontal scales are appropriately divided and numbered. In the corner on the left is the label *ẓill sallum aṣābiᶜ* (shadow scale in digits) and in the corner on the right *ẓill sallum aqdām* (shadow scale in feet). The four scales bear the following labels:

vertical scale on the left: *ẓill aṣābiᶜ maᶜkūs* (umbra versa in digits),

horizontal scale on the left: *ẓill aṣābiᶜ mustawī* (umbra recta in digits),

horizontal scale on the right: *ẓill aqdām mustawī* (umbra recta in feet),
vertical scale on the right: *.ẓill aqdām mustawī* (umbra versa in feet).

Tables of Trigons

Inside the shadow squares are the following two tables on the left and on the right respectively.

Table A013-4 Regents of the Trigons in the Daytime

Regents of the Trigons in the Daytime (*arbāb muthalthāt yawmī*)			
Fiery *ātishī*	Earthy *khākī*	Airy *bādī*	Watery *ābī*
Aries	Taurus	Gemini	Cancer
Leo	Virgo	Libra	Scorpio
Sagittarius	Capricorn	Aquarius	Pisces
Sun	Venus	Saturn	Venus
Jupiter	Moon	Mercury	Mars
Saturn	Mars	Jupiter	Moon

Table A013-5 Regents of the Trigons at Night

Regents of the Trigons at Night (*arbāb muthalthāt laylī*)			
Fiery *ātishī*	Earthy *khākī*	Airy *bādī*	Watery *ābī*
Aries	Taurus	Gemini	Cancer
Leo	Virgo	Libra	Scorpio
Sagittarius	Capricorn	Aquarius	Pisces
Jupiter	Moon	Mercury	Mars
Sun	Venus	Saturn	Venus
Saturn	Mars	Jupiter	Moon

Semicircular scales in the lower half

Around the shadow squares are six semi-circular rows. The first three rows constitute the table of limits (*al-ḥudūd*) with names of signs in the first row, the names of the planets (alphabetic symbols) in the second row and the limits (in *Abjad*) in the third row.

Table of the Limits

Table A013-6 Limits of the Signs

Aries	Jupiter 6	Venus 6	Mercury 8	Mars 5	Saturn 5
Taurus	Venus 8	Mercury 6	Jupiter 8	Saturn 5	Mars3
Gemini	Mercury 6	Jupiter 6	Venus 5	Mercury 7	Saturn 6
Cancer	Mars 7	Venus 6	Mercury 6	Jupiter 7	Saturn 4
Leo	Jupiter 6	Venus 5	Saturn 7	Mercury 6	Mars 6
Virgo	Mercury 7	Venus 10	Jupiter 4	Mars 7	Saturn 2
Libra	Saturn 6	Mercury 8	Jupiter 7	Venus 7	Mars 2
Scorpio	Mars 7	Venus 4	Mercury 8	Jupiter 5	Saturn 6
Sagittarius	Jupiter 12	Venus 5	Mercury 5	Saturn 4	Mars 4
Capricorn	Mercury 7	Jupiter 7	Venus 8	Saturn 4	Mars 4
Aquarius	Mercury 6	Venus 6	Jupiter 7	Mars 5	Saturn 5
Pisces	Venus 12	Jupiter 4	Mercury 2	Mars 9	Saturn 2

The fourth row contains another table related to the signs, but the exact significance of the 5 columns of numbers is not understood.

Table A013-7

Aries	15	20	24	24	30
Taurus	8	12	22	27	30
Gemini	6	12	17	22	30
Cancer	7	13	19	26	30
Leo	6	11	18	22	30
Virgo	7	17	21	27	30

Libra	6	12	21	20	30
Scorpio	7	11	16	22	30
Sagittarius	12	17	22	26	30
Capricorn	7	12	22	27	30
Aquarius	7	13	20	2-	30
Pisces	12?	?	?	27	30

The sixth and seventh rows show the regents of the faces or decans.

Table A013-8 Faces of the Signs

	10°	20°	30°
Aries	Mars	Sun	Venus
Taurus	Mercury	Moon	Saturn
Gemini	Jupiter	Mars	Sun
Cancer	Venus	Mercury	moon
Leo	Saturn	Jupiter	Mars
Virgo	Sun	Venus	Mercury
Libra	Moon	Saturn	Jupiter
Scorpio	Mars	Sun	Venus
Sagittarius	Mercury	Moon	Saturn
Capricorn	Jupiter	Mars	Sun
Aquarius	Venus	Mercury	Moon
Pisces	Saturn	Jupiter	Mars



Figure A013.11 – Alidade of the astrolabe (photo by S. R. Sarma)

ALIDADE ETC

The straight bar astrolabe has ornate ends and an ornate centre-piece. The left half of the alidade carries declination scales corresponding to the arcs of the signs in the upper right quadrant. On the edge, each sign is divided into parts. On the surface, starting from the centre, the names of the corresponding pairs of signs are engraved thus: *Saraṭān – Jawjā'* (Cancer – Gemini); *Asad – Thawr* (Leo – Taurus); *Sunbula - Ḥamal* (Virgo – Aries); *Mīzān – Ḥūt* (Libra – Pisces); *ᶜAqrab – Dalw* (Scorpio – Aquarius); *Qaws – Jadī* (Sagittarius – Capricorn).

The edge of the right half is divided into 60 units to match the divisions of the trigonometric quadrant. On the surface groups of 5 units are labelled, starting from the centre, as 5, 10, 15… 60.

In the lower register on the right is a scale of unequal hours, to be used when the alidade is employed as a sundial, with the sighting plate on the right functioning as the gnomon.

The rectangular sighting plates have two holes each.



Figure A013.12 – Signature of the astrolabe maker (photo by S. R. Sarma)

INSCRIPTIONS

On the back of the rete of this astrolabe, as in the astrolabe of 1627 (A011), the maker's signature is engraved on the lower half of the ecliptic ring:

> *ṣanaᶜt aqall al-ᶜibād qā'im muḥammad ibn ᶜīsā ibn allāhdād aṣṭurlābī lāhūrī humāyūnī.*
>
> 'The work of the least of the servants [of God], Qā'im Muḥammad, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker of [the Emperor] Humāyūn.'

The year of production of the astrolabe is engraved in three eras on the back of the astrolabe to the left and right of the shadow squares; *sanah 8 julūs shāhjahān* on the left margin of the shadow squares, *sanah 1045*[252] *hijrī* on the right margin of the shadow squares and *sanah 1946 rūmī* further to the right just below the semi-circular scales.

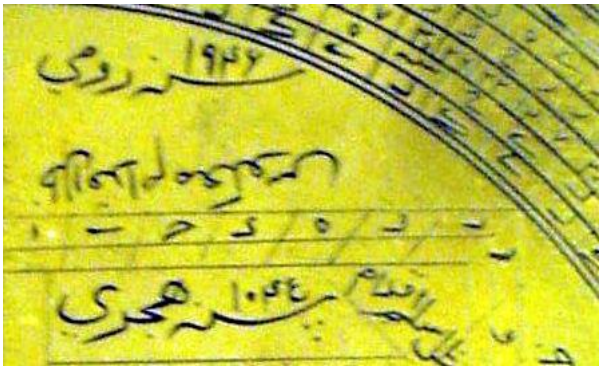


Figure A013.13 – Dates engraved to the right of the shadow squares (photo by S. R. Sarma)

The *Hijrī* year 1045 runs from 16 June 1635 to 3 June 1636 and the *Rūmī* (Syro-Macedonian) year is 1946 from 11 October 1934 to 10 October 1635. Since Shāh Jahān's coronation took place on 14 February 1628, his eighth regnal year would be roughly from February 1635 to January 1636. Therefore, the astrolabe was completed sometime during 16 June 1635 and 10 October 1635.

BIBLIOGRAPHY

Gunther 1932, no. 71, pp. 191-197, plates XLV-XLVI, figs. 94-97.

Kunitzsch 1959, pp. 62-64.

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252 The common Arabic/Persian numerical symbol used for 5 is somewhat unusual (it looks like the Arabic letter *ᶜayn* ع), but it occurs also in the *ghaṭī* scales, and is clearly different from the symbol of 4. Nevertheless, Gunther 1932, p. 191, reads the *Hijrī* year as '1044' and assigns the astrolabe to AD 1634.

A014⊙ ASTROLABE ATTRIBUTABLE TO QĀ'IM MUḤAMMAD, 1031 AH (AD 1621-22)

Diameter 169 mm

London, Nasser D. Khalili Collection of Islamic Art (#SCI 12)



Figure A014.1 – Front of the astrolabe (photo by S. R. Sarma)

This unsigned astrolabe with the richly decorated *kursī* has some features in common with Qā'im Muḥammad's astrolabe of 1045/1635-36 (A013) which has been described just above. As in A013, here also lines for *ghaṭīs* of 24 minutes are drawn on many plates; what is new here is that on many plates the maximum duration of daylight is expressed in *ghaṭīs.*[253] Also in common with A013 is the arrangement of the gazetteer; it is organized according to climates, but commences with the second climate so that the holy cities of Medina and Mecca occupy the first two places. Though unsigned, it carries the year AH 1031 on the front of the *kursī* and Jahāngīr's regnal year 17 on the back of the *kursī.* The mention of Jahāngīr's regnal year also favours the ascription of this astrolabe to Qā'im Muḥammad, for this is done also in astrolabe A011. The present astrolabe then is the earliest extant astrolabe by Qā'im Muḥammad.

COMPONENTS

Body with *kursī* (d. 169, h. 218, t. 8.5), shackle and ring, 5 plates, alidade and pin. The rete and the wedge are replacements.



Figure A014.2 – The front and back of the *kursī (*photo by S. R. Sarma)

FRONT

The ring is very small with a diamond cross-section. The shackle is trifoliate. The *kursī* is not pierced but embellished with calligraphy in relief. The profiles are made up of ogees at the base and at the top with two lobes in between. The finial is trifoliate. A pair of raised decorative lines run along the entire rim of the *kursī* and also of the finial creating a kind of groove in which red gems were embedded, some of which are now

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253 Lines for *ghaṭīs* are drawn and the maximum duration of the daylight is stated in *ghaṭīs* in several astrolabes made by Qā'im Muḥammad's son Ḍiyā' al-Dīn and in the large zoomorphic astrolabe at Jaipur (A051) which is attributable to Qā'im's younger brother Muḥammad Muqīm.

missing. There are inscriptions in *nastaʿlīq* style and in high relief on both sides of the *kursī*. The inscription on the front reads *allāh-u akabar sanah 1031 hijrī* and the inscription on the back *sanah 17 julūs jahāngīrī*. The inscriptions are surrounded by leaf and flower designs.

The Hijrī year 1031 runs from 15 November 1621 to 3 November 1622 and Jahangir's seventeenth regnal year from ca. 10 March 1622 to 9 March 1623. Therefore, the astrolabe was completed between 10 March and 3 November 1622.

The limb is divided in 5°, 1° and 0;30° and numbered in 5s clockwise from 5 to 360.

RETE

The rete is clearly not original, but a crude replacement where the edges of the fretwork are not even properly smoothened. It consists of a very broad Capricorn ring and still broader ecliptic ring. Both are joined rather clumsily by the equinoctial bar which has two counter changes at the equinoxes. The equinoctial colure does not always lie on the edges of the bar, but runs sometimes in the middle of the bar and sometimes even outside the bar. The solstitial bar is shown in the lower half between the two rings. A crude tracery joins the star pointers some of which are named and others not. The ecliptic is divided in zodiac signs and labelled with their names; each sign is divided in 5 parts on the sloping edge of the ecliptic ring but these parts are not numbered. To the left of the north point is a handle to turn the rete around the centre. There are faint traces of star names on some of the pointers; *Simāk Aʿzal* (α Virgionis), *Qalb al-ʿAqrab* (α Scorpii) and *Rās al-Ḥawwā* (α Ophiuchi) can be discerned.



Figure A014.3 – Rete of the Astrolabe (photo by S. R. Sarma)

PLATES

There are five plates; the first four serve latitudes between 19° and 40°. On some these plates, altitude circles are drawn for each 2° and numbered as 2, 6, 10, … 90; on other plates for each 3° and numbered 3, 6, 9, …90. Azimuth arcs are traced for each 9° below the horizon. Most interesting are the hour lines. Plain lines are drawn, as usual, for seasonal hours, but these are numbered from 1 to 12 in standard Arabic/Persian numerals. On many plates (1a, b; 2a, b; 3b, 4a) dotted lines are drawn for *ghaṭīs* of 24 minutes from the western horizon and numbered from 1 to 32. The maximum duration of the daylight or the longest day is expressed in hours on some plates and in *ghaṭīs* on some other plates, as shown in the table below. Here *ghaṭīs* are called *karīhā,* where *karī* stands for *ghaṭī* and *-hā* indicates plural. But the values are not very accurate in either case.

Table A014-1 Plates

	φ	Longest Day in hours	in *ghaṭīs*
1a	19°		32
1b	20;41°		32!
2a	32°		35
2b	35°		35!
3a	36°	14	
3b	40°		38
4a	27°		34
4b	22° +	13;22	
30°	13;18		
5a	Tablet ecliptic coordinates		
5b	Plate of horizons		

Plate 4b displays a composite projection for the latitudes 22° and 30°. The choice of latitude 20;41 on plate 1b is inexplicable. It is probably an error for 21;40 which is the latitude of Mecca. The fifth plate carries the ecliptic coordinates on the obverse and the horizons on the reverse.

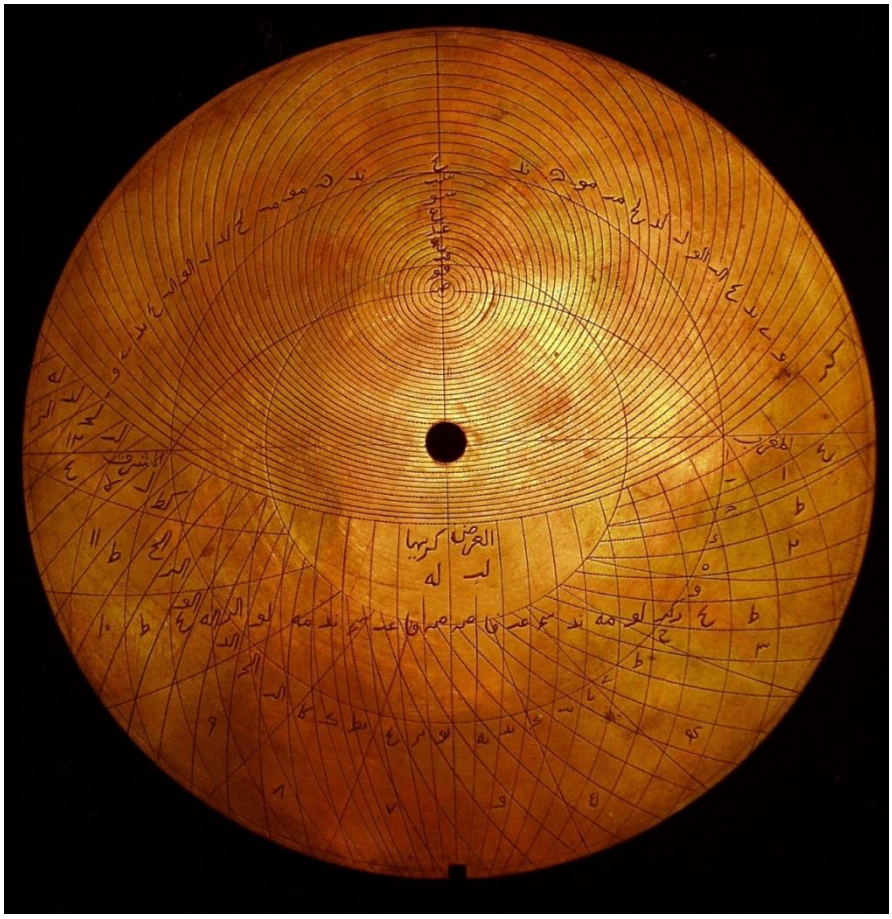


Figure A014.4 – Plate for the latitude of 32° (photo by S. R. Sarma)
Note the dotted *ghaṭī* lines numbered from 1 to32 and the daylight hours designated as *karīhā 35*.

GEOGRAPHICAL GAZETTEER

The geographical gazetteer provides the names, longitudes and latitudes of 69 places in three circles. The places are arranged according to climates which are mentioned in the headings engraved upside down in the rows between the circles. The enumeration commences in the first circle with the second climate (*iqlīm al-thānī*) so that the gazetteer begins with the names of the two holy cities of Medina and Mecca. After providing the coordinates of 16 places belonging to the second climate, five cities of the first climate are mentioned, followed by fourteen places of the third climate. Thereafter, in the second and third circles, climates are mentioned sequentially up to the seventh climate.[254]

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254 Maddison & Savage-Smith 1997, p. 223, state that 'the mater is engraved as a gazetteer of the longitudes and latitudes of 69 places, arranged according to three of the seven "climes" (the third, fourth and fifth)'. In fact, all the seven climates are represented here.



Figure A014.5 – Geographical Gazetteer (photo by S. R. Sarma)

Indian cities are mentioned in the second and first climates in the first circle. Here Kannauj (no. 5) is referred to as *Dār Mulk Hind* (capital of India)[255], Ahmedabad (15) is

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255 An attribute apparently derived from Ulugh Beg's geographical table; Sédillot 1853, p. 270.

given the suffix 'Gujarat' while Daulatabad (16), Bijapur (20) and Ahmadnagar (21) receive the epithet 'Dakkhin' (Deccan, lit. south). No other astrolabe gazetteer shows these peculiarities.

Strangely the coordinates in many entries conclude with 4 minutes. It appears that the engraver carelessly engraved the *Abjad* sign for 4 in the place of the usual symbol for zero which too is used in many places.

Table A014-2 Geographical Gazetteer

	Place name	**L**	**φ**
	First circle		
hazā al-bilād min iqlīm al-thānī (these cities belong to the Second Climate)			
01	Madīnat Rasūl	75;20	25;0
02	Makka Mubārak	77;10	21;40
03	Hurmūz	92;0	25;0
04	Tatta	102;7	25;10
05	Qannawj **Dār Mulk Hind**	115;50	26;36
06	Banārasī	117;20	26;55
07	Jawnbūr	119;6	26;36
08	Akra	114;0	27;4
09	Ajmīr	111;5	25;0
10	Kawāliyar	115;0	26;29
11	Ujjayn	102;0	22;30
12	Mandu	107;4	22;6
13	Burhānbū[r]	109;0	20;31
14	Kanbayāt	109;3	22;20
15	Ahmadābād **Kujarāt**	108;40	23;15

	Place name	L	φ
16	Dawlatābād **Dakkhin**	111;0	20;30
hazā al-bilād min iqlīm awwal (these cities belong to the First Climate)			
17	Jarmī Dār Mulk Habasha	65;0	9;30
18	ᶜAdan	76;0	12;0
19	Sanaᶜā' dār Mulk Yaman	77;0	14;30
20	Bījābūr **Dakkhin**	105;30	17;20
21	Aḥmadnakar **Dakkhin**	111;9	19;0
hazā al-bilād min iqlīm al-thālith (these cities belong to the Third Climate)			
22	Qayrawān	41;0	31;40
23	Miṣr	63;20	30;20
24	Bayt al-Maqdis	66;30	31;50
25	Kūfa	79;30	31;30
26	Baghdād	80;30	33;25
27	Shīrāz	88;0	29;36
28	Yazd	89;0	32;30
29	Iṣfahān	86;0	32;35
30	Multān	107;35	29;40
31	Qandahār	107;40	33;0
32	Lāhūr	119;20	31;50
33	Siyālkūt	109;0	33;0
34	Dihlī	114;48	28;43

	Place name	L	φ
35	Sunām[256]	114;25	30;30
	Second Circle		
ayḍā min iqlīm al-thālith (also belong to the Third Climate)			
36	Bānībatah	113;20	28;52
37	Tānīsar	112;25	30;10
38	Panbahal ?	115;0	28;4
39	Qila Rājkarī	109;15	33;20
haẓā al-bilād min iqlīm al-rābiᶜ (these cities belong to the Fourth Climate)			
40	Ḥalab	72;10	35;50
41	Marāgha	82;0	37;4
42	Tabrīz	82;0	38;0
43	Karkh	84;45	34;0
44	Qarwīn	85;0	36;55
45	Kāshān	86;0	34;0
46	Qumm	85;45	35;45
47	Rayy	86;20	35;0
48	Tāliqān	85;45	36;10
49	Ṭūs	92;30	36;0
50	Tūn	92;30	34;30
51	Harāt	94;4	34;30
52	Balkh	101;0	36;41
53	Badakhshān	104;24	37;10

[256] Spelt wrongly as Supnām

	Place name	L	φ
54	Kābulistān	104;40	35;0
55	Kashmīr	108;0	35;0
56	Rabāṭ Amīr	105;0	34;0
min iqlīm al-khāmis (belong to the Fifth Climate)			
57	Shamyāt	72;35	40;0
58	Akhlāt	75;50	39;20
	Third Circle		
ayḍā min iqlīm al-khāmis (also belong to the Fifth Climate)			
59	Bardaʿa	83;0	40;30
60	Bukhārā	92;30	39;50
61	Samarqand	99;36	39;37
62	Khujand	105;30	41;55
63	Khutan	107;0	47;0
min iqlīm al-sādis (belong to the Sixth Climate)			
64	Tubbat	110;0	40;0
65	Kāshghar	106;30	44;0
66	Bīsh Bāligh	101;0	45;50
67	Khān Bāligh	124	46;0
68	Alān	83;0	44;0
min al-sābiʿ (belongs to the Seventh [climate])			
69	Bulghār	90;0	49;0

BACK

On the back the entire rim is divided in 5°, 1° and 0;30° and numbered in 5s as 5—90; 90—5; 5—90; 90—5. In the upper left quadrant are drawn 60 horizontal

parallels, i.e., one for each 1/60 part of the Radius, and each fifth line is highlighted by dots. Also 11 quarter circles are drawn to divide the quadrant into 12 zones. In the opposite quadrant on the upper right, declination circles are drawn for each 10° of solar longitude. Each third of these arcs, which forms the boundary between two successive signs, is highlighted with dots. The names of the related signs are engraved in pairs along both radii. In each sign, the divisions of 10° are marked as 10, 20, 30.



Figure A014.6 – The Back of the astrolabe (photo by S. R. Sarma)

Shadow squares are drawn in the lower half, on the left for the base of 7 feet and on the right for the base of 12 digits. The vertical and horizontal scales are divided and

numbered accordingly. They are accompanied by the following labels:
Vertical scale on the left: *ẓill aqdām maᶜkūs* (reverse shadows in feet)
Horizontal scale on the left: *ẓill aqdām mustawī* (direct shadows in feet)
Horizontal scale on the right: *ẓill aṣābiᶜ mustawī* (direct shadows in digits)
Vertical scale on the right: *ẓill aṣābiᶜ maᶜkūs* (reverse shadows in digits).

Within the shadow squares is the table of triplicities in 4 columns and 12 rows. Here the names of the signs and the planetary regents are written in full and not with symbolic letters or numerals as on other astrolabes.

Table A014-3 Triplicities

Ātishī fiery	*Khaki* earthy	*Bādī* airy	*Ābī* watery
Aries	Taurus	Gemini	Cancer
Leo	Virgo	Libra	Scorpio
Sagittarius	Capricorn	Aquarius	Pisces

arbāb muthallathāth – shab the regents of the triplicities at night				*arbāb muthallathāth – rūz* the regents of the triplicities in the day			
Jupiter	Moon	Mercury	Mars	Sun	Venus	Saturn	Venus
Sun	Venus	Saturn	Venus	Jupiter	Moon	Mercury	Mars
Saturn	Mars	Jupiter	Moon	Saturn	Mars	Jupiter	Moon

The shadow squares are enclosed in a series of 11 semi-circular rows. Starting from outside, the first three rows carry the degree scales and the next two rows the cotangent scales. Thereafter, rows 6 and 7 are inscribed with the names of the 12 zodiac signs and the names of the 28 corresponding lunar mansions respectively. Then follow four rows containing the a table of limits and a table of decans and their regents.

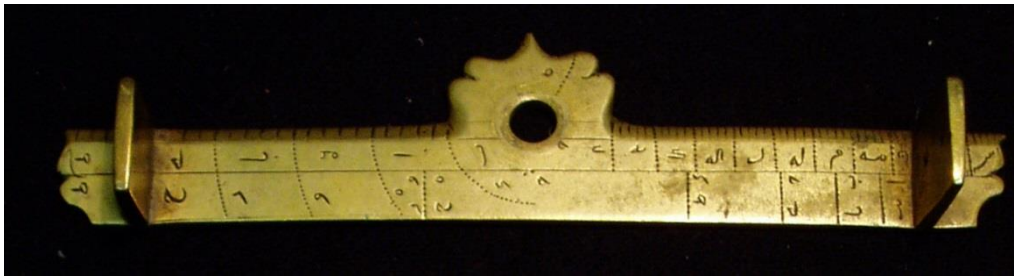


Figure A014.7 – Alidade (photo by S. R. Sarma)

ALIDADE

The straight bar alidade has ornate ends and an ornate centre-piece. The edge of the right half is graduated in divisions corresponding to the distances between the horizontal parallels in the sine quadrant, which are numbered on the surface, in 5s, from 5 to 60. On the left half is engraved the scale of solar longitude with curves matching the pairs of signs in the upper right quadrant, together with their serial numbers. In the lower register on the left, there are sundial markings for seasonal hours 9/4, 10/3, 11/2, 12/1, to be used when the alidade is employed as a sundial, with the sighting plate on the left functioning as the gnomon. The pin appears to be original. The wedge is a modern replacement.

BIBLIOGRAPHY

Maddison & Savage-Smith 1997, no. 129, pp. 223 and 225.

A015⊙ ASTROLABE ATTRIBUTABLE TO QĀ'IM MUḤAMMAD, NOT DATED

Diameter 330 mm

London, Nasser D. Khalili Collection of Islamic Art (#SCI 10)



Figure A015.1 – Front of the astrolabe (photo by S. R. Sarma)

This and the previous astrolabe, in spite of the substantial difference in size (diameter of 330 mm as against the diameter of 169 mm), are exactly alike in the technical aspects, with the same gazetteer and with the same configuration on the back.

The 5 plates also serve the same set of latitudes. What differentiates these two astrolabes are the artistic designs of the *kursī* and the rete. The workmanship of the present astrolabe is far superior and the rete displays a more elegant design.

COMPONENTS

Body with *kursī* (d. 330, h. 422, t. 12), shackle, rete, 5 plates. There is a rule, but no alidade; pin, wedge and ring are missing.

FRONT

The shackle is not trifoliate, but has ornate bases; it is too small for this large astrolabe. The *kursī* is solid; its profiles are made up of a series of ogees and lobes; the finial is not trifoliate but has the shape of a stylized diamond. The *kursī* is decorated on both sides with a pattern of flowers and leaves in high relief. The background is filled with a dark substance so that the pattern stands out. It is set with flush silver studs.

The limb is divided in 0;30°, 1° and 5° and numbered clockwise in 5s from 5 to 360.

RETE

The rete is more elegantly designed than in the previous astrolabe. But it is flat and lacks the final touches which would have given it a more contoured look. It is not known why it was left unfinished; when properly finished, it would have become one of the finest retes among the Lahore astrolabes.

A remarkable feature of this rete is that is completely devoid of the equinoctial and solstitial bars. The two rings of the Capricorn and ecliptic are held together by a floriated tracery with leaves and flowers with six petals. The ecliptic ring is divided into the 12 signs and labelled with their names; each sign is subdivided in groups of 6° and numbered from 6 to 30 separately in each sign. Star names are written on several leaves. But these names are not deeply incised and in many cases starkly abridged, so that deciphering them is rather difficult.



Figure A015.2 – Rete of the astrolabe (photo by S. R. Sarma)

PLATES

There are 5 plates. The first four plates carry altitude circles for every 2° and azimuth arcs for every 9° below the horizon. There are lines for seasonal hours which are numbered in common Arabic/Persian numerals from 1 to 12 between the circle of equator and the periphery. In addition, there are lines for *ghaṭīs* of 24 minutes which are drawn from the western horizon and numbered from there in *Abjad* numerals from 1 to 34 along the circle of equator. On several plates the duration of the longest day is expressed in *ghaṭīs* and on a few in hours; neither set of values is very accurate.

Table A015-1 Plates

	φ	Longest Day in hours	Longest Day in *ghaṭīs*
1a	19°		37
1b	20;40°		33
2a	32°		35
2b	35°		35
3a	36°	14	
3b	40°		37
4a	27°		34
4b	22°+30°	13;18 13;22	

The fifth plate carries the ecliptic coordinates on the obverse and the horizons on the reverse.

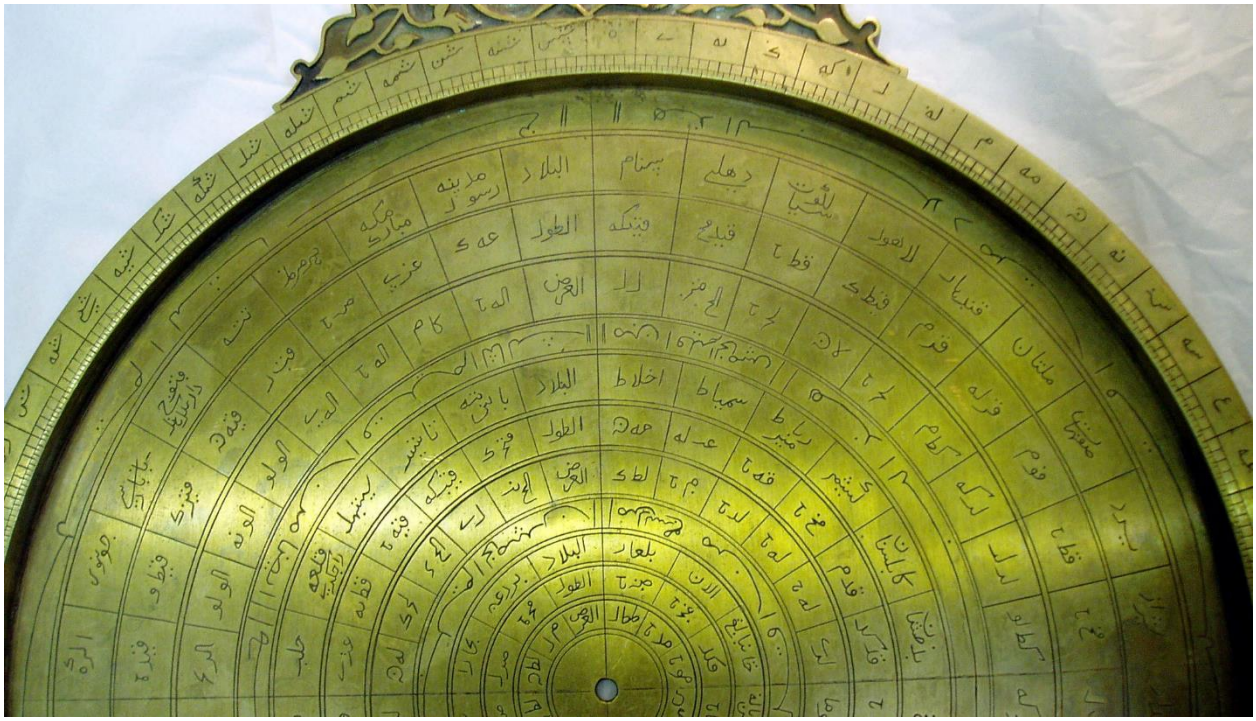


Figure A015.3 –



Figure A015.4 – Geographical gazetteer (photo by S. R. Sarma)

GEOGRAPHICAL GAZETTEER

Leaving aside minor scribal differences, the gazetteer is exactly the same as in the previous astrolabe, with the same number of 69 cities, mentioned in the same sequence with the same headings.

Table A015-2 Geographical Gazetteer

	Place name	**L**	**φ**
	First circle		
hazā al-bilād min iqlīm al-thānī (these cities belong to the Second Climate)			
01	Madīnat Rasūl	75;20	25;0
02	Makka Mubārak	77;10	21;40
03	Hurmūz	90;0	25;0
04	Tatta	102;7	25;10
05	Qannawj **Dār Mulk Hind**	115;50	26;36

	Place name	L	φ
06	Banārasī	117;20	26;55
07	Jawnbūr	119;6	26;36
08	Akra	114;0	27;3
09	Ajmīr	111;50	25;0
10	Kawāliyar	115;0	26;29
11	Ujjayn	102;0	22;30
12	Mandu	107;3	22;6
13	Burhānbū[r]	109;0	20;31
14	Kanbayāt	109;3	27;20
15	Ahmadābād **Kujarāt**	108;40	23;15
16	Dawlatābād **Dakkhin**	111;0	20;30
hazā al-bilād min iqlīm awwal (these cities belong to the First Climate)			
17	Ṣarmī Dar Mulk Ṣash[257]	65;0	9;30
18	ᶜAdan	76;0	15;0
19	Sanaᶜā' Dār Mulk Yaman	77;0	14;30
20	Bījābūr **Dakkhin**	105;30	17;20
21	Ahmadnakar **Dakkhin**	111;9	19;0
hazā al-bilād min iqlīm al-thālith (these cities belong to the Third Climate)			
22	Qayrawān	41;0	31;40

[257] Should it read "Jarmī Dār al-Mulk Habasha' ?

	Place name	L	φ
23	Miṣr	63;20	30;20
24	Bayt al-Maqdis	66;30	31;50
25	Kūfa	79;30	31;30
26	Baghdād	80;30	33;25
27	Shīrāz	88;0	29;36
28	Yazd	89;0	34;34
29	Iṣfahān	86;40	32;35
30	Multān	107;35	29;40
31	Qandahār	107;40	33;0
32	Lāhūr	119;20	31;50
33	Siyālkūt	109;0	33;0
34	Dihlī	114;48	28;47
35	Sunām[258]	114;25	30;30
	Second Circle		
ayḍā min iqlīm al-thālith (also belong to the Third Climate)			
36	Bānībaht	113;20	28;52
37	Tānīsar	112;25	30;10
38	Yatbahal?	115;0	28;4
39	Qila Rājkarī	109;15	23;4
hazā al-bilād min iqīm al-rābiᶜ (these cities belong to the Fourth Climate)			
40	Ḥalab	77;10	35;50
41	Marāgha	82;0	37;4

[258] Spelt wrongly as Supnām

	Place name	L	φ
42	Tabrīz	82;0	38;0
43	Karkh	84;45	34;0
44	Qazwīn	85;0	36;55
45	Kāshān	85;0	34;0
46	Qumm	85;40	35;45
47	Rayy	86;20	35;0
48	Tāliqān	85;45	36;10
49	Ṭūs	92;30	36;0
50	Tūn	92;30	34;30
51	Harāt	94;13	34;30
52	Balkh	101;0	36;41
53	Badakhshān	104;24	32;10
54	Kābulistān	104;40	35;0
55	Kashmīr	108;0	35;0
56	Rabāṭ [A]mīr	105;0	34;0
min iqlīm al-khāmis (belong to the Fifth Climate)			
57	Shamyāt	72;35	40;0
58	Akhlāṭ	85;50	39;20
	Third Circle		
ayḍā min iqlīm al-khāmis (also belong to the Fifth Climate)			
59	Barda^{c}a	83;0	40;30
60	Bukhārā	92;30	39;50
61	Samarqand	99;36	39;37
62	Khujand	105;30	41;55

	Place name	L	φ
63	Khutan	107;0	60;0 !
min iqlīm al-sādis (belong to the Sixth Climate)			
64	Tubbat	110;0	40;0
65	Kāshghar	86;30	44;0
66	Bīsh Bāligh	101;0	45;50
67	Khān Bāligh	124	46;0
68	Alān	73;0	44;0
min al-sābiᶜ (belongs to the Seventh [climate])			
69	Bulghār	90;0	49;30

BACK

The entire rim on the back is divided in 0;30°, 1°, 5° and labelled from 5 to 90, separately in each quadrant; the numbers start at the east and west points and reach the south and north points.

In the upper left quadrant are drawn 60 horizontal parallel lines and upon these are superimposed declination arcs, one for each sign of the zodiac or 30° solar longitude.

In the upper right quadrant, declination arcs are traced for every 6° of solar longitude. The names of the corresponding zodiac signs are engraved in full along the two radii, together with the numerical values (6, 12, 18, 24, 30) of the divisions of each sign. There are no graphs of the midday altitude of the sun in this quadrant.

In the lower half are drawn shadow squares, on the left for a gnomon of 7 feet and on the right for a gnomon of 12 digits. The vertical and horizontal scales are divided and numbered accordingly. The scales are accompanied by the following labels:
Vertical scale on the left: *ẓill aqdām māᶜkūs* (reverse shadows in feet)
Horizontal scale on the left: *ẓill aqdām mustawī* (direct shadows in feet)
Horizontal scale on the right: *ẓill aṣābiᶜ mustawī* (direct shadows in digits)
Vertical scale on the right: *ẓill aṣābiᶜ maᶜkūs* (reverse shadows in digits).

Inside the shadow squares is a table of triplicities with their planetary regents for the day as well as for the night, arranged exactly as in the previous astrolabe.



Figure A015.5 – Back of the astrolabe (photo by S. R. Sarma)

The shadow squares are enclosed in 11 semi-circular rows. Starting from the outside, the first three rows carry the degree scales and the next two the cotangent scales. Rows 6 and 7 contain respectively the names of the 12 zodiac signs and the names of

the 28 corresponding lunar mansions. Rows 8 and 9 display the limits and the last two rows the decans and their regents.

Alidade

There is no alidade with sights. There is, however, a rule engraved with declination scales, which is probably a late replacement.

Bibliography

Maddison & Savage-Smith 1997, no. 132, pp. 230-231.

A016⊙ ASTROLABE ATTRIBUTABLE TO QĀ'IM MUḤAMMAD

Date ?, Lahore

Diameter 194 mm

London, Nasser D. Khalili Collection of Islamic Art (#SCI 36)



Figure A016.1 – Front of the astrolabe (photo by S. R. Sarma)

On this exquisitely crafted astrolabe, the Khalili catalogue states: 'The astrolabe is signed on the back, in the centre of the arcs of the signs, but the impression has been badly rubbed.' The catalogue then goes on to supply the rubbed off name of the maker as Muhammad Muqim ibn 'Isa ibn Allahdad Asturlabi Humayuni Lahori and date as AH 1003 (AD 1594-95).[259] When I examined the astrolabe in 2005, I looked very closely at that part which is said to contain the name of the maker; something was indeed rubbed off there, but it was impossible to detect any traces of the maker's name or of the date. It puzzles me how the authors of the catalogue could decipher the maker's name and the date.

The date, in any case, is highly improbable for Muqīm. If he did produce this splendid astrolabe in 1594-95, he must have been a mature and accomplished astrolabist at that time, of at least 25 years. This would place the year of his birth around 1570. But the astrolabes signed by him all pertain to the period from 1621 to 1659 and no astrolabe bearing a date between 1594 and 1621 came to light so far. Therefore 1594-95 cannot be the year of production of this astrolabe.

Stylistically the astrolabe may be attributed to Muqīm; but there are stronger stylistic reasons in favour of Muqīm's elder brother Qā'im Muḥammad. In the rete the names of zodiac signs along the rim of the ecliptic are cut in silhouette almost in the same manner as in Qā'im Muḥammad's astrolabe of 1627 (A011). The *zawraqī* horizons incorporated in the rete are reminiscent of the *zawraqī* horizons in Qā'im Muḥammad's astrolabe of 1635 at Oxford (A013). Muqīm did not incorporate *zawraqī* horizons in any of his astrolabes.

COMPONENTS

Body with *kursī* (d. 193, h. 270, t. 12), shackle and ring, rete (d. 171) for 38 stars. There survives only 1 plate (d. 171.5). Alidade is a replacement.

FRONT

The ring has an octagonal cross section. The shackle with a diamond cross-section has a trifoliate shape and trifoliate bases. The high *kursī* is intricately worked *à jour* with

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[259] Cf. Maddison & Savage-Smith 1997, I, pp. 220-223.

a cartouche in the middle. The cartouche was probably meant to carry the name of the owner, but it is blank. The profiles consisting of ogees at the base and top with a lobe in between are fashioned like ropes with engraved patterns on the surface. The *kursī* is topped by a trifoliate finial.

The limb is divided in 5°, 1° and 0;20° and labelled in 5s from 5 to 360. On the inner side of the mater, a gazetteer is engraved. The lug at the north point which is meant to hold the plates in position is lost. There is just a rectangular hole.



Figure A016.2 – Rete of the astrolabe (photo by S. R. Sarama)

RETE

The most striking part of the astrolabe is the rete which has a very unusual and very delicate design. On the rim of the only surviving plate a partial gazetteer is engraved and the Tropic of Capricorn drawn some distance away from the periphery. Therefore, in the rete also the Tropic of Capricorn does not run through the peripheral

ring as in other astrolabes, but lies a few millimetres inside this peripheral ring in the empty space.

The very plain peripheral ring and the highly ornate ecliptic ring are held together by the solstitial and the equinoctial bars. The solstitial bar is fully represented and it is without counter changes, its left hand side edge marking the meridian. The equinoctial bar, on the other hand, is shown as two separate segments, each of which has a counter-change at its intersection with the ecliptic ring. The segments are not straight but somewhat curved with the result that the line of equinoctial colure does not coincide with the edges of the equinoctial bar.

Unusually the ecliptic ring has counter changes at its two intersections with the equinoctial bar. In the upper half, the names of the six signs from *al-Mīzān* to *al-Ḥūt* are engraved in relief against the hatched background below the ecliptic circle. In the lower half, the names of the six signs from *al-Ḥamal* to *al-Sunbula* are cut in silhouette on the outer edge of the ecliptic circle. The base on which the silhouettes are set up and which is an extension of the ecliptic circle is hatched. In the upper surface of the ecliptic circle, the signs are divided into units of 6° and labelled in 6s from 6 to 30. These units are further subdivided into single degrees which are marked on the outer edge of the upper half of the ecliptic ring and on the inner edge of the lower half.

Near the centre the equinoctial bar makes way to two intersecting *zawraqī* or ship arcs which represent the oblique horizons at latitudes of 30° and 33°; these numbers are engraved in *Abjad* on the respective arcs. It is not clear why these two latitudes are chosen. The plate to be used with these ship horizons is lost.

The space between the two rings is filled with a sparse tracery connecting the pointers to the stars which are south of the ecliptic. The space inside the ecliptic ring is filled by a denser tracery which connects the pointers of the stars situated to the north of the ecliptic. Here one or two star pointers may have broken and lost. Above the south point of the ecliptic circle is an arch to bridge the distance between the first point of Capricorn and the degree scale on the limb. The tip of the peripheral ring is joined to the arch by a leaf-shaped piece on the right. Such a piece on the left is broken and lost. A sturdy handle is affixed to the peripheral ring roughly at SW point. There are some construction marks on the reverse side of the rete.



Figure A016.3 – Detail of Figure A016.2, showing the names of the signs (from right to left) al-Ḥamal, al-Thawr, al-Jawzā', al-Saraṭān, al-Asad and al-Sunbula.

Following are the 38 star names engraved on the pointers.

Table A016-1 Stars on the Rete

	Star Name	Identification
01	*Dhanab al-Qayṭus J[anūbī]*	β Ceti
02	*Rijl al-Musalsala*	γ Andromedae
03	*Baṭn al-Ḥūt*	β Andromedae
04	*Fam Qayṭus*	γ Ceti
05	*Ṣadr Qayṭus*	π Ceti
06	*Kaff al-Jadhmā'*	α Ceti
07	*Rās Ghūl*	β Persei
08	*Tālī Masāfat al-Nahr*	γ Eridani
09	*ᶜAyyūq*	α Aurigae
10	*Rijl al-Jawzā' [Yusrā]*	β Orionis
11	*Yad al-Jawzā' [Yusrā]*	γ Orionis
12	*Rijl [al-Jawzā'] Yumnā*	κ Orionis
13	*Shiᶜrā Yamānī*	α Canis Majoris
14	*Rās al-Taw'm al-Muqaddam*	α Geminorum
15	?	

	Star Name	Identification
16	?	
17	*Shiᶜrā Shāmī*	α Canis Minoris
18	*Ṭarafat Safīna*	ρ Puppis
19	*Fard al-Shujāᶜ*	α Hydrae
20	*Rās al-Asad*	μ Leonis
21	*Qalb al-Asad*	α Leonis
22	*Qāᶜidāt Bāṭiya*	α Crateris
23	*ᶜAnāq*	ζ Ursae Majoris
24	*Simāk Aᶜzal*	α Virginis
25	*Simāk Rāmiḥ*	α Bootis
26	*ᶜUnuq Ḥayyā*	α Serpentis
27	*Qalb al-ᶜAqrab*	α Scorpii
28	*Rijl al-Ḥawwā*	ρ Ophiuchi
29	*[Rās al] Jāthī*	α Herculis
30	*Rās al-Ḥawwā*	α Ophiuchi
31	*[Nasr] Wāqiᶜ*	α Lyrae
32	*Minqār al-Dajājah*	β Cygni
33	*[Nasr] Ṭā'īr*	α Aquilae
34	*Dhanab Dulfīn*	ε Delphini
35	*Fam Faras*	ε Pegasi
36	*Dhanab Jadī*	δ Capricorni
37	*Sāq Sākib al-Mā' J[anūbiya]*	δ Aquarii
38	*Mankib Faras*	β Pegasi

PLATE

There survives just one plate out of possibly nine original plates. This plate is calibrated for latitude 27° on the obverse and for latitude 32° on the reverse. Interestingly, on both sides of the plate, the rim is engraved with the names and coordinates of 8 places which lie roughly on the same latitude for which the plate is calibrated. The purpose of this partial gazetteer is to show that the plate can be used for observation at all these eight places, because the differences in latitude are minimal.[260] Consequently the Tropic of Capricorn lies some distance away from the rim of the plates.

OBVERSE SIDE OF THE PLATE

The obverse side of the plate carries stereographic projections for latitude 27°, the latitude of the Mughal Imperial City of Agra, referred to as *Dār al-Khilāfat Akbarābād* in the gazetteer engraved on the rim. The latitude 27° is mentioned in the middle of the plate as also the maximum duration of the daylight hours as 13;46.

On the plate the vertical and horizontal diameters are drawn as dotted lines. Altitude circles are traced for every 1° and every sixth line is highlighted with dots. These are numbered, on both sides of the meridian, in 3s along the equatorial circle and in 6s along the Tropic of Cancer. Azimuth arcs are drawn for every 6° below the horizon and numbered in a straight line below the lower limit to the Tropic of Cancer.

Plain lines are drawn for seasonal hours and numbered from 1 to 12 from the western horizon to the eastern horizon. Dotted lines are drawn for equal half-hours since the sunset and before the sunrise; these are numbered below the equatorial circle from 1 to 15 from the western horizon to the meridian to measure the half-hours elapsed from sunset to midnight; and from 1 to 15 from the eastern horizon up to the meridian to measure the half-hours that are still remaining before sunrise.

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260 This feature occurs on all the five plates in an undated astrolabe by Muqīm (A041). It is mentioned in the chronicle *Sīrat-i Fīrūzshāhī* (Sarma 2000) and can be seen in the bilingual astrolabe of 1616 (Sarma 2011a) and in a Gurmukhi astrolabe (Sarma 2012b). While discussing these, I emphasised, wrongly, that this feature belongs to an astrolabe tradition which is different from that the Lahore family. Now I stand corrected.

In the wide rim outside the Tropic of Capricorn, between the oblique horizon and the horizontal diameter are written *al-maghrib* on the west and *al-mashriq* on the east. Then below the horizontal diameter, from the west to the east, are inscribed the names of eight localities which are roughly on the latitude of 27°, together with their coordinates; the place names are written first in larger letters within round brackets, then the longitudes and latitudes in smaller letters, one below the other, separated by a straight horizontal line. The localities and their coordinates are reproduced below.

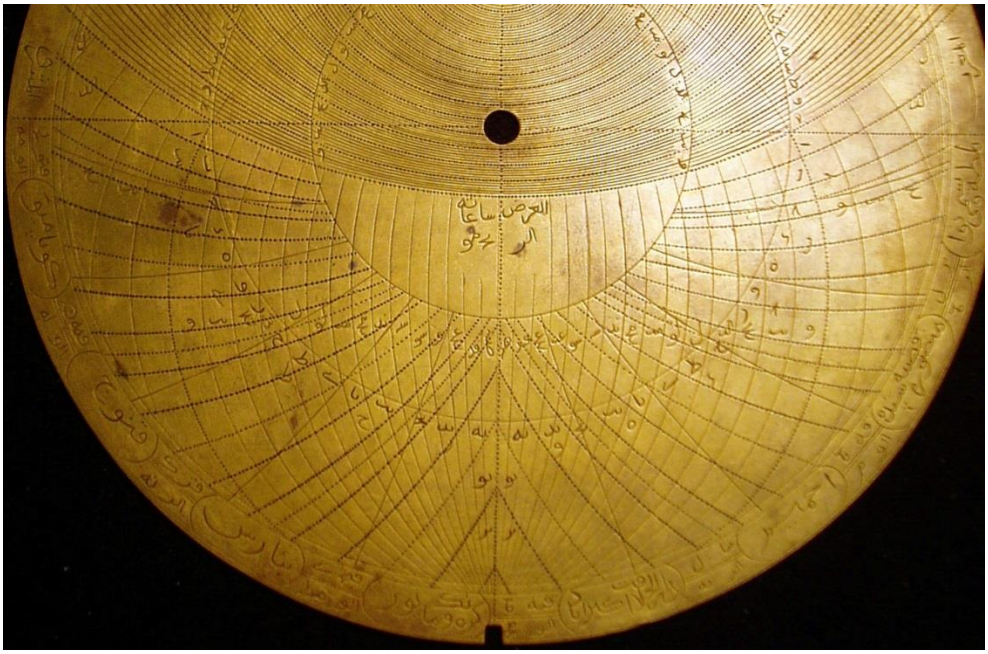


Figure A016.4 – Plate for atitude 27° (photo by S. R. Sarma)

Table A016-2 Places where this plate can be used

	Place Name	L	φ
1	Lamṭah wa Samī Nuwā	17;30	27;0
2	Qaṣba Mansūra Sindh	105;20	26;40
3	Ajmīr[261]	111;30	27;15
4	Dār al-Khilāfat Akbarābād	115;0	26;43

[261] In the gazetteer engraved on the inner side of the mater, the coordinates of Ajmīr are different; long. 104;5 and lat. 26;0.

	Place Name	L	φ
5	Kara Mānikpūr	113;10	26;49
6	Banāras	112;20	27;55
7	Qannawj	115;50	26;35
8	Kūpāmayū	116;33	26;45

REVERSE SIDE OF THE PLATE

The reverse side of the plate is calibrated for latitude 32° which is the latitude of the Mughal Imperial City of Lahore, referred as 'Dār al-Saltanat Lāhūr' in the gazetteer on the rim. The latitude 32° is mentioned in the middle of the plate as also the maximum duration of the daylight hours as 14;8.

Here the altitude circles are drawn and numbered as on the obverse side. Azimuth arcs are drawn for every 6° below the horizon as on the obverse side, but numbered in a different manner; partly along the lines of seasonal hours and partly along Tropic of Cancer. Plain lines are drawn for seasonal hours and the intervals are numbered from 1 to 12 from the western to the eastern horizon. Dotted lines are drawn for *ghaṭīs* (of 24 minutes) counted from the western horizon and these are numbered from 1 to 30 from the western to the eastern horizon, the numbers being engraved along the circle of the equator.

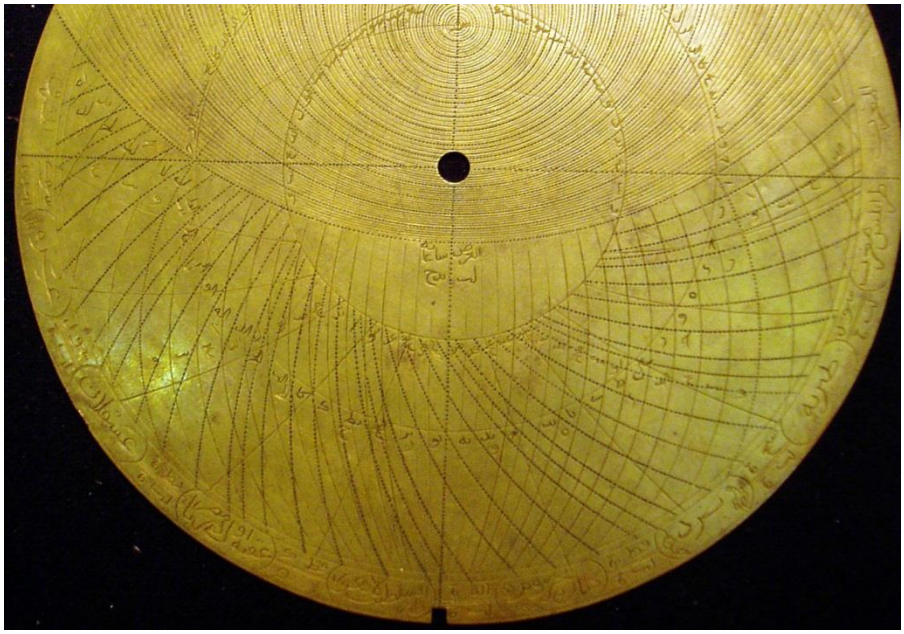


Figure A016.5 – Plate for latitude 32° (Photo by the Author)

Below the Tropic of Capricorn, the names of eight localities situated on the latitude of 32° and their coordinates are engraved as follows:

Table A016-3 Places where this plate can be used

	Place Name	L	φ	
1	Ṭarabulus Maghrib	66;30	32;0	Tripoli
2	Ṭiberiyya	68;0	32;0	
3	Yazd	89;0	32;0	
4	Kanār Bahr Rūm	25;0	32;0	Edge of the Roman Sea
5	Dar al-Saltanat Lāhūr	109;20	31;50	Lahore
6	cAqabah Daryā Miṣr	59;0	32;0	
7	cAsqalān	66;30	32;0	
8	cUrih-- ?	66;20	32;0	

GEOGRAPHICAL GAZETTEER

The gazetteer of 69 localities is arranged in three circles with varying patterns; in the first two circles, the data are inscribed in two different styles of cartouches, in the third circle in a spiral formation.

The localities are organized according to climates, which are mentioned at appropriate places above the three circles. Very few Indian towns are listed in this gazetteer. Lucknow occurs for the first time, but not Lahore and Agra probably because they are mentioned in the gazetteers engraved on the plate. Of the places outside India, Mecca and Medina are not listed, but they may have been listed on the respective plates.



Figure A016.6 – Geographical gazetteer (photo by S. R. Sarma)

Table A016-4 Geographical Gazetteer

	Place Name	L	φ
	Outer Circle		
[-I] *az khaṭṭ istiwā' tā iqlīm awwal* (from the equator to the first climate)			
01	Sāḥil Baḥr Awqiyānūs	11;0	0;0
02	Ghāna Maᶜadan al-Dhahab	39;0	10;0
03	Kūkū	14;0	10;0
04	Zaghāwa	66;0	1;10
05	Jamkūt	176;0	5;0
06	Kankandaz	180;0	0;0
[I] *al-iqlīm al-awwal 12 48* (the first climate [beginning at Lat] 12;48°)			
07	Dunqula	53;0	14;30
08	Jabil	75;0	13;00
09	Janad	75;30	14;30
10	Ṣanaᶜān	77;0	14;30
11	Damār	77;15	13;30
12	Jurshan	77;50	17;15
[II] *al-iqlīm al-thānī 20 31* (the second climate [beginning at Lat] 20;31°)			
13	ᶜAllāqī	68;0	47;15
14	Khaybar	75;20	24;20
15	Fayd	78;10	26;50
16	Kanbāyat	109;20	22;20
17	Dawlatābād	111;0	20;30
18	Kawāliyar	114;0	26;29

	Place Name	L	φ
19	Lakhnaū	114;53	26;30
20	Jawnbūr	119;6	26;36
21	Ajmīr	104;5	26;0
22	Awadh	118;6	27;22
23	Burhānbūr	113;0	20;30
[III] *al-iqlīm al-thālith 2734* (the third climate [beginning at Lat] 27;34°)			
24	Qayrawān	41;15	31;15
25	Mahdiyya	42;15	34;30
26	Miṣr	63;0	30;20
27	Bayt al-Maqdis	66;30	31;50
28	Dimashq	70;0	33;20
29	Baghdād	80;15	33;20
30	Iṣfahān	86;40	33;25
31	Fīrūzābād	87;30	28;10
	Middle Circle		
[III] *tatimma iqlīm al-thālith 27 34* (continuation of the third climate [beginning at Lat] 27;34°)			
32	Kirmān	91;30	30;5
33	Qandahār	107;40	33;0
34	Multān	106;25	25;40!
35	Sālkūt	109;0	33;0
36	Bānīhata	113;20	28;52 Panipat
37	Dihlī Dār al-Mulk Hind	113;35	28;39
[IV] *iqlīm al-rābiᶜ 33 43* (the fourth climate [beginning at Lat] 33;43°)			

	Place Name	L	φ
38	ᶜĀna	76;30	34;0
39	Qazwīn	105;0	36;15
40	Hamadān	83;0	36;0
41	Ḥalab	72;10	35;50
42	Harāt	94;20	34;30
43	Mashhad Qᶜuds	92;30	36;0
44	Astarābād	89;35	36;50
45	Kashmīr	105;0	35;0
46	Balkh	101;0	36;41
47	Badakhshān	104;25	36;10
48	Marāgha	80;0	36;20
49	Marw	97;0	37;40
[V] *al-iqlīm al-khāmis 39 1* (the fifth climate [beginning at Lat] 39;1°)			
50	Bardaᶜa	83;0	40;30
51	Samarqand	99;16	39;37
52	Khujand	105;35	41;55
53	Farghāna	104;0	42;20
54	Aylāq	99;10	43;20
	Inner Circle		
[VI] *al-iqlīm al-sādis 43 30* (the sixth climate [beginning at Lat] 43;30°)			
55	Halīqiya	20;0	46;0
56	Yanbalūna	34;55	45;15
57	Heraqla	67;20	46;30
58	Kāshghar	106;30	44;0

	Place Name	L	φ
59	Bīsh Bāligh	111;0	45;50
60	Khān Bāligh	124;0	46;0
[V] *al-iqlīm al-sābiᶜ 47 33* (the seventh climate [beginning at Lat] 47;33°)[262]			
61	Aqjākirmān	65;0	50;0
62	Qirqir	65;30	50;0
63	Ṭirnū	67;30	50;15
64	Araq	105;0	48;0
65	Ṣarāy	106;0	48;0
[VII+] *khārij az iqlīm ṭaraf shamāl* (beyond the climates in the northern extremity)[263]			
66	Mārīkirmān	65;50	50;0
67	Jazāīr Qūlī	*aṭwā*	64;0
68	Jazāīr Rūdjard	*lahāghīr*	62;0
69	Nahāyah Bahr Awqiyānūs	*maᶜlūm*	71;0

[262] Elsewhere the latitude is 47;38°.

[263] Nos. 67, 68, 69 are mentioned also in the gazetteer of Muqim's astrolabe of 1643 (A030) but without any longitudes, probably because these localities stretch over several longitudes. The words engraved in the column of longitudes in the present astrolabe are intriguing.

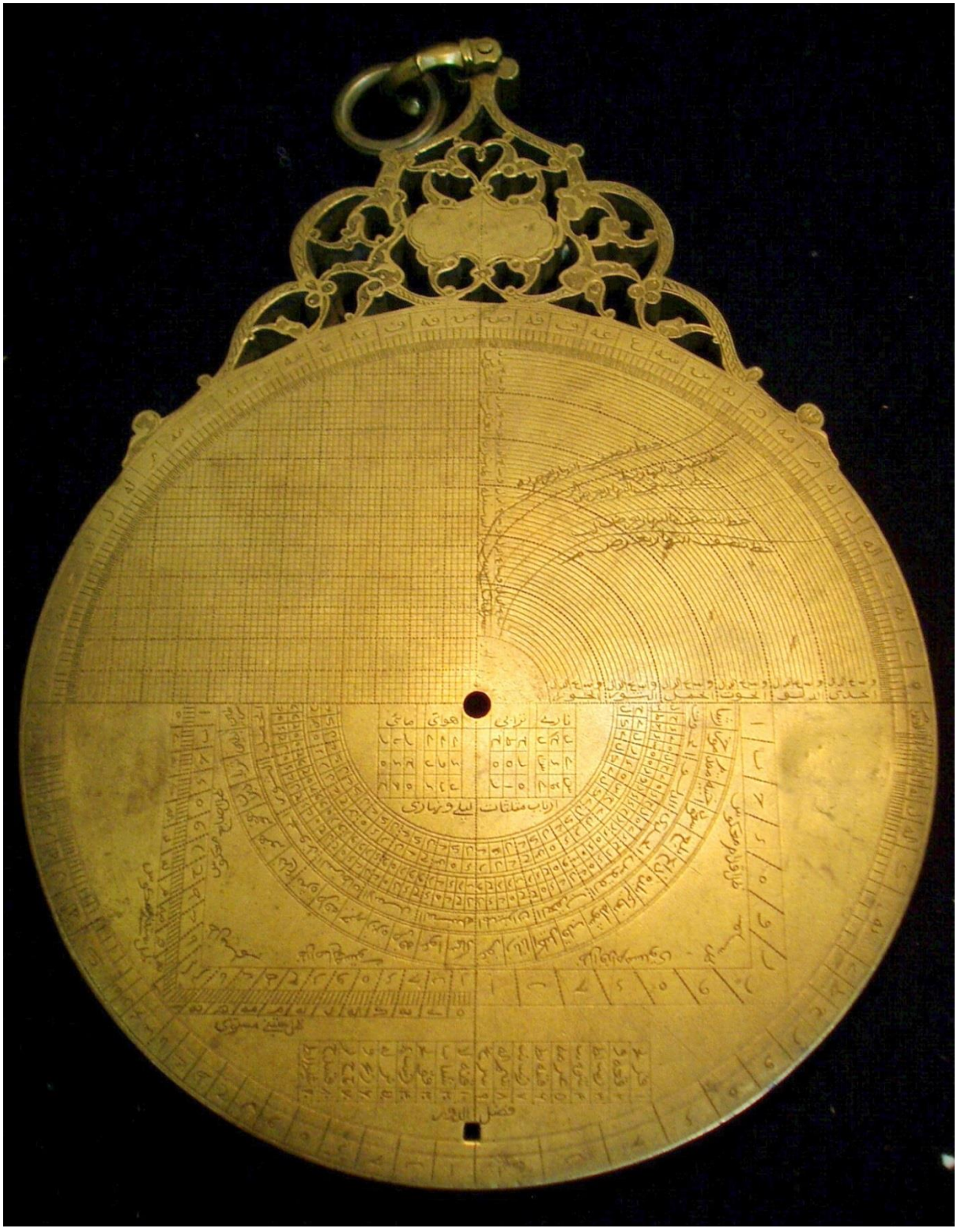


Figure A016.7 – Back of the astrolabe (photo by S. R. Sarma)

BACK

On the back the rim of the two upper quadrants carries the altitude scales which are divided in 5°, 1° and 0;20° and numbered as 5—90; 90—5.

The upper left quadrant is engraved with a sine-cosine graph with 60 horizontal and 60 vertical parallels, each fifth line being highlighted with dots. In the upper right is the solar quadrant with declination arcs for each 3° of solar longitude; of these every tenth arc which forms the boundary between two zodiac signs is dotted. The names of the signs as also the numbers of 1/5 parts of the signs are inscribed along the two radii. Five sigmoid curves for the meridian altitude of the sun throughout the year at the latitudes of 15°, 19°, 27°, 32° and 40° are plotted on this quadrant. These are labelled *khaṭṭ niṣf al-nahār bi-ᶜarḍ* followed by the value of the latitude in *Abjad.*

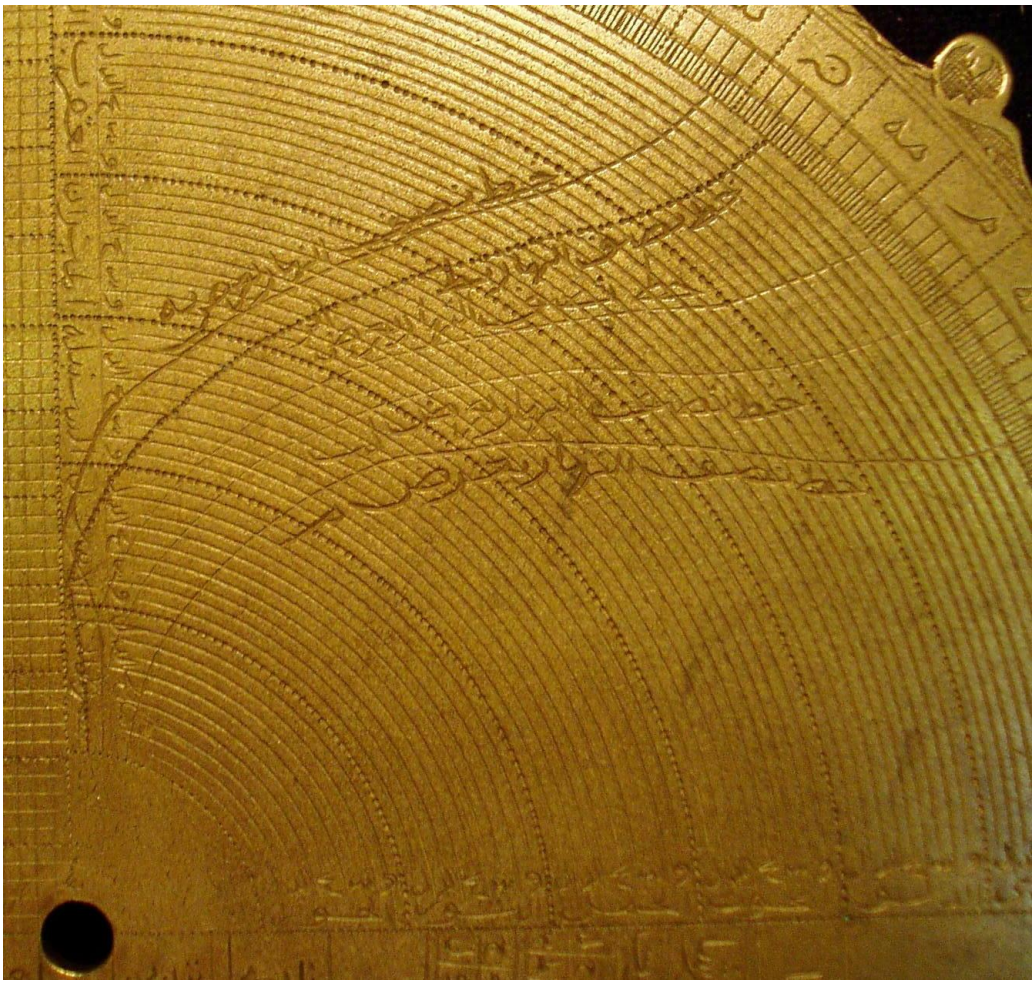


Figure A016.8 – Upper Right Quadrant with the five curves for the meridian altitude of the sun (photo by S. R. Sarma)

In the lower half are drawn the shadow squares, on the left for a base of 12 and 60 and on the right for a base of 7. On the left the vertical and horizontal scales have three bands each; first the scales are divided in 12 units and numbered accordingly in the inner band of the vertical scale and in the upper band of the horizontal scale. In the middle band, each unit (1/12th part) is divided in 5 sub-units. In the outer band these sub-units are numbered in 5s; from 5 to 60.

The vertical scale has the label *ẓill sullam aṣābiᶜ maᶜkūs* and the horizontal scale is accompanied by the label *ẓill sullam aṣābiᶜ mustawī.* These labels are inscribed inside the shadow squares. Outside the shadow squares, there are additional labels for the sexagesimal scale; to the left of the vertical scale is engraved *ẓill sittaynī maᶜkūs* and under the horizontal *ẓill sittaynī mustawī.*

The shadow square on the right is simpler. Here the horizontal and vertical scales are divided in 7 parts each and numbered accordingly. The horizontal scale is accompanied by the label *ẓill sullam aqdām mustawī* and the vertical scale by *ẓill sullam aqadām maᶜkūs.*

Within these shadow squares are engraved six concentric semi-circular rows. In the outermost row are engraved the names of the 28 lunar mansions and in the next row the names of the 12 corresponding zodiac signs. These are followed by two rows which contain a table of limits (*al-ḥudūd*) and two more rows containing a table of decans and their regents (*al-wujūḥ*). These semi-circular rows enclose a rectangular table which is engraved immediately below the horizontal diameter. Entitled *arbāb muthallathāt laylī wa nahārī*, this table displays the triplicities and their diurnal and nocturnal regents, divided in four sub-tables according to their natures, viz. fiery (*nārī*), earthy (*tarābī*), airy (*hawā'ī*) and watery (*mā'ī*).

Below the shadow squares is another rectangular table with the heading *faḍl al-dawr*, showing the multiples of differences in degrees and minutes between the length of the tropical year and 365 days.

On the rim of the lower half are engraved cotangent scales, on the left in digits and on the right in feet. The unequal divisions in the scale on the left are numbered clockwise from the meridian as 1, 2, 3, …15, 20, 25, … 90, followed by the label *al-aṣābiᶜ*. The unequal divisions in the scale on the right are numbered anticlockwise from the meridian as 1, 2, 3, …10, 15, 20, … 90, followed by the *label al-aqdām.*

BIBLIOGRAPHY

Christie's, London, catalogue: 29 September 1988, lot no. 287.

Maddison & Savage-Smith 1997, I, no. 126, pp. 220-223.

A017 ASTROLABE BY QĀIM MUḤAMMAD & MUḤAMMAD MUQĪM

Not dated

Diameter 120 mm[264]

Baghdad, Museum of Arab Antiquities (#9720) = National Museum of Iraq

CCA 3820=3826; Répertoire lists this astrolabe as Muḥammad Muqīm 2

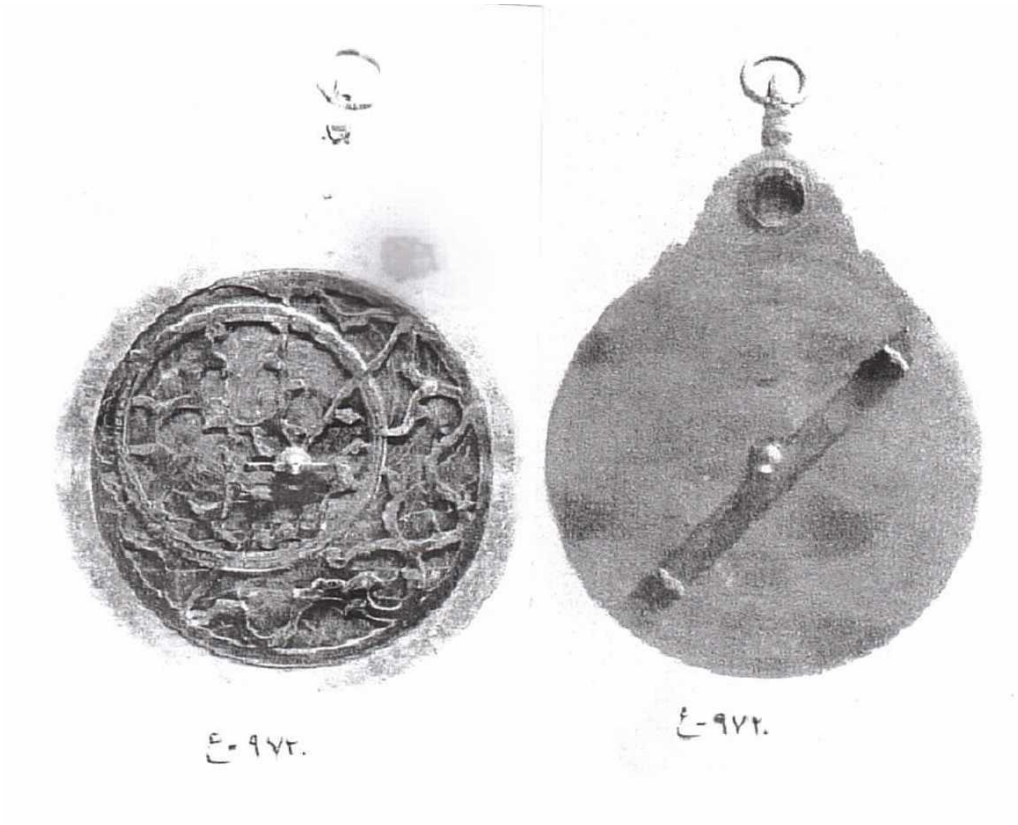


Figure A017.1 – Front and back of the astrolabe (from King 2005, p. 435)

The inscription on the back of this astrolabe is cited in the Répertoire:

> *tam al-ᶜamal bi-yadī aḍᶜafī al-ᶜbād qā'im muḥammad wa muḥammad muqīm ibnī mullā ᶜīsā ibn allāhdād asṭurlābī humāyūnī lāhūrī*
>
> 'The work was achieved by the hands of the weakest of the servants [of God], Qā'im Muḥammad and Muḥammad Muqīm, the two sons of Mullā ᶜĪsā, the son of Allāhdād of Lahore, the astrolabe maker of [the Emperor] Humāyūn.'

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[264] Both King and the Répertoire state that this astrolabe (#9720) and the one by Qā'im Muḥammad (A012) (#9721) measure 12 cm. But from the photos published in King 2005, p. 345, the relative dimensions of the two astrolabes at the Baghdad Museum can discerned: #9720 is 1.36 times larger than #9721. If #9721 measures 120 mm, #9720 should have a diameter of about 164 mm.

No date is mentioned in the inscription. The Répertoire estimates it c. 1018 = AD 1609/10, because the Hannover astrolabe by 'the two sons of ᶜĪsā' (A009) is dated in this year. But it is not certain if the expression 'two sons' in these astrolabes refers to the same pair of brothers. Even if it does, A008 is a juvenile work, whereas the present astrolabe appears to be a mature product of the 1620s.

BIBLIOGRAPHY

Faransīs & Naqshabandī 1957, pp. 25-28.

King 2005, pp. 434-435.

Répertoire, s.v. Muḥammad Muqīm, no. 2.

MUḤAMMAD MUQĪM

Muḥammad Muqīm (*fl.* 1621-1659) is the second son of Mullā ᶜĪsa and a grandson of the patriarch Allāhdād. He is a prolific astrolabe maker. There are extant 33 astrolabes and 1 celestial globe which bear his signature.[265] There are also eight unsigned astrolabes which can be attributed to him. He also produced an astrolabe jointly with his elder brother Qā'im Muḥammad (A017). There is yet another astrolabe in Hannover (A009) which is said to have been produced by the sons of ᶜĪsā (*ibnī ᶜīsā ibn allāhdād*), but it is uncertain whether these sons are indeed Qā'im and Muqīm and whether the inscription itself is authentic.

Muqīm's brother Qā'im made a name for himself in casting celestial globes by the *cire perdue* process. Muqīm seems to have produced just one single globe.[266] Muqīm's main forte is the astrolabe. Although he made a large number of astrolabes, he rarely repeats the design or even the size. The sizes of his astrolabes range from 344 to 45 mm in diameter. While the one with the diameter of 45 mm is the world's smallest astrolabe (A050), there are about a dozen small pieces with diameters measuring less than 100 mm. Neither the large ones nor the very small pieces are really convenient for actual use, but must have been highly prized collector's items at the Mughal court.

Unlike the other members of his family, he does not add non-standard features in his astrolabes. The only exception are two astrolabes with zoomorphic retes (A026) and (A051). While Allāhdād gives bird shapes to two star pointers, α Lyrae and α Aquilae,

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265 No images are available for 8 of the 33 astrolabes. It is possible that the same astrolabe was listed twice in the CCA or in the Répertoire. The Peabody Essex Museum, Salem, MA, holds an astrolabe (# M2560) which the Museum thinks is 'possibly by Muhammad Maqim (sic!) at Lahore'. But it carries certain features characteristic of the astrolabes by Muḥammad Ṣāliḥ. Therefore it is attributed to him and will be described under B014. CCA 3565 records an astrolabe by Muqīm at the National Maritime Museum, Haifa. The museum sent me some images of the astrolabes in their holdings, but none of these can be by Muqīm. Anon 1989, p. 4, states that in the collection at Arriyadh 'Mughal astrolabist Muhammad Muqim [is] represented by three instruments.' It cannot be determined which the three are.

266 Répertoire records, by mistake, two celestial globes: no. 12, dated 1049/1639-40, Kuwait, PC, and no. 17, dated 1067/1656-57, London, Victoria and Albert Museum (#2324-1883). The second globe is actually by Ḍiyā' al-Dīn as the inscription cited in the Répertoire clearly indicates.

in his undated astrolabe (A002), the grandson Muqīm fills the retes with dozens of zoomorphic and anthropomorphic shapes.[267]

Muqīm's elegantly crafted *kursīs* are generally reticulated, but display much variety. Some have highly complex patterns; some others are pierced by just a few large incisions so that what remains looks like an arrangement of tulips, their flared petals forming the profiles of the *kursī* (A020, A021, A049, A058). Some *kursīs* are solid without any reticulation. In two cases florals patterns are engraved in low relief (A032 and A036); two others have extravagant profiles (A042 and A056).

Likewise, the floral traceries connecting the various star pointers in the rete also display much variety. A recurring motif in these retes are bell-shaped flowers or tulips with two flared petals, one long and another short, the longer petal usually forming the star-pointer.

The back contains a trigonometric quadrant in the upper left and a solar quadrant in the upper right with two sigmoid graphs for the latitudes of the two imperial cities of Agra (27°) and Lahore (32°). In three astrolabes (A040, A054, A057), lines for *ʿasr* prayers are drawn in the solar quadrants. In A056 there is a universal horary quadrant in the upper right. In the lower half are engraved double shadow squares and an assortment of astrological tables. The latter vary according to size of the astrolabe. In smaller astrolabes, just two semicircular rows display the names of the 12 zodiac signs and the names of the 28 corresponding lunar mansions. In larger astrolabes, there are usually tables of the limits, faces or decans, triplicities, multiples of excess of revolution; sometimes also tables of climates.

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267 On zoomorphic astrolabes, see Gingerich 1987a.

A018 ASTROLABE BY MUḤAMMAD MUQĪM, 1030 AH (AD 1621-22)[268]

Diameter ca. 130 mm

PLU, Ex-Kazan, Russia

Répertoire 3

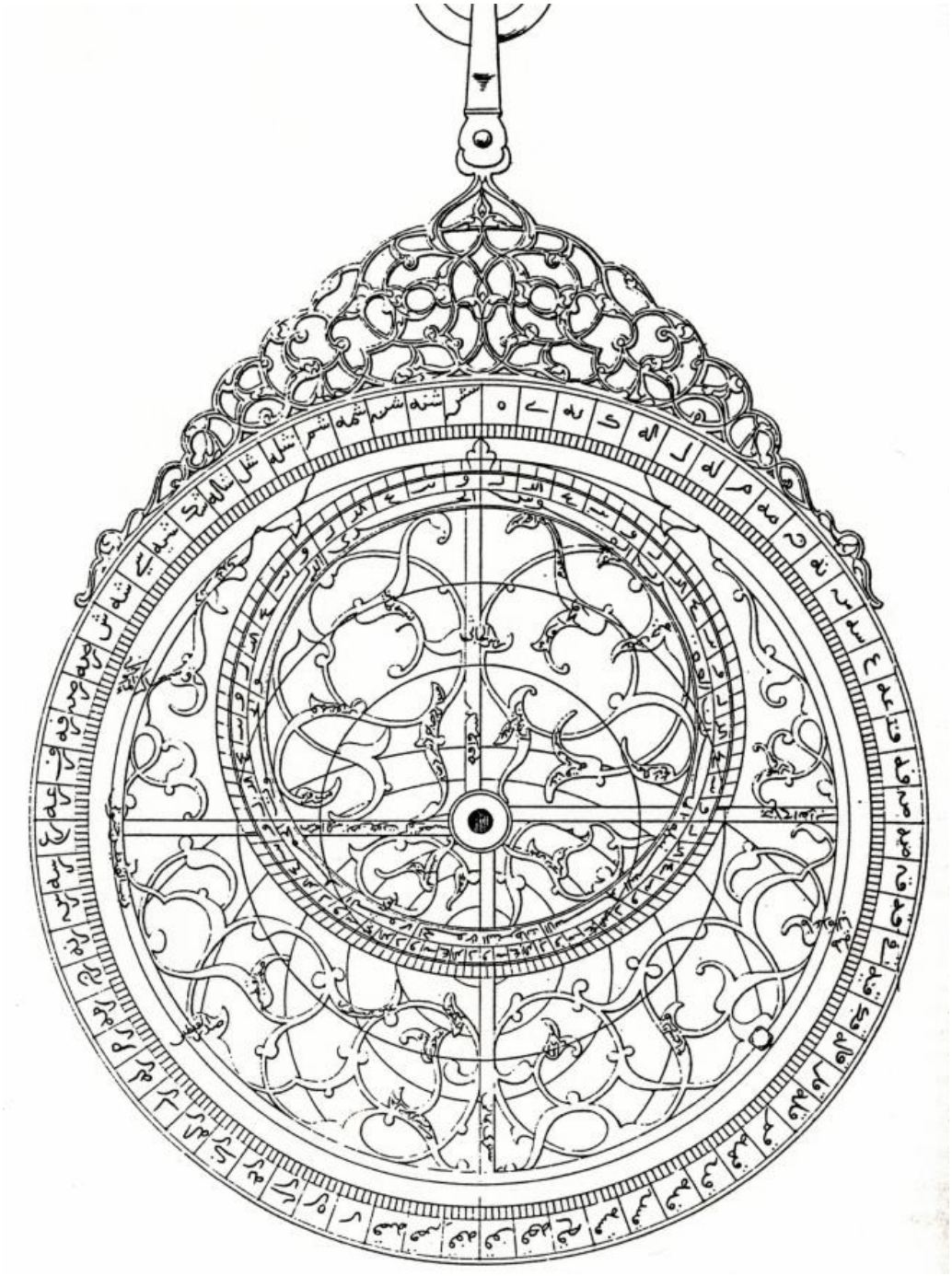


Figure A018.1 – Front of the astrolabe (from Dorn 1842)

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[268] Entry based on Dorn 1842.

This is the earliest extant astrolabe signed by Muḥammad Muqīm; even so it is a mature product displaying his technical and artistic skills. In 1842, when Dorn described it, it was in the private collection of Mirza Alexander Kasembeg who was a professor at the University of Kazan, the capital city of Tatarstan in Russia. It is not known what happened to the astrolabe subsequently. Perhaps it is in some private or public collection in Russia. Dorn provides excellent line drawings of the front and back of the astrolabe, which are so clear that all the inscriptions can be read and the beauty of the instrument appreciated. But, in his detailed description of the astrolabe, Dorn fails to mention the size of the astrolabe. It is probably of medium size, ca. 130 mm, as the altitude circles were drawn for every 3°on the plates.

COMPONENTS

Body with *kursī,* shackle and ring, rete for 38 stars, 5 plates, pin and horse. The alidade is missing.

FRONT

The ring is fairly large; the bases of the shackle are faintly trifoliate. The *kursī* is very intricately pierced with foliate design, with lobed profiles and a trifoliate finial. It is one of exquisitely crafted *kursīs* in the Indo-Persian astrolabes.

The scale on the limb is divided in 1° and 5° and numbered from 5 to 360 in clockwise direction.

RETE

The two rings of the Capricorn and ecliptic are held together by complete equinoctial and solstitial bars which are counter-changed at the centre. The space between the two rings and that inside the ecliptic ring is filled with arabesque tendrils with leaves and tulip-like flowers with two flared petals, one of which is much longer. This motif of tulips with two flared petals occurs in several astrolabes by Muqīm.

Table A018-1 Stars on the Rete

	Star Name	Identification
01	*Dhanab al-Qayṭus Janūbī*	β Ceti
02	*Batn al-Ḥūt*	β Andromedae

	Star Name	Identification
03	*Rijl al-Musalsala*	γ Andromedae
04	*Fam al-Qayṭus*	γ Ceti
05	*Ṣadr al-Qayṭus*	π Ceti
06	*ᶜAyn al-Thawr*	α Tauri
07	*ᶜAyyūq*	α Aurigae
08	*Rijl Jawjā' Yusrā*[269]	β Orionis
09	*Yad Jawjā' Yusrā*	γ Orionis
10	*Yad Jawjā' Yumnā*	α Orionis
11	*Shiᶜrā Yāmānī*	α Canis Majoris
12	*Shiᶜrā Shāmī*	α Canis Minoris
13	*Fard al-Shujāᶜ*	α Hydrae
14	*Ẓahr Dubb Akbar*	α Ursae Majoris
15	*Qāᶜidat al-Bāṭiya*	α Crateri
16	*ᶜAnāq*	ξ Ursae Majoris
17	*Janāḥ al-Ghurāb*	γ Corvi
18	*Simāk Aᶜzal*	α Virginis
19	*Simāk Ramiḥ*	α Bootis
20	*Nayyir Fakkah*	α Coronae Borealis
21	*ᶜUnuq Ḥayyah*	α Serpentis
22	*Rās al-Jāthī*	α Herculis
23	*Rās al-Ḥawwā*	α Ophiuchi
24	*ᶜAyn al-Tinnīn*	γ Draconis

269 Dorn 1842 records the name as *jawjā yasrā rijl.*

	Star Name	Identification
25	*Yad Ḥawwā Yumnā Muqaddam*[270]	δ Ophiuchi
26	*Nasr Wākiᶜ*	α Lyrae
27	*Minqār Dajājah*	β Cygni
28	*Nasr Ṭā'ir*	α Aquilae
29	*Dhanab Dajājah*	α Cygni
30	*Fam al-Faras*	ε Pegasi
31	*Dhanab al-Jadī*	δ Capricorni
32	*Sāq Sākib al-Mā' Janūbī*	δ Aquarii
33	*Mankib Faras*	β Pegasi
34	*Kaff al-Khaḍīb*	β Cassiopeiae
35	*Al-Faras Nathra*	?
36	?	
37	?	
38	?	

PLATES

There are five plates serving the following latitudes

Table A018-2 Plates

	φ	Longest Day
1a	35°	14;12 hours
1b	32°	14;8 hous

[270] Dorn 1842 reads this as two stars: (17) *muqaddam* and (18) *yad ḥawwā yumnā.*

	φ	Longest Day
2a	36° + 42°	14;28 hours; 15;5 hours
2b	40°	14;52 hours
3a	25°	13;36 hours
3b	no inscription about the latitude	
4a	22°	13;21 hours
4b	27°	13;43 hours

Dorn does not describe the fifth plate; perhaps it contained the ecliptic coordinates on one side and the multiple horizons on the other. About the four plates, Dorn states that they carry altitude circles for every 3°, but does not mention the azimuths or hour lines. It is surprising that the projections for the two imperial cities of Agra (27°) and Lahore (32°) are not engraved on the two sides of the same plate as is done often in Mughal astrolabes.

GEOGRAPHICAL GAZETTEER

On the inner side of the mater a gazetteer of 63 localities with their longitudes and latitudes is engraved in two concentric circles. In the outer circle are listed Central Asian localities and in the inner circle several places of northern India. The localities are arranged roughly according to increasing longitude. It is remarkable that the enumeration does not commence with Mecca.

Table A018-3 Geographical Gazetteer

	Place Name	L	φ
	Outer Circle		
01	Qayrawān	41;0	31;40
02	Miṣr	65;20	30;20
03	ᶜAdan	76;0	11;0
04	Madīnat Rasūl		

	Place Name	L	φ
	ᶜAlayhi al-Salām	75;20	25;0
05	Makka Muᶜaẓẓam	77;10	21;40
06	Hazar Baḥrayn	83;0	25;15
07	Bayt al-Maqdis	66;30	31;50
08	Dimashq	70;0	33;15
09	Ḥalab	72;10	35;50
10	Iṣṭanbul	59;50	45;0
11	Nakhjawān	81;15	38;40
12	Marāgha	82;0	37;20
13	Tabrīz	82;0	38;0
14	Bardaᶜa	85;0	40;30
15	Bāb al-Abwāb	85;0	43;0
16	Bulghār	90;0	49;30
17	Kūfa	79;30	31;30
18	Baghdād	80;0	35;25
19	Baṣra	84;0	30;11
20	Fīrūzābād	87;30	28;10
21	Yazd	89;0	32;0
22	Shīrāz	88;10	29;36
23	Hamadān	83;0	35;10
24	Qazwīn	85;0	36;0
25	Iṣfahān	86;40	32;25
26	Kāshān	86;0	34;10
27	Astarābād	89;35	36;50

	Place Name	L	φ
28	Busṭām	89;30	36;20
29	Sabzwār	91;20	36;5
30	Nīshābūr	92;30	36;21
31	Ṭūs	92;30	36;0
32	Harat	94;20	34;30
33	Marw	97;0	37;40
34	Balkh	101;0	36;41
35	Badakhshān	104;24	37;10
36	Bukhārā	97;30	39;50
37	Samarqand	98;35	38;37
38	Khujand	100;33	41;55
39	Kashghar	106;30	44;0
	Inner Circle		
40	Khutan	107;0	42;0
41	Hurmūz	92;0	25;50
42	Ghazna	104;20	33;35
43	Kābul	101;40	34;30
44	Peshawar	107;10	33;25
45	Dabīl	102;30	25;10
46	Bakir	105;0	27;40
47	Qandahār	107;40	33;0
48	Utsch ?	106;20	28;40
49	Multān	107;35	29;40
50	Lāhūr	109;20	31;50

	Place Name	L	φ
51	Siālkūt	109;0	33;0
52	Tubbat	110;3	40;0
53	Kashmīr	105;0	35;0
54	Sarandīb	130;0	10;0
55	Haḍrat Dihlī	108;35	28;15
57	Kannawj	105;50	26;33
58	Banāras	117;20	26;55
59	Tānesar	112;3	30;10
60	Akrah	114;0	27;13
61	Kawāliyar	115;0	26;29
62	Ujjayn	102;0	22;30
63	Kanbāyat	109;4	22;20

BACK

On the back, the entire rim is divided in 1° and 5° and groups of 5° are numbered from 5 to 90, separately for each of the four quadrants (not only for the two upper quadrants as is the common practice), starting from the east and west points and reaching up to the south and north points.

The upper left quadrant carries a trigonometric graph with 60 horizontal parallels. The solar quadrant on the right is divided by 18 declination arcs, one for each 10° solar longitude. On the two radii are marked the serial numbers of the zodiac signs and the 1/3 parts thereof as 10, 20, 30. Upon this quadrant are projected two graphs of meridian altitude of the sun in all seasons for the latitudes of 27° and 32°, which are the latitudes of the two imperial cities of Agra and Lahore. These carry the labels *khaṭṭ niṣf al-nahār ᶜarḍ k.z* and *khaṭṭ niṣf al-nahār ᶜarḍ l.b.*

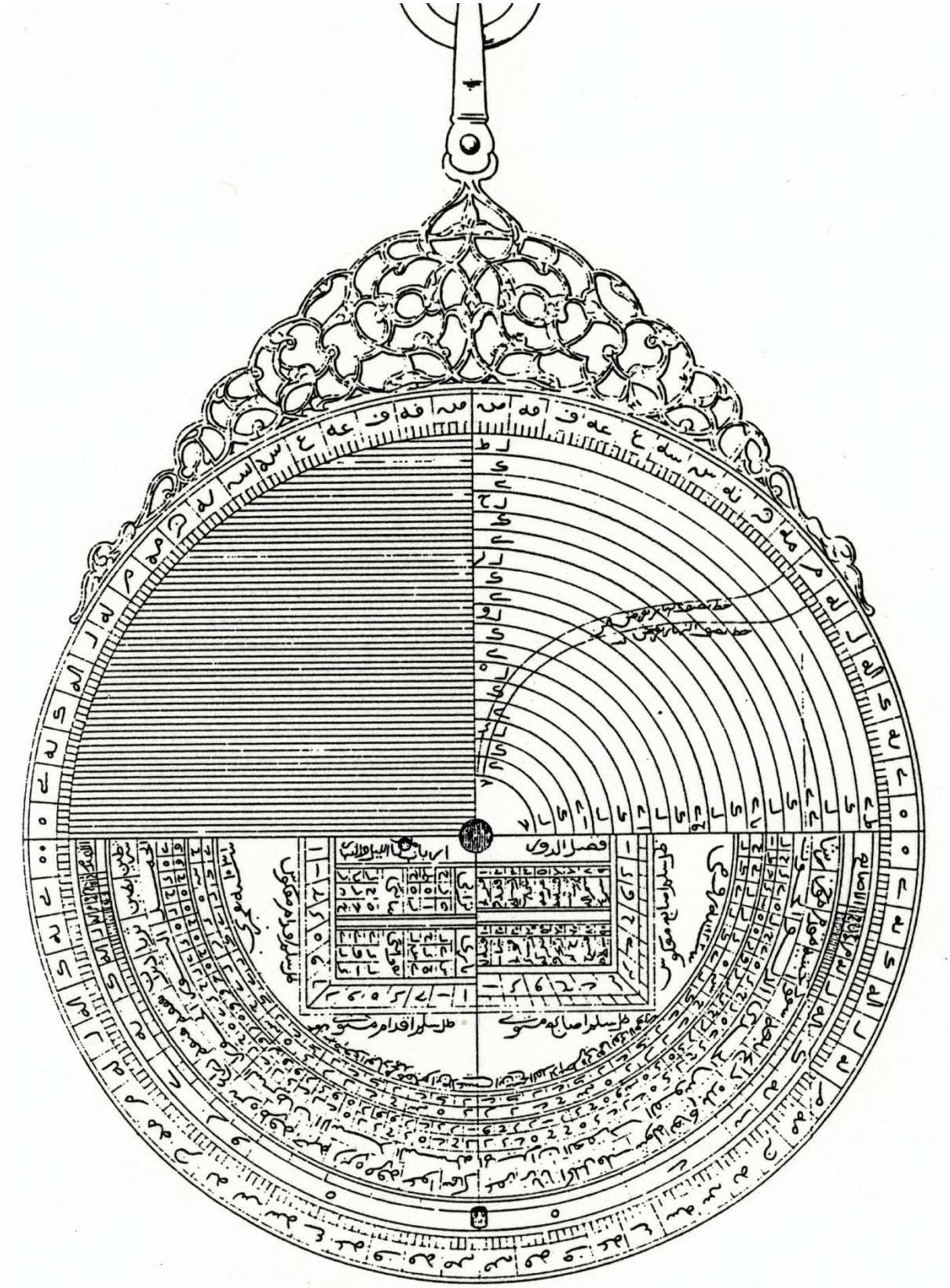


Figure A018.2 – Back of the astrolabe (after Dorn 1824)

There are two shadow squares in the lower half, on the left for a base of 7 and on the right for a base of 6/12. The vertical and horizontal scales on the left are divided into

7 parts and those on the right into 6 parts and numbered accordingly. The four scales are accompanied by the usual labels.

Vertical scale on the left: *ẓill sullam aqdām maᶜkūs*

Horizontal scale on the left: *ẓill sullam aqdām mustawī*

Horizontal scale on the right: *ẓill sullam aṣābiᶜ mustawī*

Vertical scale on the right: *ẓill sullam aṣābiᶜ maᶜkūs*

There are two tables inside these shadow squares. The table on the left has the heading *arbāb muthallathāt al-layl wa al-nahār* (regents of the triplicities at night and in the day). Here in the three rows in each category, the middle row shows the zodiac signs, the first row the regents of the night and the third row the regents of the day.[271] The signs are represented by their serial numbers (0 = Aries) and the planets by the last letters of their Arabic names.

Table A018-4 Triplicities

Fiery *nārī*			Earthy *tarābī*		
Sun	Jupiter	Saturn	Venus	Mercury	Mars
Aries	Leo	Sagittarius	Taurus	Virgo	Capricorn
Jupiter	Sun	Saturn	Moon	Venus	Mars
Airy *hawā'ī*			Watery *mā'ī*		
Saturn	Mercury	Jupiter	Venus	Mercury	Moon
Gemini	Libra	Aquarius	Cancer	Scorpio	Pisces
Mercury	Saturn	Jupiter	Mars	Venus	Moon

On the right is a table with the heading *faḍl al-dawr* (excess of revolution); it shows the multiples of the difference between the length of the tropical year and 365 days. It is the first time that this table appears on a Lahore astrolabe.

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[271] The arrangement is different from the same table in the astrolabe of 1635 by Qā'im Muḥammad (A013).

Table A018-5 Excess of Revolution

1	87 33	10	155 31
2	175 6	20	61 2
3	262 39	30	106 33
4	350 12	40	262 4
5	77 45	50	57 35
6	164 19	60	213 6
7	252 52	70	08 37
8	340 25	80	164 8
9	67 58	90	319 39

Below the shadow squares, there are 10 concentric semi-circular rows. Starting from the outside, these rows contain the following.

1-2. Row 2 carries the degree scale as in the upper half, while the groups of 5° are numbered in row 2, as in the upper half.

3-4. The cotangent divisions on the shadow squares are projected on row 3. In the left half are the divisions in feet. There are 14 unequal divisions carrying the numbers 5, 6, 7, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60. At the end, just below the horizontal diameter is the word *al-qadām.* To the right of the meridian line, the band is divided in 13 unequal divisions, which are marked with the numbers, from the meridian onwards 5, 10, 12, 15, 20, 30, 35, 40, 45, 50, 55, 60, followed by the expression *al-aṣābiʿ.* In the next row are the subdivisions of the cotangent scales.

5. The names of the 28 lunar mansions

6. The names of the corresponding zodiac signs.

7-8. Rows 7-8 carry the table limits of signs (*ḥudūd*) as shown below.

Table A018-6 Limits of the Signs

Aries	Jupiter 6	Venus 6	Mercury 8	Mars 5	Saturn 5
Taurus	Venus 8	Mercury 6	Saturn 5	Jupiter 8	Mars 3
Gemini	Mercury 6	Jupiter 6	Venus 5	Mars 7	Saturn 6
Cancer	Mars 7	Venus 6	Mercury 6	Jupiter 7	Saturn 4

Leo	Jupiter 6	Venus 5	Saturn 7	Mercury 6	Mars 6
Virgo	Mercury 7	Venus 10	Jupiter 4	Mars 7	Saturn 2
Libra	Saturn 6	Mercury 8	Jupiter 7	Venus 7	Mars 2
Scorpio	Mars 7	Venus 4	Mercury 8	Jupiter 5	Saturn 6
Sagittarius	Jupiter 12	Venus 5	Mercury 4	Saturn 5	Mars 4
Capricorn	Mercury 7	Jupiter 7	Venus 8	Saturn 4	Mars 4
Aquarius	Mercury 7	Venus 6	Jupiter 7	Mars 5	Saturn 5
Pisces	Venus 12	Jupiter 4	Mercury 3	Mars 9	Saturn 2

9-10. Rows 9-10 display the decans (*wujūh*) and their lords, as shown below.

Table A018-7 Decans and Regents

Signs	10°	20°	30°
Aries	Mars	Sun	Venus
Taurus	Mercury	Moon	Saturn
Gemini	Jupiter	Mars	Sun
Cancer	Venus	Mercury	Moon
Leo	Saturn	Jupiter	Mars
Virgo	Sun	Venus	Mercury
Libra	Moon	Saturn	Jupiter
Scorpio	Mars	Sun	Venus
Sagittarius	Mercury	Moon	Saturn
Capricorn	Jupiter	Mars	Sun
Aquarius	Venus	Mercury	Moon
Pisces	Saturn	Jupiter	Mars

Alidade

The alidade is lost. There is a pin and a horse-headed wedge, both with matching tips.

Inscription

On the back, below the shadow squares, upside down along the semi-circular table:

> *ᶜamal bi-yad aḍᶜaf al-ᶜibād muḥammad muqīm ibn mullā ᶜīsā ibn shaykh allāhdād asṭurlābī humāyūnī lahūrī.*
>
> 'The work [done] by the hands of the weakest of the servants [of God] Muḥammad Muqīm, the son of Mullā ᶜĪsā, the son of Shaykh Allāhdād of Lahore, the astrolabe-maker of [the Emperor] Humāyūn.'

To the left of the shadow squares is engraved the date *sanah 1031 ḥijrī* ([in] the year 1031 Hijrī) and to the right *fī sanah 1933 rūmī* (in the year 1933 of the Rūmī era).

The Hijrī year 1031 corresponds to 16 November 1621 to 4 November 1622 and the year 1933 in the Rūmī or the Syro-Macedonian era to 11 October 1621 to 10 October 1622. The astrolabe therefore was completed during the period from 16 November 1621 to 10 October 1622.

Bibliography

Dorn 1842.

A019⊙ ASTROLABE BY MUḤAMMAD MUQĪM, 1032 AH (AD 1622-23)

Diameter 67.5 mm

Paris, PC

Répertoire 4



Figure A019.1 – Front of the astrolabe (photo by S. R. Sarma)

This is Muqīm's second smallest astrolabe. On the inner side of the mater, there is a grid for the geographical gazetteer but it was not filled in, which is very unusual. The alidade also has unusual ends.

Components

Body with *kursī* (d. 67.5, h. 91.5, t. 5.5), rete for 28 stars, 5 plates, alidade, pin and horse. Ring and shackle are missing.

Front

The *kursī* is worked *à jour*; the profiles are formed by ogees at the base and at the top, and two lobes in the middle; the finial is trifoliate. The front and back surfaces are not flat but elegantly contoured.

The limb is divided in 1° and 6° and numbered in 6s separately for each quadrant from 6 to 90 in the clockwise direction: 6—90; 6—90; 6—90; 6—90.

Rete

The narrow Capricorn ring and the much wider ecliptic ring are joined by the equinoctial bar with one counter-change. The ecliptic ring divided into the 12 signs of the zodiac and labelled, each sign is subdivided into groups of 6° and numbered. A large handle with a finely crafted tip on the rim is placed roughly between the west and south points. There are 12 star-pointers outside the ecliptic and 16 inside.



Figure A019.2 – Rete of the astrolabe (photo by S. R. Sarma)

Plates

There are 5 plates; four of these carry altitude circles for each 6°, azimuths below the horizon for every 10°, and lines for seasonal hours. The plates have notches at the north point.

Table A019-1 Plates

	φ	Longest Day
1a	36°	14;28 hours
1b	0° + 90°	
2a	32°	14;8 hours
2b	40°	14;52 hours
3a	18°	13;5 hours
3b	27°	13;43 hours
4a	22°	13;21 hours
4b	24° + 22° (?)	
5a	Plate of ecliptic coordinates	
5b	Plate of horizons	

Geographical Gazetteer

The inner side of the mater is engraved with a grid of two circles which are divided by radial lines for 28 + 16 cells, but not filled in with a geographical gazetteer. At the north point is a small peg which fits into the notches made in the corresponding place on the plates.

Back

The rim of the upper two quadrants bears an altitude scale divided in 1° and 6° and numbered as 6—90; 90—6.

The upper left quadrant with 30 horizontal parallels, each fifth highlighted with dots. The upper right quadrant is divided into 6 arcs, one for a pair of zodiac signs; their names are engraved along the two radii.



Figure A019.3 – Back of the astrolabe (photo by S. R. Sarma)

Shadow squares in the lower half. On the left for a base of 6/12, on the right for a base of 7. The vertical and horizontal scales are divided and numbered accordingly, with the usual labels.

The cotangent scales are extended to the rim of the lower half, inside which are two semi-circular bands bearing the names of the 12 zodiac signs and 28 lunar mansions respectively.

Alidade

The alidade is unusual, the line corresponding to the diameter of the astrolabe runs in the middle of the width and not on a side. There is no centre piece with the hole; instead the hole is in the width itself. The ends are shaped like lance-heads. It is does not carry scales. Obviously it is not original, but a replacement.

Inscription

Inside the shadow squares is the maker's inscription in two lines written upside-down:

> *ᶜamal bi-yad aḍaᶜaf al-ᶜibād muḥammad muqīm ibn mullā ᶜīsā*
> *ibn shaykh allāhdād asṭurlābī humāyūnī lāhūrī*
>
> 'The work [by] the hands of the least of the servants [of God], Muḥammad Muqīm, the son of Mullā ᶜĪsā, the son of Shaykh Allāhdād of Lahore, the astrolabe maker of [the Emperor] Humāyūn.

Below the shadow squares is written, also upside-down, *sanah 1032 hijrī* (AD 1622-23).

A020 ASTROLABE BY MUḤAMMAD MUQĪM, 1034 AH (AD 1624-25)

Diameter 86 mm

Istanbul, Kandilli Observatory (No. 6) [272]

Répertoire 5



Figure A020.1 – Front of the astrolabe (photo courtesy Professor Mustafa Aktar)

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[272] It is a pleasure to record the help of Professor Mustafa Aktar of the Kandilli Observatory and Earthquake Research Institute for providing me the images and other details of this astrolabe.

COMPONENTS

Body with *kursī* (d. 86, h. 129, t. 7.4), shackle and ring, rete for 35 stars, 5 plates, alidade and pin. The horse is missing.

FRONT

The ring is plain; the shackle is also plain but with a trifoliate shape. The *kursī* is very high (45 mm) with an unusually broad base occupying about 120° of the limb. In the *kursī* four large incisions are made in the form of bells or upside-down tulip flowers so that the left out portion looks like an asymmetrical arrangement of five flowers, the outlines of their petals forming the profiles of the *kursī.* Lines engraved parallel to the edge of the *kursī* and parallel to the edges of the four incisions give depth and emphasis to the tulip-shape of the incisions. Such incisions in the *kursī* is a favourite motif of Muqīm and this motif occurs in different variations in some of Muqīm's other astrolabes.[273] The *kursī* is topped with a prominent trifoliate finial.

The limb of the astrolabe is divided in 1° and 6° and labelled in 6s from 6° to 360°.

RETE

In the openwork rete, the slender ring of the Tropic of Capricorn and the much broader ring of the ecliptic are held together by the equinoctial bar which has a counter change at the centre. The space inside the two rings is filled by a tracery which joins the various star pointers. The latter are mostly curved like tiger's claws and on these are engraved the names of the corresponding stars.

The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names. Each sign is divided into groups of 6° and these divisions are numbered as 6, 12, 18, 24, 30, separately for each signs. The sloped edge of the ecliptic ring is also divided into groups of 6°. The first point of Capricorn on the ecliptic ring is extended like a small finger to reach up to the degree scale on the limb. To facilitate the rotation of the rete around the centre, a large handle is mounted on the ring of the Tropic of Capricorn, midway between the west and the north points.

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273 For example, in the astrolabe made in the same year which is now in the Mumtaj Mahal Museum at the Red Fort, Delhi (A019). See also A045 and A053.

Because of the small size of the astrolabe, the star names are often too small to be deciphered fully. In most cases, the Arabic article *al-* is omitted in the star names. In the following table, the stars are arranged according to the increasing right ascension, starting from the vernal equinox.

Table A020-1 Stars on the Rete

	Star Name	Identification
01	*Dhanab al-Qayṭus al-Janūbī*	β Ceti
02	*Rijl al-Musalsala*	γ Andromedae
03	*Fam al-Qayṭus*	γ Ceti
04	*Ṣadr al-Qayṭus*	π Ceti
05	*Rās Ghūl*	β Persei
06	*Tālī Masāfat al-Nahr*	γ Eridan
07	*ᶜAyn Thawr*	α Tauri
08	*Rijl al-Jawjā' al-Yusrā*	β Orionis
09	*Yad al-Jawjā' Yumnā*	κ Orionis
10	*Shiᶜrā Yamānī*	α Canis Majoris
11	*Shiᶜrā Shāmī*	α Canis Minoris
12	?	?
13	*Fard al-Shujāᶜ*	α Hydrae
14	*Qalb al-Asad*	α Leonis
15	*Ẓahr Dub Akbar*	α Ursae Majoris
16	*ᶜAnāq*	ζ Ursae Majoris
17	*Qāᶜidat al-Bāṭiya*	α Crateri
18	*Janāḥ al-Ghurāb*	γ Corvi
19	*Simāk Aᶜzal*	α Virginis
20	*Simāk Rāmiḥ*	α Bootis

	Star Name	Identification
21	*Nayyir Fakkah*	α Coronae Borealis
22	*ᶜUnuq al-Ḥayyah*	α Serpentis
23	*Rās Jāthī* (?)	α Herculis
24	*Rās al-Ḥawwā* (?)	α Ophiuchi
25	*ᶜAyn Tinnīn*	γ Draconis
26	[*Nasr*] *Wāqiᶜ*	α Lyrae
27	*Minqar Dajājah*	β Cygni
28	*Nasr* (?) *Ṭā'ir*	α Aquilae
29	*Dhanab al-Dulfīn*	ε Delphini
30	*Dhanab Dajājah*	α Cygni
31	*Fam Faras*	ε Pegasi
32	*Dhanab al-Jadī*	δ Capricorni
33	*Sāk Aāqib al-Mā'*	δ Aquarii
34	*Mankib* (?) *Faras*	β Pegasi
35	*Kaff Khaḍīb*	β Cassiopeiae

PLATES

There are five plates with small rectangular notches cut at the north point. The peg at the corresponding place on the limb fits into these notches and holds them in place.

Table A020-2 Plates

	φ	Longest Day
1a	22°	13;22 hours
1b	25°	13;25 hours
2a	27°	13;46 hours

	φ	Longest Day
2b	32°	14;8 hours
3a	36°	14;32 hours
3b	40°	14;54 hours
4a	0°+90° Double Projection	
4b	18°+30° Double Projection	
5a	Plate of ecliptic coordinates	
5b	Plate of horizons	

On plates 1 to 3, altitude circles are drawn for every 6° and azimuth arcs for every 10° below the horizon. Both the sets are numbered in the usual style. There are plain lines for seasonal hours. On plate 1 (22° and 25°) there are dotted lines for equal hours as counted from the western and eastern horizons; on plates 2 and 3, the dotted lines for equal hours are drawn from the western horizon. On all the three plates, under the western horizon is written *al-maghrib* and under the eastern horizon *al-mashriq.*

Plate 4 carries double projections on both the sides. Therefore, it ought to have two notches at the north and south points so that both projections could be made use of, but no notch was cut at the south point.

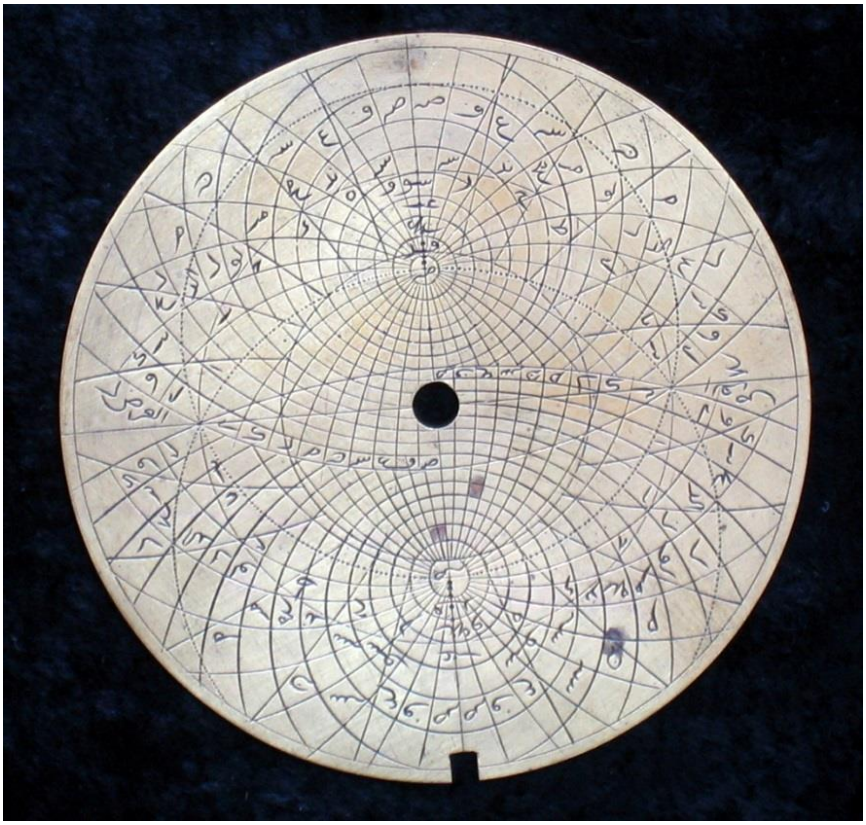


Figure A020.2 – Plate for latitudes 30° (above) and 18° (below)
(photo courtesy Professor Mustafa Aktat)

On 4a are engraved the stereographic projections for the zero latitude in the upper half and for 90° in the lower half. The equator and the tropic of Cancer are marked by dotted lines. In the upper half there are altitude circles for every 6° and azimuth lines for every 10°. Below the horizon are written on the west as well on the east lā carḍ lahu (there is no latitude).

In the lower half also altitude circles are drawn for each 6°. These are numbered from 6 to 90, starting from the equator and reaching up to the north celestial pole at the centre of the plate. Below the equator, the altitude circles from the equator up to the Tropic of Capricorn are numbered as 6, 12, 18 and 23;30. Lines for seasonal hours are drawn and numbered from 1 to 12, starting from the western horizon and reaching up to the western horizon. A little above the notch is a label stating carḍ tiscīn, ‘latitude ninety [degrees]’.

Plate 4b carries double projections for the latitude 30° in the upper half and for the latitude of 18° in the lower half, with their respective oblique horizons. In both projections, prime meridians are drawn as dotted circles. In both halves the altitudes circles are drawn for every 6° in such a way that the circles for altitudes 6° to 48° in

the in the upper half take a S-turn at the meridian and continue as the altitude circles in the lower half. The altitude circles are numbered in 6s on the eastern and western sides in both halves. In both projections azimuth curves are drawn for 10 degrees and numbered separately in the two projections. Lines for seasonal hours are drawn in both projections and numbered from 1 to 12, starting from the western horizon. In the upper half, below the eastern horizon is the label *al-ᶜarḍ 30,* 'the latitude 30 [degrees]'. In the lower half also, there is a label below its eastern horizon which merely reads *al-ᶜarḍ 18,* 'the latitude 18'.

Plate 5a contains a stereographic projection relative to latitude 66;30°, which is the complement of the total obliquity of 23;30°. Besides the projections of the equator and the two tropics, it also contains the projection of the ecliptic. The arcs radiating from the centre are the lines of the celestial longitudes at intervals of 10° or one decan. The circles of celestial latitudes are drawn for each 6° and numbered from 6 to 90 to the north of ecliptic and from 6 to 23;30 to the south of the ecliptic. The names of the zodiac signs are written along the ecliptic circle and below them the numerical values of each decan. The names of the ten signs *al-Dalw, al-Ḥūt, al-Ḥamal, al-Thawr, al-Jawjā', al-Saraṭān, al-Asad, al-Sunbulah, al-Mīzān, al-ᶜAqrab* are engraved outside the ecliptic circle and the remaining two names *al-Qaws, al-Jadī,* inside the ecliptic circle. There is, however, no label identifying the plate.

On plate 5b are drawn four sets of half horizons for each 2°for latitudes from 8° to 66° in four sets thus:

Table A020-3 Latitudes of the Horizons

8	16	24	32	40	48	56	64
10	18	26	34	42	50	58	66
12	20	28	36	44	52	60	
14	22	30	38	46	54	62	

Scales of declination are marked along each radius, for both south and north, which are divided into 3 and 6 units and labelled 6, 12, 18 and 23;30, the last value being the obliquity of the ecliptic. There is, however, no label engraved identifying the plate.

Notches should have been cut at the four points of compass so that the four sets of horizons can be made use of, but there is only the notch at the north point as in the rest of the plates. Therefore, the horizon plate is not completely functional.



Figure A020.3 – Geographical Gazetteer (Photo courtesy Professor Mustafa Aktar, Kandilli Observatory)

GEOGRAPHICAL GAZETTEER

On the inner side of the mater is engraved a geographical gazetteer in two concentric circles, providing the names (*al-bilād*), logitudes (*al-ṭūl*) and latitudes (*al-ᶜarḍ*) of 50 (35 + 15) localities.

Table A020-4 Geographical Gazetteer

	Place Name	L	φ
	al-bilād	*al-ṭūl*	*al-ᶜarḍ*
	Outer Circle		
01	Miṣr	63;20	30;20
02	Madīnat Rasūl	75;20	25;0
03	Makka Mubārak	77;10	21;40
04	Bayt al-Maqdis	66;30	31;50
05	Ṭarābulus Shām	69;40	34;0
06	Dimashq	70;0	33;15
07	Ḥalab	72;10	35;50
08	Qusṭanṭiniyya	59;50	44;0
09	Ṣaṭīl?	59;50	45;0
10	Tabrīz	82;0	38;0
11	Baghdād	80;0	33;25
12	Baṣra	84;0	30;11
13	Rāmhurmūz	85;45	31;0
14	Kāzirūn	87;0	29;15
15	Fīrūzābād	87;30	28;10
16	Shīrāz	88;0	29;36
17	Yazd	89;0	32;0
18	Hamadān	83;0	35;10

	Place Name	L	φ
19	Sāwa	85;0	35;0
20	Qazwīn	85;0	36;0
21	Iṣfahān	86;40	32;25
22	Kāshān	86;0	34;0
23	Qum	85;0	34;45
24	Rayy	86;20	35;0
25	Sārī	88;20	34;0
26	Amul	88;20	36;15
27	Astarābād	89;35	36;50
28	Dāmghān	88;55	36;20
29	Nīshābūr	92;30	36;41
30	Mashhad	92;30	37;0
31	Tūn	92;30	34;30
32	Qā'īn	93;20	33;40
33	Harāh	94;20	34;30
34	Balkh	101;0	36;41
35	Badakhshān	104;24	37;10
	Inner Circle		
36	Bukhārā	97;30	39;50
37	Samarqand	99;36	39;37
38	Kāshghar	106;30	44;0
39	Khutan	107;0	42;0
40	Kirmān	91;30	30;5
41	Qandahār	107;40	33;0

	Place Name	L	φ
42	Mūltān	107;35	29;40
43	Lahāwar	109;20	31;50
44	Haḍrat Dihlī	114;18	28;4!
45	Akra	114;0	27;4!
46	Qannawj	115;50	26;35
47	Bānārasī	117;20	26;55
48	Burhānbūr	113;0	20;30
49	Sarāndib	130;0	10;0
50	Khanbāyat	109;4	22;20

BACK

On the back, the rim of the two upper quadrants carries the altitude scales which are divided in 1° and 6° and labelled 6—90; 90—6. The rim of the lower half carries the cotangent scales along with the subdivisions.

In the upper left is the trigonometric quadrant with 60 horizontal parallels where each sixth line is highlighted with dots. In the upper right is the solar quadrant with six concentric and equally spaced declination arcs. The corresponding zodiac signs are marked by their serial numbers along the two radii; 3 (Cancer) to 9 (Capricorn) along the vertical radius from the centre to the arc; and 9 (Capricorn) to 3 (Cancer) along the horizontal radius from the arc to the centre. It is surprising that the curves of the sun's midday altitude at the two latitudes of 27° and 32° (i.e., for the two Mughal imperial cities of Agra and Lahore) are not plotted on this quadrant, as is usually done on the other astrolabes by Muqīm.

In the lower half are drawn the shadow squares, on the left for a base of 7 feet and on the right for a base of 12 digits. The horizontal and vertical scales on both sides are divided and numbered accordingly and are accompanied by the following labels:

Vertical scale on the left: *ẓill sullam aqdām maʿkūs*

Horizontal scale on the left: *ẓill sullam aqdām mustawī*

Horizontal scale on the right: *ẓill sullam aṣābi ᶜ mustawī*

Vertical scale on the right: *.ẓill sullam aṣābi ᶜ maᶜkūs*

The shadow squares are enclosed in two semi-circular scales which display the relationship between the 12 signs of the zodiac and the 28 lunar mansions. In the outer semicircle are engraved the names of the 12 signs and in the inner semicircle those of the corresponding lunar mansions.

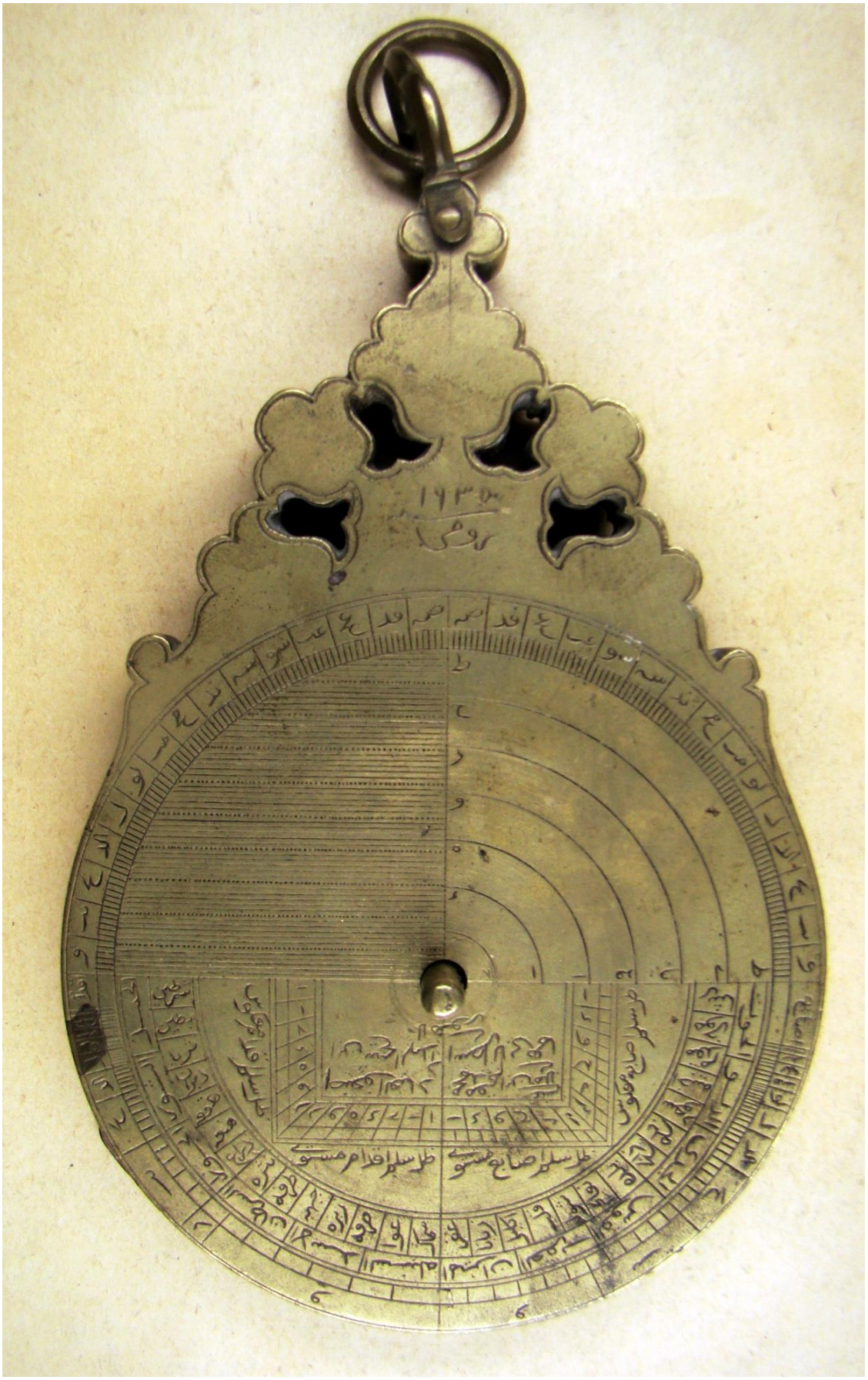


Figure A020.4 – Back of the astrolabe (photo courtesy Professor Mustafa Aktar)

ALIDADE ETC

The alidade has ornate ends and an ornate cetre piece. One half of it is engraved with arcs which correspond to the declination arcs in the upper right quadrant and labelled with the serial numbers of the zodiac signs as in the same quadrant. The other half is divided into 60 equal parts which correspond to the 60 parallels in the upper left quadrant; these divisions are numbered in groups of 6, from 6 to 60. The two sighting vanes are equipped with two holes each. It looks as if the vanes were broken at some time and were welded to the star bar later. The pin is plain with a flat broad head, which looks like a washer. The hole through which the wedge passes has become corroded and elongated. The wedge is missing.

INSCRIPTION

Inside the shadow squares is engraved the signature of the astrolabe maker in three lines upside down:

aḍaᶜaf al-ᶜibād muḥammad muqīm ibn mullā ᶜīsā
ibn shaykh allāhdād asṭurlābī humā[yūn]ī
lāhūrī

'[Made by] the least of the servants [of God], Muḥammad Muqīm, the son of Mullā ᶜĪsā, the son of Shaykh Allāhdād of Lahore, the astrolabe maker of [Emperor] Humāyūn.'

The year of the manufacture is engraved on the front side of the *kursī* in Hijrī era as *sanah 1034 hijrī* and on the back of the *kursī* in the Rūmī era as *sanah 1935 rūmī.*

Hijrī 1034 = 13 October 1624 – 1 October 1625.

Rūmī 1935 = 11 October 1623 – 10 October 1624.

Thus these two years do not coincide at any point. Probably Muqīm used a convention where the Rūmī year commences on 1 March (in the present case, on 1 March 1624). See also A020.

BIBLIOGRAPHY

Dizer 1986, plate 7, where the astrolabe is erroneously attributed to ᶜĪsā.

A021⊙ ASTROLABE BY MUḤAMMAD MUQĪM, 1034 AH (AD 1624-25)

Diameter 114 mm

New Delhi, Red Fort, Mumtaj Mahal Museum (Registration No. 40,420; Acc. No. 66)

CCA 2700 =3723[274];Répertoire 6



Figure A021.1 – Front of the astrolabe (photo by Dr Jean-Michel Delire)

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[274] CCA 2700 lists a Lahore astrolabe dated 1034/1624 by M Muqim b Isa at DEN = Delhi National Museum; CCA 3723 refers to a Lahore astrolabe dated 1034/1624, with a diameter of 114 by the same person at DDA = Delhi, Archaeological Museum at Red Fort. The National Museum does not have such an astrolabe. The same astrolabe is recorded twice by mistake in the CCA. The *Répertoire* (no. 6) recognises the mistake and identifies the two as one and the same 2700 = 3723.

COMPONENTS

Body with *kursī* (d. 114, h. 137, t. 6), ring, shackle, rete (d. 102) for 35 stars, 5 plates (d. 102). The pin and horse are missing. The components are held together now by a modern nut and bolt.

FRONT

A large ring with a diamond cross-section; the shackle has a trifoliate form, attached to the *kursī* by a copper pin. The *kursī* is pierced by 6 symmetric perforations so that what remains looks like a cluster of four tulips, their flared petals forming the profiles of the *kursī,* which is topped by a trifoliate finial. The surface of the *kursī* is plain and smooth without any decorations on both sides.

The limb is graduated in 1° and 6° and labelled from 6 to 360.

RETE

The two circles are held together by the equinoctial bar with counter change at the centre. There is a handle at NW on the band of the Tropic of Capricorn and a well-defined Capricorn index at the topmost point of the ecliptic ring. The ecliptic ring is divided in 12 signs and labelled with their names. Each sign is further subdivided into units of 6° and numbered. These divisions are extended into the sloping edge of the ecliptic circle. There are 35 star pointers which are joined by an almost symmetric floriate tracery, where the motif of tulips with flared petals (which dominates the design of the *kursī*) is repeated a few times. There is also a star-like flower with six petals just below the zero point of Capricorn.

Table A021-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus Janūbī*	β Ceti
2	*Batn al-Ḥūt*	β Andromedae
3	*Fam al-Qayṭus*	γ Ceti
4	*Ṣadr al-Qayṭus*	π Ceti
5	*Rās al-Ghūl*	β Persei
6	*Tālī Masāfat al-Nahr*	γ Eridani

	Star Name	Identification
7	*ᶜAyn al-Thawr*	α Tauri
8	*Al-ᶜAyyūq*	α Aurigae
9	*Rijl al-Jawjā' al-Yusrā*	β Orionis
10	*Yad al-Jawjā' al-Yumnā*	α Orionis
11	*Shiᶜrā Yamānī*	α Canis Majoris
12	*Shiᶜrā Shāmī*	α Canis Minoris
13	[*Ṭarfat al-Safīna*][275]	ρ Puppis
14	*Fard al-Shujāᶜ*	α Hydrae
15	*Ẓahr al-Dubb al-Akbar*	α Ursae Majoris
16	*Qāᶜidāt al-Bāṭiya*	α Crateris
17	*Ẓahr al-Asad*	δ Leonis
18	*ᶜAnāq*	ξ Ursae Majoris
19	*Janāḥ al-Ghurāb*	γ Corvi
20	*Simāk al-Aᶜzal*	α Virginis
21	*Simāk Rāmiḥ*	α Bootis
22	*Munīr [min] al-Fakkah*[276]	α Coronae Borealis
23	*ᶜUnuq al-Ḥayyah*	α Serpentis
24	*Rukbat al-Hawwā' al-Yusrā*	ρ Ophiuchi
25	*Rās al-Jāthī*	α Herculis
26	*Rās al-Ḥawwā*	α Ophiuchi

[275] By mistake, the astrolabist engraved the name *fard al-shujāᶜ* on two successive pointers; on this pointer the correct name is *ṭarfat al-ṣafīna.*

[276] Instead of the common designation *nayyir al-fakkah,* Muqīm employs a rare designation used by al-Ṣūfī; cf. Savage-Smith 1985, p. 142: 'Al-Ṣūfī (*Ṣuwar*, 57) also calls it *al-munīr min al-fakkah.*' See also Muqīm's astrolabe of 1047/1637-8 (A023).

	Star Name	Identification
27	*Al-Nasr al-Wāqiʿ*	α Lyrae
28	*Minqār al-Dajājah*	β Cygni
29	*Nasr Ṭā'ir*	α Aquilae
30	*Dhanab al-Dajājah*	α Cygni
31	*Fam al-Faras*	ε Pegasi
32	*Dhanab al-Jadī*	δ Capricorni
33	*Sāq Sākib al-Mā'*	δ Aquarii
34	*Surrat al-Faras*	δ Pegasi
35	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are five plates with the following specifications.

Table A021-2 Plates

	φ	Longest Day
1a	18°	13;3 hours
1b	29°	13;52 hours
2a	22°	13;21 hours
2b	24°	?
3a	27°	13;46 hours
3b	32°	14;8 hours
4a	0° + 90°	Double projection
4b	36° + 42°	Double projection
5a	Plate of ecliptic coordinates	
5b	Plate of horizons	

φ	Longest Day

On plates 1a, 1b, 2a, 3a and 3b, altitude circles are drawn for every 6°, azimuth circles for every 10°, lines for seasonal hours and lines for equal hours since sunrise.

Plate 2b serving the latitude 24° (roughly the Tropic of Cancer) is unusual. It has altitude circles for each 6° above and below the horizon and azimuth circles for each 10° above and below the horizon, as well as curves for each of 10° of the astrological houses and lines for seasonal hours. The words *ᶜarḍ k-d,* 'latitude 24' are engraved in a small circle on the horizon.[277]

On plate 4a, there is a double projection for latitude 0° in the upper half and of latitude 90° in the lower half. Below the horizon on the east and west are mentioned the cardinal directions *al-mashriq* and *al-maghrib* respectively. There also the label *lā ᶜarḍ lahū* (no latitude for this), on both sides. In the lower half is written across the meridian line *ᶜarḍ tis ᶜūn,* (latitude ninety).

On plate 4b, there is again a double projection for latitudes 36° and 42° with altitude circles for each 6° and azimuth arcs for every 10° above the horizon.

The plate of horizons has half horizons serving latitudes with even numbers from 4° to 66° in four batches:

4	12	20	28 … 60
6	14	22	30 … 62
8	16	24	32 … 64
10	18	26	34 … 66

Declination scales are divided at 6°, 12°, 18° and 23;30°.

Geographical Gazetteer

The gazetteer is engraved in two circles.

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277 Cf. Qā'im's astrolabe of 1635 (A013); it has plate for 23;30° where the latitude circles are drawn both above and below the horizon; see Figure A013.4.

Table A021-3 Geographical Gazetteer

	Place Name	L	φ
	Outer Circle		
01	Qayrawān	41;0	31;40
02	Miṣr	63;20	30;20
03	Madīnat Rasūl	75;20	25;0
04	Makka Muᶜaẓẓam	76;10	21;40
05	Bayt al-Maqdis	66;30	31;50
06	Ṭarābulus Maghrib	69;40	34;0
07	Dimashq	70;0	33;15
08	Ḥalab	72;10	35;50
09	Marāgha	82;0	36;20
10	Tabrīz	82;0	38;0
11	Kūfa	79;30	31;30
12	Baghdād	80;0	33;25
13	Baṣra	84;0	30;11
14	Fīrūzābād	87;30	28;10
15	Shīrāz	88;0	29;36
16	Yazd	89;0	32;0
17	Suhraward	83;20	36;30
18	Qazwīn	85;0	36;0
19	Iṣfahān	86;40	32;25
20	Mashhad	92;30	37;0
21	Harāt	94;20	34;30
22	Marw	97;0	37;40

	Place Name	L	φ	
23	Balkh	81;0	36;41	
24	Badakhshān	84;24	37;10	
25	Bukhārā	97;30	39;50	
26	Samarqand	99;36	39;37	
27	Khujand	100;35	41;15	
28	Kāshghar	106;30	44;0	
29	Khutan	107;0	42;0	
30	Hurmūz	92;0	25;0	
31	Ghazna	104;20	43;35	
	Inner Circle			
32	Kābul	104;40	34;30	
33	Dabīl	102;30	25;10	
34	Qandahār	107;40	33;0	
35	Multān	107;35	29;40	
36	Lahāwar	109;20	31;50	
37	Qannawj	115;50	26;35	
38	Bānārasī	117;20	26;15	
39	Sarandib	130;0	10;0	
40	Tubbat	110;0	40;0	
41	Kashmīr	108;0	35;0	
42	Haḍrat Dihlī	114;18?	28;39	
43	Akra	114;0	26;43	
44	Jānāpūr	119;6	26;36	Jaunpur
45	Ajmīr	112;0	26;0	

	Place Name	L	φ
46	Aḥmadābād	108;40	23;15

BACK

The rim of the two upper quadrants carries two altitude scales which are divided in 1° and 6° as in the front and labelled 6—90; 90—6. The rim of the lower half is inscribed with the cotangent scales. In the upper left quadrant are drawn 60 horizontal parallels, with each sixth highlighted with dots. The upper right quadrant is divided by declination arcs into 6 zones, one each for a pair of zodiac signs, which are marked along the two radii. Two graphs of solar meridian altitudes for the latitudes of 27° and 32° are drawn on this quadrant, with the usual labels.

In the lower half, there are shadow squares, on the left for a base of 7 feet and on the right for a base of 6/12 digits, with the usual labels. These shadow squares are enclosed in two semi-circles where the outer one carries the names of the 12 zodiac signs and the inner one those of the 28 lunar mansions.



Figure A021.2 – Back of the astrolabe (photo courtesy A. J. Turner)

ALIDADE

Straight bar alidade with ornate ends and ornate centre-piece graduated in both halves to match the divisions in the two upper quadrants.



Figure A021.3 – Maker's signature on the back (photo courtesy A. J. Turner)

INSCRIPTION

Inside the shadow squares is inscribed the signature of the maker in three lines:

sanah 20 julūs jahāngīrī sanah 1034

bi-yad aḍᶜaf al-ᶜibād muḥammad muqīm ibn mullā ᶜīsā

ibn shaykh allāhdād asṭurlābī lāhūrī humāyūnī

'[In] the regnal year 20 of [the Emperor] Jahāngīr, in the year 1034 [Hijrī] [this astrolabe was made] by the hand of the weakest servant [of God], Muḥammad Muqīm, son of Mullā ᶜĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn.'

Hijrī 1034 = 13 October 1624 – 1 October 1625. The 20th regnal year of Jahāngīr commences approximately on 9 March 1625. Therefore, the astrolabe was completed between 9 March and 1 October 1625.

BIBLIOGRAPHY

Behari & Govind 1980, p. 101, no. 7.

Sen 1990.

A022 ASTROLABE BY MUḤAMMAD MUQĪM, 1034 AH (AD 1624-25)

Diameter 84 mm

Samarkand, The Samarkand Museum of History and Art of Uzbek People (#131, A.172.2)

Répertoire 7

The Répertoire cites the following inscription:

> *aḍᶜaf al-ᶜibād muḥammad muqīm ibn mullā ᶜīsā ibn shaykh allāhdād asṭurlābī humāyūnī lāhūrī sanah 1034 hijrī sanah 1935 rūmī*
>
> '[Made by] the weakest of the servants [of God], Muḥammad Muqīm, son of Mullā ᶜĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, [in] the year 1034 of Hijra, [in] the year 1935 of the Rūmī era.'

Hijrī 1034 = 13 October 1624 – 1 October 1625

Rūmī 1935 = 11 October 1623 – 10 October 1624

Thus these two years do not coincide at any point. Probably Muqīm used a convention where the Rūmī year commences on 1 March (in the present case, on 1 March 1624). See also A018.

No other information is available. A letter addressed to the Samarkand Museum of History and Art of Uzbek People came back undelivered.

A023⊙ ASTROLABE BY MUḤAMMAD MUQĪM, 1047 AH (AD 1637-38)

Diameter 94.5 mm

PLU, ex. PC, Brussels

CCA 2061; Répertoire 8



Figure A023.1 – Front of the astrolabe (photo courtesy A. J. Turner)

COMPONENTS

Body with *kursī* (d. 94.5, h. 121.5, t. 6), shackle and ring, rete for 27 stars, 5 plates, alidade, pin and horse. The alidade is uninscribed and is a replacement.

FRONT

The ring and shackle have diamond cross-section. The *kursī* is worked *à jour* with lobed profiles and a trifoliate finial. The limb is graduated in 1° and 6° and the groups of 6° are numbered clockwise from 6 to 90, separately for each quadrant.

RETE

The Capricorn ring and the ecliptic ring are held together by the equinoctial bar with three counter changes and by the solstitial bar which is interrupted twice by inverted arch-like forms. There are 27 star pointers.

PLATES

There are five plates, four of which serve eight different latitudes between 22° to 40°. On these four plates, altitude circles are drawn for every 6°; azimuth arcs are drawn sometimes below, sometimes above and other times both above and below the horizon. There are lines for seasonal hours on all four plates, some have lines for equal hours since sunrise while others have also lines for equal hours before sunrise. The duration of the longest day is erratic as in a few other astrolabes.

Table A023-1 Plates

	φ	Longest Day
1a	22°	13;21 hours
1b	25°	13 hours!
2a	27°	13;13 hours!
2b	30°	13;58 hours
3a	32°	14;8 hours
3b	36°	14;32 hours

	φ	Longest Day
4a	40°	14 hours!
4b	0° + 18°	double projection
5a	Plate of ecliptic coordinates	
5b	Plate of horizons	

GEOGRAPHICAL GAZETTEER

The gazetteer provides, in three circles, the longitude, names and latutudes of 65 localities, in this order.



Figure A023.2 – Geographical gazetteer (photo by S. R. Sarma)



Figure A023.3 – Back of the astrolabe (photo by S. R. Sarma)

BACK

The two upper quadrants carry the same scales on the rim as in the front, and labelled 6-90; 90-6. The two lower quadrants have cotangent scales on the rim.

The upper left quadrant carries a cosine graph with 30 horizontal parallels, each third of which is highlighted. In the upper right quadrant are drawn 5 declination arcs; on the vertical and horizontal diameters are marked the corresponding signs of the zodiac with the serial numbers. On these are plotted two sigmoid curves for the latitudes 27° (Agra) and 32° (Lahore); the labels read *khaṭṭ niṣf al-nahār bi-ᶜarḍ 27* and *khaṭṭ niṣf al-nahār bi-ᶜarḍ 27* respectively.

In the lower half are shadow squares, on the left for a base of 12, on the right for a base of 7. The vertical and horizontal scales are divided and labelled accordingly. Inside these squares, there is a semicircular table with the names of the 12 zodiac signs and those of the corresponding 28 lunar mansions.

Inscription

Within the semi-circular table is engraved the signature of the maker:

ṣan ᶜat muḥammad muqīm ibn ᶜīsā ibn
allāhdād asturlābī humāyūnī
lāhūrī

'The work of Muḥammad Muqīm, son of ᶜĪsā, son of Allahādad of Lahore, the astrolabe maker to [the Emperor] Humāyūn.'

Below the shadow squares is the date: *fī sanah* 1047 (in the year 1047) which corresponds to AD 1637-38.

Provenance

Exhibited in 1984 in Brussels; then in it was in a private collection. Came up for auction at Sotheby's on 12.7.91. In 1996 it was in a private collection at Brussels when I saw it. Again it came up for auction at Christie's on 17 May 2007.

Bibliography

Anon 1984.
Christie's catalogue of 17 May 2007, lot 88.

A024 ASTROLABE BY MUḤAMMAD MUQĪM, 1047 AH (AD 1637-38)[278]

Diameter 256 mm

Islamabad, Islamabad Museum (# ID 186)

CCA 2704; Répertoire 9



Figure A024.1 – Front of the astrolabe (photo by Mubashir Ul-Haq Abbasi)

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[278] This entry is an abridged version of Abbasi & Sarma 2014.

Components

Body with *kursī* (d. 256, h. 375), rete (d. 240) for 46 stars, 5 plates, washer, alidade, and horse; the alidade is a replacement.

Front

With its delicate fretwork, the *kursī* is one of the most exquisitely crafted *kursīs* to be found in Lahore astrolabes. The two profiles are made up of ogees at the base and top with a lobe in between. The finial has the shape of a trefoil, so also the shackle. The ring is plain. On a cartouche in the middle of the *kursī* is engraved the following in Persian: *az ghafūr maghfirat umīd dāram* (I hope to be forgiven by the Forgiver). The limb carries a degree scale which is divided in 1° and 5° and labelled from 5 to 360.



Figure A024.2 – Rete of the Astrolabe (photo by Mubashir Ul-Haq Abbasi)

Rete

In the rete, the broad ring of the ecliptic is joined to the Tropic of Capricorn by the equinoctial bar, which has counter changes at its two intersections with the ecliptic ring.

The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names. Each sign is subdivided into group of 5° and numbered accordingly. These units of 5° degrees are divided into single degrees on the sloping edge of the ecliptic ring. There are 46 star pointers which are joined by a nearly symmetric tracery. There is a small knob to the right of the north point for rotating the rete. The 46 star pointers represent the following stars.

Table A024-1 Stars on the Rete

	Star Name	Identification
01	*Dhanab al-Qayṭus al-Janūbī*	β Ceti
02	*Baṭn al-Ḥūt*	β Andromedae
03	*Rijl al-Musalsala*	γ Andromedae
04	*Fam al-Qayṭus*	γ Ceti
05	*Ṣadr al-Qayṭus*	π Ceti
06	*Kaff al-Jadhmā'*	α Ceti
07	*Rās al-Ghūl*	β Persei
08	*Thānī Masāfat al-Nahr*	θ Eridani
09	*Dabarān*	α Tauri
10	*Al-ᶜAyyūq*	α Aurigae
11	*Rijl al-Jawzā' al-Yusrā*	β Orionis
12	*Yad al-Jawzā' al-Yusrā*	γ Orionis
13	*Yad al-Jawzā' al-Yumnā*	α Orionis
14	*Rijl al-Jawzā' al-Yumnā*	κ Orionis
15	*Shiᶜrā Yamānī*	α Canis Majoris
16	*Shiᶜrā Shāmī*	α Canis Minoris
17	*Mankhar al-Shujᶜa*	σ Hydrae
18	*Rās al-Asad*	ε Leonis

	Star Name	Identification
19	*Qalb al-Asad*	α Leonis
20	*Ẓahr al-Dubb al-Akbar*	α Ursae Majoris
21	*Fard al-Shujāᶜ*	α Hydrae
22	*Ẓahr al-Asad*	δ Leonis
23	*Qāᶜidat al-Bāṭiya*	α Crateris
24	*Ṣarfa*	β Leonis
25	*ᶜAnāq*	ζ Ursae Majoris
26	*Janāḥ al Ghurāb*	γ Corvi
27	*Simāk al-Aᶜzal*	α Virginis
28	*Simāk al-Rāmiḥ*	α Bootis
29	*ᶜUnuq al-Ḥayyah*	α Serpentis
30	*Kiffa Shamālī*	β Librae
31	*Rās al-Jāthī*	α Herculis
32	*Rukbat al-Ḥawwa' al-Yusrā*	ζ Ophiuchi
33	*Rās al-Ḥawwā*	α Ophiuchi
34	*Yad al-Ḥawwā al-Yumnā al-Muqaddam*	δ Ophiuchi
35	*Nasr al-Wāqiᶜ*	α Lyrae
36	*Minqār al-Dajaja*	β Cygni
37	*Nasr al-Ṭā'ir*	α Aquilae
38	*Dhanab al-Dajāja*	α Cygni
39	*Dhanab al-Dulf īn*	ε Delphini
40	*Fam al-Faras*	ε Pegasi
41	*Dhanab al-Jadī*	δ Capricorni

	Star Name	Identification
42	*Sāq Sakib al-Mā' al-Janubī*	δ Aquarii
43	*Dhanab al-Qayṭus Shamālī*	ι Ceti
44	*Mankib al-Faras*	β Pegasi
45	*Sirrat al-Faras*	δ Pegasi / α Andromedae
46	*Kaff al-Khadīb*	β Cassiopeiae

PLATES

There are five plates with the following specifications. The durations given for the longest day are often erratic.

Table A024-2 Plates

	φ	Longest Day
1a	20°	13 hours
1b	36°	14 hours !
2a	25°	13;25 hours
2b	30°	13;18 hours !
3a	27°	13;46 hours
3b	32°	14;8 hours
4a	34°	14;16 hours
4b	42°	15;2 hours
5a	Plate of ecliptic coordinates	
5b	Plate of horizons	

On the plates 1-4, altitude circles are drawn for every degree, with each fifth circle dotted. Azimuth arcs drawn below the horizon at intervals of 5° on all plates with the

exception of 4b for the latitude 42^0, where these are drawn above the horizon at the same intervals. In the lower half of the plates are drawn plain lines for seasonal hours and dotted lines for equal hours. On some plates, lines for equal hours are drawn from the western horizon and on some others both from the eastern and western horizons.

On the plate of ecliptic coordinates, latitude circles are drawn for each degree and alternate circles are numbered. The azimuth or longitude circles are drawn for every 5 degrees and numbered separately in each sign. Along the ecliptic circle the names of the zodiac signs are inscribed in long strokes anti-clockwise. However, the name of the plate *mīẓān al-ᶜankabūt* is not engraved.

On the plate of horizons are drawn half horizons for each degree of latitude from 4 to 65 degrees. Declination scales are engraved along the diameters. The scales are numbered in units of 5 up to 23;30 which is the obliquity. Here also the name of the plate *ṣafīḥa āfāqiyya* is not written.



Figure A024.3 – Geographical Gazetteer (photo by Mubashir Ul-Haq Abbasi)

GEOGRAPHICAL GAZETTEER

On the inner surface of the mater is engraved a geographical gazetteer containing the names of the following 120 localities with their longitudes and latitudes in four circles, in a spiral formation. The localities are arranged according to climates with appropriate headings engraved between the circular rows.[279]

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279 In his astrolabe of 1667 (A087), Muqīm's nephew Ḍiyā' al-Dīn engraves exactly the same gazetteer, but with an addition of four place names at the end.

Table A024-3 Geographical Gazetteer

	Place Name (*al-bilād*)	L (*al-ṭūl*)	φ (*al-ᶜarḍ*)
	First Circle		
[-I] *az khaṭṭ istiwā tā iqlīm awwal* (from the Equator to the First Climate)			
01	Sāḥil Baḥr Awqiyānūs	11;00	0;0
02	Jazīra Qanbala	21;0	3;0
03	Jamkūt	177;0	5;0
04	Shila	180;0	5;0
05	Kuku	54;10	10;0
06	ᶜAdan	76;0	11;00
[1] *iqlīm awwal* (the First Climate)			
07	Jabal	75;0	13;30
08	Dammār	77;15	13;30
09	Bajja az Barbar	10;5	14;0
10	Zabayd	74;20	14;10
11	Ṣanaᶜān dār Mulk Yaman	77;0	14;30
12	Janad	75;30	14;30
13	Sawmnāt	107;0	17;0
14	Zatūn	114;0	17;15
15	Panjāpūr	105;30	17;20
16	Burhānpūr	108;0	20;30
17	Dawlatābād	111;0	20;30
[II] *iqlīm dūyum* (the Second Climate)			

	Place Name (*al-bilād*)	L (*al-ṭūl*)	φ (*al-ᶜarḍ*)
18	Jadda	76;0	21;0
19	Ṭāᶜif	77;30	21;20
20	Makka Mubārak	77;10	21;40
21	Kanbayāt	109;20	22;20
22	Khaybar	75;20	24;20
23	Madīnaat Ṭayyiba	75;20	25;00
24	Hurmūz	92;0	25;00
25	Ajmīr	110;5	26;0
26	Kawāliyar	114;0	26;29
27	Lakhnawtī	114;18	26;30
28	Qannawj	105;50	26;35
29	Jawnpūr	119;6	26;26
30	Akbarābad dār al-Khilāfat	115;0	26;43
31	Kūbāmaū	116;38	26;45
32	Mānikpūr Garh	115;10	26;49
33	Awadh	118;6	27;22
34	Badā'ūn	115;14	27;40
[III] *iqlīm siwum* (the Third Climate)			
35	Bakar	105;0	27;40
36	Kūlkandah	114;20	28;4
37	Kūl [wa] Jalālī	114;19	28;4
38	Fīrūzābād	87;30	28;10
39	Sulṭānkūt	115;0	28;30

	Place Name (***al-bilād***)	**L** (***al-ṭūl***)	**φ** (***al-ᶜarḍ***)
40	Dihlī dār al-Mulk al-Hind	103;35	28;39
41	Baran	114;0	28;48
42	Pānīpat	113;20	28;52
43	Shīrāz	88;0	29;36
44	Multān	107;35	29;40
45	Hansī	112;25	29;45
46	Baṣra	84;0	30;0
47	Kirmān	91;30	30;5
	Second Circle		
[III] *tatimma iqlīm siwum* (continuation of the Third Climate)			
48	Tānīsar	112;38	30;10
49	Iskandariyya	61;54	30;18
50	Miṣr	63;20	30;20
51	Sunām	112;25	30;30
52	Parshūr	85;55	31;0
53	Kūfa	79;30	31;30
54	Bayt al-Maqdis	66;30	31;50
55	Lāhūr dār al-Salṭanat	109;20	31;50
56	Yazd	89;0	32;0
57	Iṣfahān	87;40	32;25
58	Farmal	104;35	32;55
59	Qandahār	107;40	33;0

	Place Name (*al-bilād*)	L (*al-ṭūl*)	φ (*al-ᶜarḍ*)
60	Siālkūt	109;0	33;0
61	Madā'īn	72;0	33;15
62	Dimashq	70;0	33;15
63	Maymand	101;55	33;20
64	Baghdād	82;0	33;25
[IV] *iqlīm chahārum*			
65	Ṭarābulus	69;40	34;0
66	ᶜĀna	76;0	34;0
67	Kāshān	86;0	34;0
68	Mawṣil	77;0	34;30
69	Tūn	92;30	34;30
70	Harāt	94;30	34;30
71	Kābul	104;40	34;30
72	Qumm	85;40	34;45
73	Rayy	86;20	35;0
74	Sāwah	85;0	35;0
75	Kashmīr	108;0	35;0
76	Hamadān	83;0	35;10
77	Ḥalab	72;10	35;50
78	Mashhad	92;30	36;0
79	Suhraward	88;20	36;0
80	Sabzawar	91;30	36;5
81	Basṭām	89;30	36;10

	Place Name (*al-bilād*)	L (*al-ṭūl*)	φ (*al-ʿarḍ*)
82	Balkh	101;0	36;11
	Third Circle		
(IV) *tatimma iqlīm chahārum* (continuation of the Fourth Climate)			
83	Tāliqān	85;45	36;10
84	Abhar	84;30	36;45
85	Astarābād	89;35	36;50
86	Qazwīn	85;0	35;55
87	Badakhshān	84;24	37;10
88	Marāgha	82;0	37;20
89	Sarakhs	94;30	37;30
90	Marw	97;0	37;40
91	Tabrīz	82;0	38;0
92	Ardabil	80;30	38;0
93	Nawshahr	78;20	38;10
94	Nakhjawān	8;15	38;40
[V] *iqlīm panjum*			
95	Bākuya	84;30	39;30
96	Samarqand	99;16	39;37
97	Bukhārā	97;30	39;50
98	Tubbat	110;0	40;0
99	Bardaʿa	83;0	40;30
100	Shamākhī	84;30	40;50
101	Qūniya	66;30	41;0

	Place Name (***al-bilād***)	**L** (***al-ṭūl***)	**φ** (***al-ᶜarḍ***)
102	Khujand	105;35	41;55
103	Khutan	107;0	42;0
104	Kāshān	81;35	42;0
105	Farghāna	102;0	42;20
	Fourth Circle		
[VI] *iqlīm shashum* (the Sixth Circle)			
106	Kāshghar	106;30	44;0
107	Bandaqiya	92;0	44;0
108	Shalkh	100;30	44;0
109	Ṭarāz	99;50	44;31
110	Bīsh Bāligh	110;0	45;50
111	Qarāqūrūm	115;0	46;0
112	Khān Bāligh	124;0	46;0
113	Harqala	67;20	46;30
[VII] *iqlīm haftum* (the Seventh Climate)			
114	Araq	100;0	48;0
115	Bulghār	90;0	49;30
116	Aqchā Kirmān	62;0	50;0
117	Qirqir	65;30	50;0
[VII+] *khāriz az iqlīm haftum* (beyond the Seventh Climate)			
118	Mārī Kirmān	65;45	50;40
119	Jazā'ir Rūdjard	68;50	62;0
120	Ṣūdāq	65;5	51;0

BACK

On the back, the rim of the upper half carries two altitude scales divided in 1° and 5° and numbered as 5—90; 90—5. The upper left quadrant contains the sine-cosine graph with 60 horizontal and 60 vertical parallel lines, where every fifth line is highlighted with dots.

In upper right quadrant are drawn 60 declination circles, one for every 3° of solar longitude; the names of the related zodiac signs are written along the two radii. Each sign is divided into ten parts of 3 degrees each and every alternate division is numbered.

In this quadrant two sigmoid curves for the midday altitude of the sun are drawn for the latitudes of 27° and 32° with the labels *khaṭṭ nisf al-nahār bi-ᶜarḍ 27* and *khaṭṭ nisf al-nahār bi-ᶜarḍ 32*.



Figure A024.4 – Back of the astrolabe (photo by Mubashir Ul-Haq Abbasi)

In the lower half are drawn the shadow squares, on the left for a base of 12 and on the right for a base of 7. The vertical and horizontal scales are divided and numbered accordingly. On the two lower corners there is a label each reading *ẓill sullam,* 'the scale of shadows'. The 4 scales are accompanied by the following labels:

Vertical scale on the left: *ẓill aṣābiʿ maʿkūs*

Horizontal scale on the left: *ẓill aṣābiʿ mustawī*

Horizontal scale on the right: *ẓill aqdām mustawī*

Vertical scale on the right: *ẓill aqdām maʿkūs.*

Within the shadow squares, there are five semi-circular rows. In the first or the outermost row are the names of the 12 signs of the zodiac; in the next row are the names of the 28 corresponding lunar mansions. Again rows 1, 3, 4, 5 form a table of trigons or triplicities with their regents. In other astrolabes, the regents of the day and the regents of the night are shown separately. Here they are in the same column; the first and the third row show the sign and the day regent, while the next two rows mention the sign and the night regent. Thus Aries has the sun as the regent in the daytime and Jupiter as the regent at night. The table is reproduced below, omitting row 2 with the names of the lunar mansions.

Table A024-4 Triplicities

Aries	Taurus	Gemini	Cancer	Leo	Virgo
Sun	Jupiter	Saturn	Venus	Moon	Mars
Aries	Leo	Sagittarius	Taurus	Virgo	Capricorn
Jupiter	Sun	Saturn	Moon	Venus	Mars
Fiery (*nārī*)			Earthy (*tarabī*)		
Libra	Scorpio	Sagittarius	Capricorn	Aquarius	Pisces
Saturn	Mercury	Jupiter	Venus	Mercury	Moon
Gemini	Libra	Aquarius	Cancer	Scorpio	Pisces
Mercury	Saturn	Jupiter	Mars	Venus	Moon
Airy (*hawā'ī*)			Watery (*mā'ī*)		

Inside these semi-circular tables, immediately below the horizontal diameter, is a table consisting of 3 columns and 8 rows, with the title *mubādī aqālīm sabʿa* (beginnings of the seven climates). Strangely, the last row is engraved outside the table as an afterthought.

Table A024-5 Climates

Climates (*aqālīm*)	**Latitudes (*ᶜarūḍ*)**	**Hours (*sāᶜāt*)**
First (*awwal*)	12;48	12;45
Second (*thānī*)	20;31	13;15
Third (*thālith*)	27;34	13;45
Fourth (*rābiᶜ*)	33;43	14;15
Fifth (*khāmis*)	39;1	14;45
Sixth (*sādis*)	43;30	15;15
Seventh (*sābiᶜ*)	47;38	15;45
End *(intihā)* [of the seventh climate]	50;31	16;15

On the rim of the lower half are two cotangent scales, on the left in digits and on the right in feet, corresponding to the shadow scales. The unequal divisions in these scales have numbers written from the centre to either side as 5, 10, 15, and so on up to 90.

Below the cotangent scales there are two astrological tables engraved in five concentric semi-circular rows. The first three rows constitute the table of limits (*ḥudūd*). The second row, together with the fourth and fifth rows, forms the table of decans (*wujūh*) and their regents.

Alidade

The alidade is plain and without any scale. It is clearly a late replacement. But the washer, pin and the horse are original. The mane of the horse, the head and the eyes are nicely engraved.

Inscription

Below the shadow squares, there is an inscription engraved along the inner boundary of the semi-circular table:

ṣanᶜat aḍaᶜf al-ᶜibād muḥammad muqīm ibn ᶜīsā ibn allāhdād asṭurlabī humāyunī lāhorī fī san 1047 hijrī

'Made by the weakest of the creatures [of God] Muḥammad Muqīm, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker of [the Emperor] Humāyūn, in the year 1047 Hijrī.'

On either side of the shadow squares are engraved two other dates 'in 1007 year Yazdegirdī' and 'in 1949 year Rūmī'. The Yazdegirdī year 1007 is from 18 October 1637 to 17 October 1638. The Rūmī (i.e. Syro-Macedonian era) year 1949 is from 11 October 1637 to 10 October 1638. The Hijrī year 1047 is from 27 May 1637 to 14 May 1638. Therefore, this astrolabe was completed sometime between 18 October 1637 and 27 May 1638.

A025⊙ ASTROLABE BY MUḤAMMAD MUQĪM, 1047 AH (AD 1637-38)

Diameter 205 mm

New Delhi, Red Fort, Mumtaj Mahal Museum (Reg. No. 40.421, Acc. No. 65.)

CCA 3721; Répertoire 10



Figure A025.1 – Front of the astrolabe (photo courtesy A. J. Turner)

COMPONENTS

Body with *kursī* (d. 205, h. 254, t. 9), rete (d. 189) for 44 stars, 5 plates (d. 189), alidade (187 x 14). The finial of the *kursī* is broken off and the ring and the shackle are lost. In the absence of the finial, the exact height cannot be determined.

FRONT

The *kursī* is elegantly reticulated; its profiles are made up of the flared petals of two tulips on each side; between these two, there is a third tulip placed in the reverse direction.

The limb is divided in 1° and 5° and labelled from 5 to 360.

RETE

The two rings of Capricorn and ecliptic are held together by the equinoctial bar with two counter changes at its two intersections with the ecliptic circle. The ecliptic circle is divided in 12 signs of zodiac and labelled with their names. Each sign is subdivided into units of 6° and numbered accordingly. Each of these is further subdivided into units of 2° and marked on the sloping edge of the ecliptic circle.

The star pointers are joined by a floriated tracery where the motif of tulips with flared petals reoccurs. There are about 44 star pointers.[280]

There is a handle to the left of the north point on the Capricorn ring.

Table A025-1 Stars on the Rete

	Star Name	Identification
01	*Dhanab Qayṭus J[anūbī]*	β Ceti
02	*Baṭn Ḥūt*	β Andromedae
03	*Rijl Musalsalah*	γ Andromedae
04	*Fam Qayṭus*	γ Ceti
05	*Ṣadr Qayṭus*	π Ceti

[280] A selection of the star list is given in Sen 1990, p. 122.

	Star Name	Identification
06	*Ghūl*	β Persei
07	*Kaff Jadhmā'*	α Ceti
08	*Tālī Masāfat al-Nahr*	γ Eridani
09	*Dabarān*	α Tauri
10	*ᶜAyyūq*	α Aurigae
11	*Rijl Jawjā' Yusrā*	β Orionis
12	*Yad Yusrā*	γ Orionis
13	*Yad Yumnā*	α Orionis
14	*Rijl Yumnā*	κ Orionis
15	*ᶜAbūr*[281]	α Canis Majoris
16	*Ghumayṣā'*[282]	α Canis Minoris
17	*Fard Shujāᶜ*	α Hydrae
18	*Rās Asad*	μ Leonis
19	*Ẓahr Dubb Akbar*	α Ursae Majoris
20	*Qāᶜidat Bāṭiya*	α Crateris
21	*Ẓahr Asad*	δ Leonis
22	*Ṣarfa*	β Leonis
24	*Janāḥ Ghurāb*	γ Corvi
25	*Simāk Aᶜzal*	α Virginis
23	*ᶜAnāq*	ξ Ursae Majoris

[281] The engraving reads *ᶜanūr,* but it must be an error for *ᶜabūr,* another Arabic designation for Sirius; cf. Kunitzsch 1959, p. 73: 'Etymon arab. *al-ᶜabur,* Beiwort des Namens des Sirius: *aš-šiᶜrā al-ᶜabūr* "S., der (die Milchstrasse) überquert hat)…'

[282] Another Arabic name for Procyon; cf. Kunitzsch 1959, p. 74: 'Auf orientalistischen Instrumenten ebenso wie in Europa auch nur kurz *al-ġumayṣā'* genannt;…'

	Star Name	Identification
26	*Simāk Rāmiḥ*	α Bootis
27	*Kiffa Shamālī*	β Librae
28	*Munīr [min] Fakkah*[283]	α Coronae Borealis
29	*ᶜUnuq Ḥayyah*	α Serpentis
30	*Rukbat al-Ḥawwā al-Yusrā*	ρ Ophiuchi
31	*Jāthī*	α Herculis
32	*Rās Ḥawwā*	α Ophiuchi
33	*Waqiᶜ*	α Lyrae
34	*Minqār Dajājah*	β Cygni
35	*Ṭā'ir*	α Aquilae
36	*Dūlfīn*	ε Delphini
37	*Ridf*	α Cygni
38	*Dhanab al-Jadī*	δ Capricorni
39	*Fam Faras*	ε Pegasi
40	*Sāq Sākib al-Mā'*	δ Aquarii
41	*Mankib al-Faras*	β Pegasi
42	*Dhanab al-Qayṭus Sh[amālī]*	ι Ceti
43	*Surrat al-Faras*[284]	δ Pegasi
44	*Khaḍīb*	β Cassiopeiae

283 Instead of the common designation *nayyir al-fakkah,* the astrolabist employs a designation used by al-Ṣūfī; cf. Savage-Smith 1985, p. 142: 'Al-Ṣūfī (*Ṣuwar*, 57) also calls it *al-munīr min al-fakkah.*'

284 The two designations *Surrat al-Faras* (δ Peg, no. 43 here) and *Rijl Musalsala* (γ And, no. 3 here) pertain to one and the same star, but here two stars are shown separately; cf. Savage-Smith 1985, pp. 158, 160.

Star Name	Identification

PLATES

There are 5 plates with following specifications:

Table A025-2 Plates

	φ	Longest Day
1a	21°	13;21 hours
1b	24	13;22 hours
2a	27°	13;46 hours
2b	32°	14;8 hours
3a	36°	14;32 hours
3b	40°	14;52 hours
4a	0° +90°	
4b	36° + 42°	
5a	Plate of ecliptic coordinates	
5a	Plate of horizons	

On plates 1-4, altitude circles are drawn for every 2° and every fifth is highlighted with dots; azimuth circles are drawn for every 10° below the horizon, occasionally also above or both above and below the horizon. There are lines for seasonal hours and lines drawn from the western horizon for equal hours; sometimes these lines for equal hours are drawn from the western horizon and also from the eastern horizon up to the meridian. East and west points on the horizon are labelled with *al-mashriq* and *al-maghrib*.

GEOGRAPHICAL GAZETTEER

There is a gazetteer arranged in spiral form in four annular circles (48 + 36 + 24 + 12 -4) = 116 localities.

BACK

The rim of the two upper quadrants carries the altitude scales, which are divided in 1° and 5° and labelled 5—90; 90—5. The rim of the lower half bears the cotangent scale.

The The trigonometric quadrant in the upper left is engraved with 60 horizontal and 60 vertical parallels, where each fifth line is highlighted with dots. In the upper right quadrant are 30 declination arcs for each 6° of solar longitude; along the two radii are marked the names of the signs and their divisions. On this quadrant are drawn two solar meridian altitude graphs for the latitudes of 27° and 32° with the labels *khaṭṭ niṣf al-nahār bi-ᶜarḍ 27* and *khaṭṭ niṣf al-nahār bi-ᶜarḍ 32*.

In the lower half are drawn the shadow squares, on the left for the base of 12 digits and on the right for the base of 7 feet. The vertical and horizontal scales related to the shadow squares are divided and numbered accordingly and carry the following labels.
Vertical scale on the left: *ẓill aṣābiᶜ maᶜkūs* (reverse shadow in digits)
Horizontal scale on the left: *ẓill aṣabiᶜ mustawī* (direct shadow in digits)
Horizontal scale on the right: *ẓill aqdām mustawī* (direct show in feet)
Vertical scale on the right: *ẓill aqdām maᶜkūs* (reverse shadow in feet)
In the two inner corners of the squares is written *ẓill sullam* (scale of shadows)

Inside the shadow squares, there are six semi-circular rows. In the first two are engraved the names of the lunar mansions and the names of the corresponding signs respectively. The next two rows contain the table of limits (*ḥudūd*) and the last two rows the decans and their regents (*wujūh*).

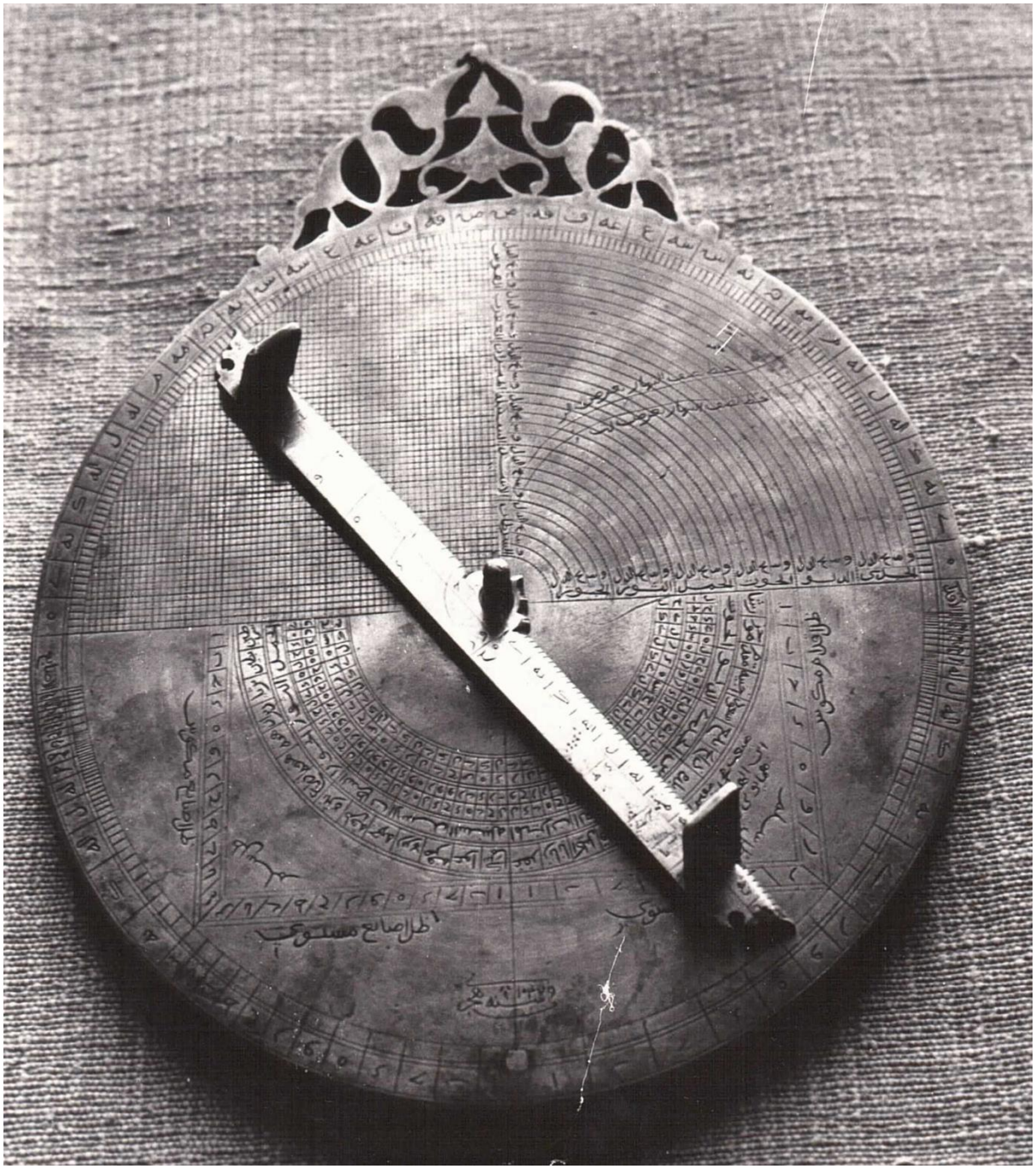


Figure A025.2 – Back of the astrolabe (photo courtesy A. J. Turner)

ALIDADE

Straight bar alidade with ornate ends (crab-claw variety) and ornate centre-piece; it bears a zodiacal scale on one side and a sexagesimal scale and universal hour scale on the other.



Figure A025.3 – Signature of the astrolabe maker (photo by S. R. Sarma)

INSCRIPTION

In the space between the shadow squares and the semi-circular tables, in the right hand side corner, is engraved the signature of the maker in three lines, as follows:

ṣanᶜat muḥammad muqīm ibn ᶜīsā
ibn allāhdād asṭurlābī
humāyūnī lāhūrī

and a fourth line is engraved below the shadow squares, on the meridian line just above the cotangent scale:

fī sanah 1047 hijrī

‘The work of Muḥammad Muqīm, son of ᶜĪsā,
son of Allāhdād of Lahore, the astrolabe maker to
[the Emperor] Humāyūn,
in the year 1047 of Hijrā.’

BIBLIOGRAPHY

Behari & Govind 1980, p. 101-2, no. 8.
Sen 1990, p. 122: a selection of the stars.

A026⊙ ZOOMORPHIC ASTROLABE BY MUḤAMMAD MUQĪM, 1047 AH (AD 1637)

Diameter 258 mm

Hyderabad, Salar Jung Museum (#114/1/xxxv)

CCA-nil



Figure A026.1 – Front of the astrolabe (photo by S. R. Sarma)

This astrolabe is a fabulous creation by Muḥammad Muqīm. It may be recalled Allāhdād, the patriarch of the Lahore family, incorporated finely crafted zoomorphic images of the two stars Vega and Altair in the rete of his undated astrolabe (A002). In the present fabulous astrolabe, his grandson Muqīm playfully gave zoomorphic and anthropomorphic shapes to 29 star pointers in the rete.[285] Playful also is the arrangement of the geographical gazetteer which begins in the inner circle and continues up to the outer circle.

Components

Body with *kursī* (d. 258, h. 327, t. 12), shackle and ring, rete (d. 238) for 45 stars, 4 plates (d. 238). One of the plates is completely blank on both sides and is a replacement. The alidade with a sighting tube, bolt and nut are also replacements.

Front

The astrolabe is suspended by a large ring with a diamond-shaped cross section. To this is attached a small shackle; its upper part also has diamond-shaped cross-section, and the lower part is riveted to the top of the *kursī*.

The *kursī* is high and is intricately pierced with several interlinking triangles and vines. The *kursī* terminates in a trefoil design. Both sides of the surface of the fretwork of the *kursī* display leaves and tendrils in shallow engraving with a slightly different colouration, which was achieved by closely drawn crisscross lines.[286]

The scale on the limb is divided in 1° and in 5° and numbered in 5s from 5 to 360 clockwise from the south point.

Rete

The two rings of the Tropic of Capricorn and the ecliptic are held together by the equinoctial bar which is counter-changed at the two equinoxes. The upper edge of the middle segment of the bar represents the equinoctial colure. The ecliptic circle is divided

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285 He made a still grander version but neglected to add his signature in that astrolabe (see A051 below); his son Jamāl al-Dīn also produced a zoomorphic astrolabe in 1666 (A121). On zoomorphic astrolabes, see Gingerich 1987a.

286 Such surface ornamentation can be seen also in the *kursī* of the astrolabe Muqīm made in 1643 (A030) which will be described below; cf. Gunther 1932, vol. I, Pl. XLVII, p. 199.

into the 12 signs and labelled with their names. Each sign is further subdivided into groups of 5° and in single degrees. Like the other productions of Muqīm, this rete too exhibits an intricate floral pattern, with circular loops of vines, tendrils, leaves, buds and flowers.

More important still is the fact that of the 45 star pointers as many as 29 pointers display the zoomorphic or anthropomorphic shapes of the respective constellations as conceived in the Hellenistic or Bedouin traditions. Here Muqīm cut the outline of the desired shape as a silhouette and engraved on it the appropriate lines for the eyes, mouth and so on.

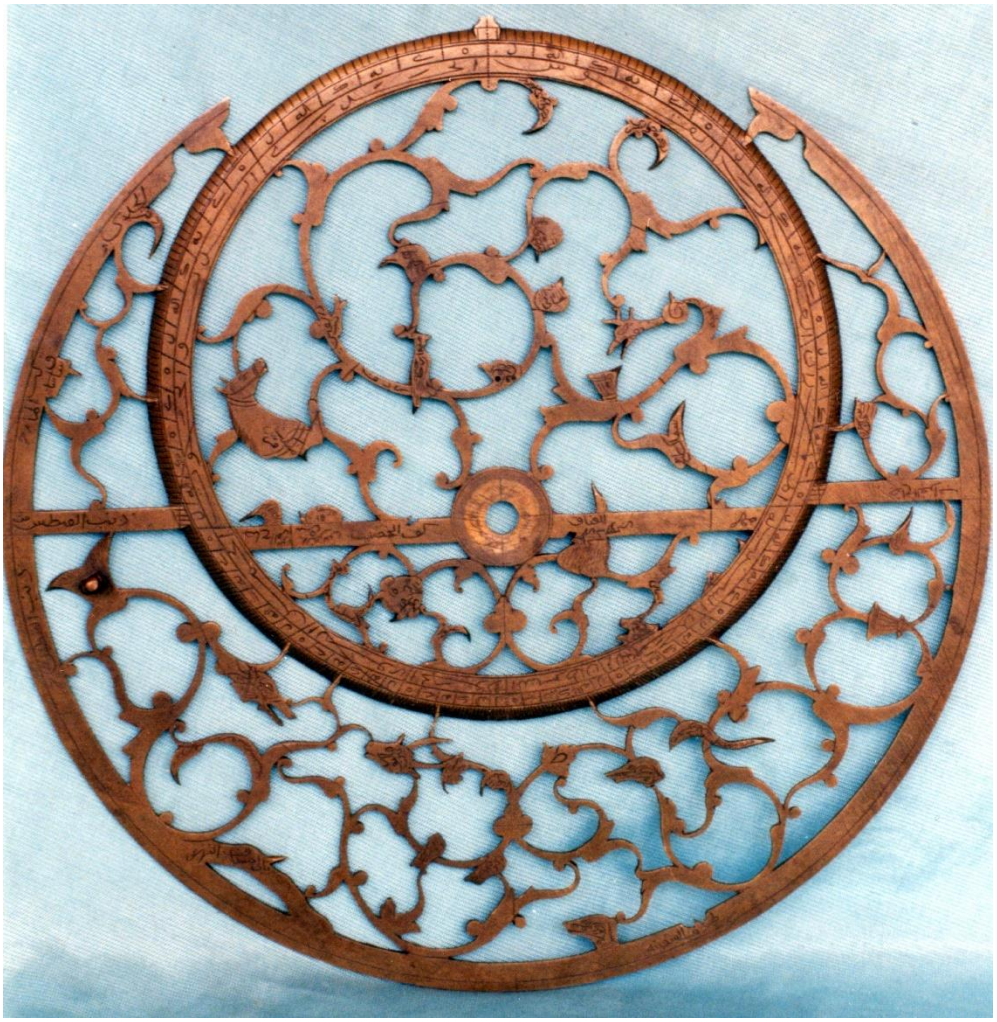


Figure A026.2 – Zoomorphic Rete (photo by S. R. Sarma)

Table A026-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus J[anūbī]*	β Ceti

	Star Name	Identification
2	*Baṭn al-Ḥūt*	β Andromedae
3	*Rijl al-Musalsala*	γ Andromedae
4	*Fam al-Qayṭus*	γ Ceti
5	*Ṣadr al-Qayṭus*	π Ceti
6	*Ghūl*	β Persei
7	*Tālī Masāfat al-Nahar*	γ Eridani
8	*ᶜAyn al-Thawr*	α Tauri
9	*ᶜAyyūq*	α Aurigae
10	*Rijl Yusrā*	β Orionis
11	*Yad Yusrā*	γ Orionis
12	*Yad Yumnā*	α Orionis
13	*Rijl Yumnā*	κ Orionis
14	*Shiᶜrā Yamānī*	α Canis Majoris
15	*Shiᶜrā Shāmī*	α Canis Minoris
16	*Ṭarfat al-Safīna*	ρ Puppis
17	*Mankhar al-Shujāᶜ*	σ Hydrae
18	*Fard al-Shujāᶜ*	α Hydrae
19	*Rās al-Asad Shamālī*	μ Leonis
20	*Ẓahr Dubb Akbar*	α Ursae Majoris
21	*Qāᶜidat al-Bāṭiya*	α Crateris
22	*Ẓahr [al-Asad]*	δ Leonis
23	*Ṣarfa*	β Leonis
24	*Janāḥ al-Ghurāb*	γ Corvi
25	*Simāk Aᶜzal*	α Virginis

	Star Name	Identification
26	*Al-ᶜAnāq*	ξ Ursae Majoris
27	*Simāk Rāmiḥ*	α Bootis
28	*Fakkah*	α Coronae Borealis
29	*ᶜUnuq al-Ḥayyah*	α Serpentis
30	*Rakbat Ḥawwā al-Yusrā*	ρ Ophiuchi
31	*Al-Jāthī*	α Herculis
32	*Al-Ḥawwā*	α Ophiuchi
33	*Yad Ḥawwā Yumnā Muqaddam*	δ Ophiuchi
34	*Al-Wāqiᶜ*	α Lyrae
35	*Minqār al-Dajājah*	β Cygni
36	*Al-Ṭā'ir*	α Aquilae
37	*Dhanab Dālfīn*!	ε Delphini
38	*Ridf*	α Cygni
39	*Dhanab al-Jadī*	δ Capricorni
40	*Sāq-i Sākib al-Mā' J[anūbiya]*	δ Aquarii
41	*Mankib al-Faras*	β Pegasi
42	*Surrat al-Faras*	δ Pegasi
43	*Janāḥ al-Faras*	γ Pegasi
44	*Dhanab al-Qaytus Sh[amālī]*	ι Ceti
45	*Kaff al-Khaḍīb*	β Cassiopeiae

The zoomorphic shapes of the 29 star pointers will be listed below and shown how they were pictorially depicted. For each star, we shall provide first the Arabic name of

the star as engraved on the astrolabe and its literal meaning and then show how Muqīm lends a visual form to this meaning.

The first major constellation south of the ecliptic is the sea-monster Cetus, transliterated as *al-Qayṭus* in Arabic. The Greeks thought of it as a whale, but in the Islamic world, it assumed a more fantastic shape with 'a snarling dog's head, bird's feet, and a feathered fish tail'.[287] Such a shape is drawn fully on Mughal globes.[288] But the full form cannot be shown on the rete of the astrolabe. Therefore, Muqīm just depicts the fish tail with the two fins (northern and southern) and the dog's head, placing the appropriate stars in these parts. The tips of the tail fins become the pointers to the stars called respectively after these. At the intersection of these two tail fins, there is also a handle to rotate the rete.

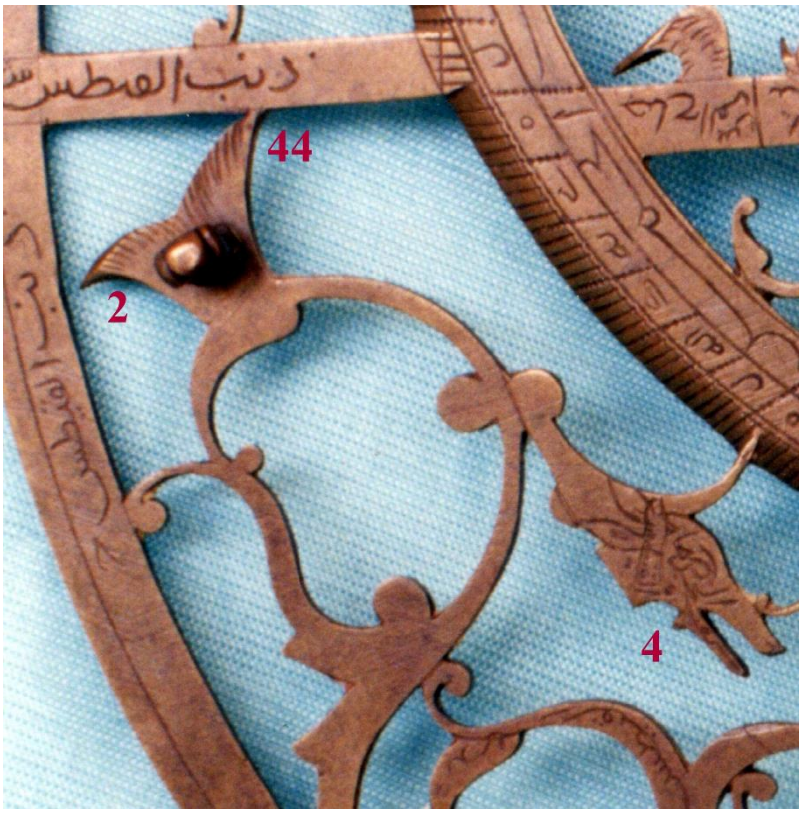


Figure A026.3 – Detail of Figure A026.2. The constellation Cetus with the stars β Ceti (2), ι Ceti (44) and γ Ceti (4).

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287 Savage-Smith 1985, p. 187.

288 Savage-Smith 1985, p. 188, fig. 75; Sarma 2015a, p. 273, fig. 19.8.

1. *Dhanab al-Qayṭus J[anūbī]* (southern tail of Cetus), shown as the tip of the southern fin of the fish tail.

4. *Fam al-Qayṭus* (mouth of Cetus), snarling dog's head

6. *Ghūl* (actually *Rās al-Ghūl,* 'head of the ghoul'), demon's head with horns.

7. *Talī Masāfat al-Nahr* (valley or expanse of the river [Eridanus], the river is shown as an arc, from which projects the thin star pointer.

8. *ᶜAyn al-Thawr* (eye of the bull), a well-executed head of a bull with slender horns and an engraved eye.

10-11-12-13. The next four stars depict the two hands and the two feet of Orion. The hands are skillfully represented: the three last fingers are folded, and the index finger outstretched to form the star pointer. The feet are depicted through tapering shoes.

14. *Shiᶜrā Yamānī* (the southern Shiᶜra, α Canis Majoris, Sirius), dog's head.

15. *Shiᶜrā Shāmī* (the northern Shiᶜra, α Canis Minoris, Procyon), dog's head.

17. *Mankhar al-Shujāᶜ* (the nose of the serpent), snake's head.

19. *Rās al-Asad Shamālī* (the northern head of the lion), lion's head.

20. *Ẓahr Dubb Akbar* (back of the Great Bear), outline of the grizzly or serrated back of the bear.

21. *Qā'idat al-Bāṭiyā* (bottom of the cup), a bucket with vertical serrations.

24. *Janāḥ al-Ghurrāb* (wing of the raven), pointed stylized wing.

25. *Simāk Aᶜzal* (α Virginis, Spica), Virgo's hand.

28. *Al-Fakkah* (α Coronae Borealis, Alphecca), crown, more like a bucket.

29. *ᶜUnuq al-Ḥayyah* (neck of the serpent), open mouthed snake's head.

31. *Al-Jāthī* (actually *Rās al-Jāthī,* the head of the kneeling man, i.e. Herculus), a human face.

32. *Al-Ḥawwā* (actually *Rās al-Ḥawwā*, the head of the serpent charmer) a human face.

34. *Al-Wāqiᶜ* (actually *al-Nasr al-Wāqiᶜ*, the falling eagle), bird's beak.

35. *Minqār al-Dajājah* (the bird's beak), chicken.

36. *Al-Ṭā'ir* (short for *al-Nasr al-Ṭā'ir*, the flying eagle), eagle's head with a curved beak and an engraved eye.

39. *Dhanab al-Jadī* (tail of the goat), tail.

41. *Mankib al-Faras* (shoulder of the horse), horse's head and shoulder, excellently executed and engraved.

42. *Surrat al-Faras* (the navel of the horse, δ Pegasi = α Andromedae). This star is common to the two constellations Pegasus and Andromeda. Here it is named after Pegasus but represented with Andromeda's face with demure eyes.

43. *Janāḥ al-Faras* (wing of the horse), a stylized wing.

44. *Dhanab al-Qayṭus Sh[amālī],* (northern tail of Cetus), shown as the tip of the northern fin of the fish tail.

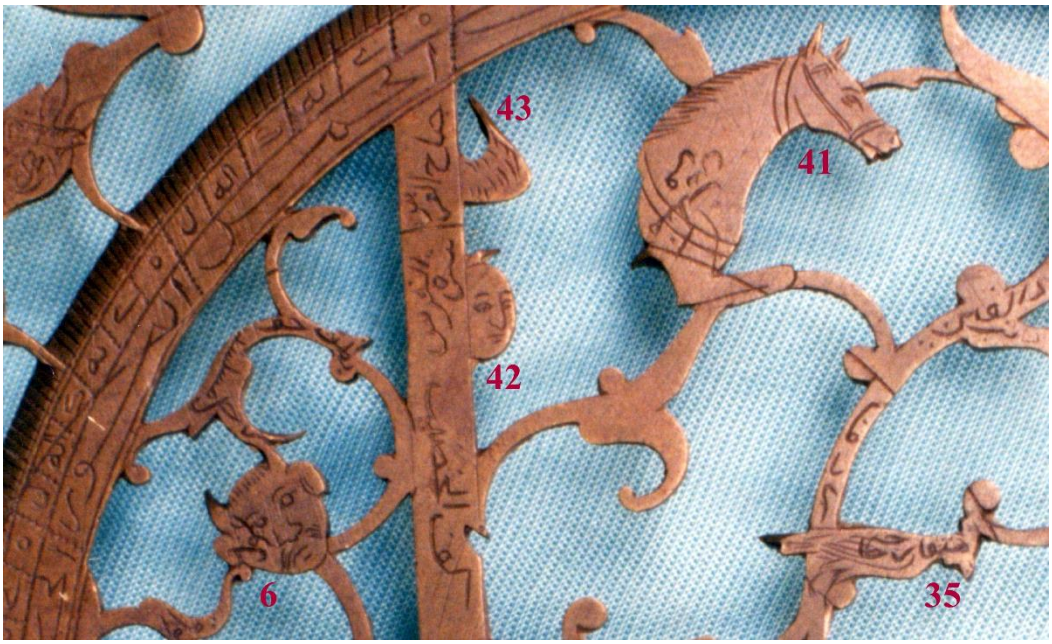


Figure A026.4 – Detail of Figure A026.2. Here can be seen two anthropomorphic and three zoomorphic images together with their names: β Persei (6: *Ghūl*), α Andromedae (42: *Surrat al-faras*), γ Pegasi (43: *Janāḥ al-faras*), β Pegasi (41: *mankib al-faras*) and β Cygni (35: *Miqār Dajājah*).

PLATES

There are four plates. One of these is completely blank on both sides and is obviously a replacement for a lost original. The other plates contain equal altitude circles for every single degree. Every second circle is numbered on both the sides and every fifth circle is highlighted with dots. The azimuth curves are drawn below the horizon for each 5°. In addition to the unequal hour lines, some plates have curves for the hours since sunset, others also for the hours before sunrise. Under the western horizon is engraved *al-maghrib* and under the eastern horizon *al-mashriq.* The three inscribed plates serve the following latitudes:

Table A026-2 Plates

	φ	Longest Day
1a	18°	13;9 hours
1b	21°	13;22 hours
2a	23;30°	13;21 hours !
2b	Plate of ecliptic coordinates	
3a	36°	14;54 hours
3b	39°	14:14 (!) hours

Perhaps the lost plate carried projections for the latitudes 27° and 32°. Perhaps there was also another plate bearing the plate of horizons.

GEOGRAPHICAL GAZETTEER

On the inner side of the mater is an elaborate gazetteer of 155 towns with their longitudes and latitudes, engraved in five concentric circles which are separated from one another by double lines. The gazetteer does not commence at the south point in the outer circle as in almost all astrolabes, but in the inner circle. Therefore, the data is inscribed upside-down, that is to say, the upper part of the letters are towards the centre and the lower part towards the rim. In each circle to the left of the vertical radius there is the argument in the three successive rows: *al-bilād* (place name), *al-ṭūl* (longitude) and *al-ᶜarḍ* (latitude). The gazetteer is read from the argument onwards from right to left, from the innermost (first) circle to the outermost (fifth) circle. The gazetteer is arranged according to increasing longitudes, although occasionally it goes back and forth.



Figure A026.5 – Geographical gazetteer (photo by S. R. Sarma)

Table A026-3 Geographical Gazetteer

	Place Name	L	φ
	Innermost/First Circle		
001	Qayrawān	41;0	31;30
002	Mahdiyya	42;0	32;30
003	Miṣr	63;20	30;20

	Place Name	L	φ
004	ᶜAdan	76;0	11;0
005	Madīnat Tayyiba	75;20	25;0
006	Makka Musharraf	77;10	21;40
007	Tā'īf	77;30	21;30
008	Bayt al-Maqdis	66;30	31;50
009	Dimashq	70;0	33;15
010	Baᶜalbak	70;45	33;15
011	Ḥimṣ	70;45	34;0
012	Ḥalab	72;10	35;50
013	Ṭarsūs	68;40	36;42
014	Malaṭiya	71;0	37;0
015	Ardhan al-Rūm	77;0	39;40
	Second Circle		
016	Arzinkān	77;0	38;0
017	Sīwās	71;40	39;0
018	Qūnya	66;30	41;0
019	Raqqa	73;15	36;0
020	ᶜĀna	76;30	34;0
021	Mawṣil	77;0	34;30
022	Arjīs	77;0	38;30
023	Salamās	79;15	34;40
024	Khuway	79;40	34;40
025	Awrṣiya ?	79;45	34;0
026	Nakhjawān	81;15	38;40

	Place Name	L	φ
027	Tabrīz	82;0	38;0
028	Ardabīl	82;30	38;0
029	Mūqān	83;0	38;0
030	Barda^{c}a	83;0	40;30
031	Bākūya	84;30	39;30
032	Shamākhī	84;30	40;50
033	Bāb al-Abwāb	85;0	45;0
034	Bulghār	90;0	49;0
035	Kūfa	79;30	31;30
036	Madā’īn	72;0	33;10
037	Baghdād	80;0	33;25
038	Baṣra	84;0	30;0
	Third Circle		
039	Rāmhurmūz	85;45	31;0
040	Arjān	86;30	35;30
041	Fīrūzābād	87;30	28;10
042	Shīrāz	88;0	29;36
043	Iṣtakhr	88;30	30;0
044	Yazd	89;0	32;40
045	Shahrazūr	82;20	32;30
046	Zankān	83;40	36;30
047	Abhar	84;30	36;30
048	Hamadān	83;0	35;10
049	Karaj	84;45	34;0

	Place Name	L	φ
050	Sāwa	85;0	35;0
051	Qazwīn	85;0	36;0
052	Iṣfahān	86;40	32;25
053	Kāshān	86;0	34;0
054	Qumm	85;40	34;45
055	Rayy	86;20	35;0
056	Khuwār	87;10	36;40
057	Ṭāliqān	85;45	36;10
058	Astarābād	89;35	36;50
059	Jarjān	90;0	36;50
060	Samnān	88;0	36;0
061	Damghān	88;55	36;20
062	Busṭām	89;30	36;10
063	Sabzwār	91;30	36;0
064	Nīshābūr	92;30	36;21
065	Mashhad	91;30	34;0
066	Turshīz	91;0	35;0
067	Tūn	92;30	34;0
068	Qā'īn	93;20	33;40
069	Harāt	94;20	34;30
	Fourth Circle		
070	Bādghīs	94;30	35;20
071	Sarakhs	94;30	37;0
072	Marw	94;0	37;40

	Place Name	L	φ
073	Jūrjān	98;0	35;30
074	Fāriyāb	99;0	36;45
075	Balkh	101;0	36;41
076	Bāmiyān	102;0	37;35
077	Samankān	102;0	36;0
078	Qabādhiyān	102;0	37;45
079	Walwālij	102;20	36;55
080	Andarāb	103;45	36;0
081	Badakhshān	104;24	37;10
082	Bulūr	108;0	37;0
083	Hazār Asf	95;0	41;0
084	Darqān	94;15	39;30
085	Bukhārā	97;30	39;50
086	Samarqand	99;16	39;37
087	Nasaf	98;0	39;0
088	Ṭarāz	99;50	44;30
089	Khujand	105;35	41;55
090	Uzkand	102;50	44;0
091	Ush	102;20	43;20
092	Kāshghar	106;30	44;0
093	Jāj	109;0	42;30
094	Khutan	107;0	42;0
095	Al-Māligh	102;30	44;0
096	Bīsh Bāligh	101;0	45;50

	Place Name	L	φ
097	Qarāqūrūm	105;0	46;0
098	Khān Bāligh	124;0	46;0
099	Mahrī	140;0	30;0
100	Hurmūz	92;0	25;0
101	Bardshīr	92;30	29;50
102	Jīruft	93;0	24;30
103	Bamm	94;0	28;30
104	Barmāsīr	94;3	29;0
105	Khabīṣ	93;0	31;0
106	Pust	105;0	33;0
107	Maymand	101;55	33;20
108	Ghaznah	104;20	33;35
	Outer/Fifth Circle		
109	Banjahir	104;40	35;0
110	Ribāṭ Amīr	105;0	34;0
111	Kach Makrān	99;0	28;0
112	Kirmān	91;30	30;5
113	Dabīl	102;30	25;10
114	Bakir	105;0	27;40
115	Nahlawara	102;30	22;0
116	Sawmnāth	106;0	17;0
117	Multān	104;35	29;40
118	Qandahār	109;20	31;50
119	Lāhūr	109;20	31;50

	Place Name	L	φ
120	Qannawj	105;50	26;30
121	Bānāras	107;20	26;55
122	Sarandīb	104;0	10;0
123	Tubbat	110;0	40;0
124	Kasmīr	108;0	35;0
125	Jamkūt	177;0	5;0
126	Shilā	180;0	5;0
127	Jind	75;30	14;30
128	Damār	77;15	13;30
129	Maᶜbar	102;0	17;30
130	Maᶜdan Rami	66;0	21;0
131	Maᶜdan Dhahab	67;35	21;45
132	Khaybar	75;20	24;20
133	Jidda	76;0	21;0
134	Bīrūn	84;30	24;45
135	Kanbāyat	109;20	26;20
136	Dawlatābād	111;0	20;30
137	Kawāliyar	114;0	26;29
138	Lahkanūtī	114;13	26;30
139	Kopāmayū	116;33	25;45
140	Jawnpūr	119;6	26;36
141	Karah wa Mānakpūr	118;10	26;49
142	Ajmīr	111;5	26;0
143	Awadh	118;6	27;22

	Place Name	L	φ
144	Akbarābād	115;0	26;43
145	Farmal	104;35	32;55
146	Sālkot	109;0	33;0
147	Hānsī	112;35	29;45
148	Sanām	112;25	30;30
149	Thānīsar	112;33	30;10
150	Bānībaht	113;20	28;52
151	Ḥaḍrat Dihlī	113;35	28;39
152	Baran	114;0	28;40
153	Kol wa Jalālī	114;19	28;4
154	Burhānpūr	113;0	20;30
155	Pajānpūr	105;30	16;20



Figure A026.6 – Back of the astrolabe (photo by S. R. Sarma)

BACK

On the back, the rim of the upper half carries the two altitude scales which are divided 1° and 5° and numbered in 5s as 5—90; 90—5.

In the upper left is the sexagesimal trigonometric quadrant with 60 horizontal parallels, one for each unit of the Radius. Every fifth line here is dotted. In the upper

right is the solar quadrant with declination circles for each 6° of solar longitude. The corresponding zodiac signs are labelled along the two radii, and groups of 6° are numbered separately for each sign. Upon these declination circles are drawn two sigmoid curves of the solar meridian altitude at the latitudes of 27° (Agra) and 32° (Lahore). There carry the labels *khaṭṭ niṣf al-nahār bi-ᶜarḍ 27* and *khaṭṭ niṣf al-nahār bi-ᶜarḍ 32* respectively.

In the lower half are the shadow squares, on the left for a base of 12 and the right for a base of 7. In the two corners of the squares is the label *ẓill sullam* (shadow scale). The vertical and horizontal scales are divided and numbered. They carry the following brief labels:

Vertical scale on the left: *aṣābiᶜ maᶜkūs* (reverse [shadows] in digits)
Horizontal scale on the left: *aṣābiᶜ mustawī* (direct [shadows] in digits)
Horizontal scale on the right: *aqdām mustawī* (direct [shadows] in feet)
Vertical scale on the right: *aqdām maᶜkūs* (reverse [shadows] in feet).

On the rim of the lower half are the corresponding scales of cotangents. The scale on the left is divided in digits as stated by the label *al-aṣābiᶜ* at the end of the scale. The irregular divisions are numbered as 5, 10, 12, 15, 20, 25, … 90. In the next semi-circular row, these divisions are subdivided into 5 parts.

The scale on the right is divided in feet as stated by the label *al-qadām* at the end of the scale. The irregular divisions are numbered as 5, 7, 10, 15, 20, 25, … 90. In the next semi-circular row, these divisions are subdivided into 5 parts.

Inside the shadow squares are six semi-circular rows containing the following. Rows 1-2 contain the names of the 28 lunar mansions and the names of the 12 corresponding zodiac signs. Rows 2-4 constitute a table of limits (*hudūd*) and rows 2, 5-6 a table of decans (*wujūh*) and their regents. These tables are the same as in A016.

Inside these semi-circular rows, just below the horizontal diameter, are two rectangular tables. The one of the left has the title *faḍl al-dawr* (excess of revolution). It shows the multiples of the difference between the length of the tropical year and 365 days. It is almost the same as in A016, with one minor difference for 6.

Table A026-4 Excess of Revolution

1	87 33	10	155 31
2	175 6	20	61 2
3	262 39	30	106 33
4	350 12	40	262 4
5	77 45	50	57 35
6	165[289] 19	60	213 6
7	252 52	70	08 37
8	340 25	80	164 8
9	67 58	90	319 39

The table on the right is entitled *arbāb muthallathāt laylī wa nahārī* (the regents of the triplicities at night and in the day). It differs in two items from the table in A016.

Table A026-5 Triplicities

Fiery *nārī*				Earthy *tarābī*		
Sun	Jupiter	Saturn		Venus	Moon[290]	Mars
Aries	Leo	Sagittarius		Taurus	Virgo	Capricorn
Jupiter	Sun	Saturn		Moon	Venus	Mars
Airy *hawā'ī*				Watery *mā'ī*		
Saturn	Mercury	Jupiter		Venus	Mars[291]	Moon
Gemini	Libra	Aquarius		Cancer	Scorpio	Pisces
Mercury	Saturn	Jupiter		Mars	Venus	Moon

289 It is 164 in A016.

290 It is Mercury in A016.

291 It is Mercury in A016.

Alidade etc

The original alidade, pin, and horse are missing. These are replaced by a crude sighting tube attached to a straight alidade with a three-lobed central part, a screw and a bolt.

Inscription

The maker's signature is engraved in two parts, inside the half-circle close to the centre and below the half circle near the rim and reads as follows:

> *ṣanᶜat muḥammad muqīm ibn ᶜīsā ibn allāhdād asṭurlābī humāyūnī lāhūrī fī sanaḥ 1047 ḥijrī.*
>
> 'Made by Muḥammad Muqīm, son of ᶜĪsa, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the Hijrī year 1047 [= 1637-38 AD].'

Bibliography

Gingerich 1987a.

Sarma 1996a, pp. 11-17, pls. 4-5.

A027 ASTROLABE BY MUḤAMMAD MUQĪM, 1038 AH (AD 1638-39)

Diameter 102 mm

Kolkata, Indian Museum (# 24430)

CCA 3730; Répertoire 11

The Répertoire contains the following information

RETE

The ecliptic is divided into the 12 signs of the zodiac and labelled with their names. The star pointers carry the names of 17 the fixed stars. The Répertoire adds that the rete is incomplete without explaining in what way it is incomplete.

PLATES

Five plates.

BACK

On the back, trigonometric quadrant on the upper left, solar quadrant on the upper right with two curves for the midday altitude of the sun at the latitudes 27° and 32° and shadow squares and astrological tables in the lower half.

INSCRIPTION

The maker's signature reads:

ṣanᶜat muḥammad muqīm ibn ᶜīsā ibn allāhdād asṭurlābī

humāyūnī lāhūrī

fī sanah 1048 hijrī

'Made [by] Muḥammad Muqīm, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn in the year 1048 of Hijrā.'

No other details are available. The museum authorities did not respond to my request for permission to study the astrolabe.

A028⊙ ASTROLABE BY MUḤAMMAD MUQĪM, 1051 AH (AD 1641-42)

Diameter 128 mm

Oxford, Museum of the History of Science (#46935)

CCA 2531; Répertoire 13



Figure A028.1 – Front of the astrolabe (photo by S. R. Sarma)

Components

Body with *kursī* (d. 128, h. 160, t. 8), shackle, ring and rope, rete (d. 116) for 39 stars, 4 plates (d. 116), alidade, pin and horse. The alidade is plain and maybe a replacement. The horse is extravagantly long. There is space for one more plate; maybe one is missing.

Front

The rope (*ilāqa*) is made of white, cream and blue threads. The ring has an oval cross-section; the ends are not soldered together, it is not even very circular; maybe a replacement. The shackle is a finely crafted Mughal specimen in the trifoliate form. The finial of the *kursī* is also trifoliate. The *kursī* is finely pierced. The profiles consist of an ogee at the base, followed by scallops and lobes. Decorative engraving on the surface of the *kursī* on both sides.

The limb is divided in 1° and 5° and numbered from 5 to 90, separately in each quadrant.



Figure A028.2 – Rete of the Astrolabe (photo by S. R. Sarma)

RETE

The Capricorn ring and the much wider ecliptic ring are held together by the equinoctial bar which has counter changes at its two intersections with the ecliptic ring. The latter is divided in the 12 signs of the zodiac and labelled with their names; each sign is subdivided into units of 6° and numbered accordingly. These units are halved on the sloping edge of the ecliptic ring.

This rete is the most unusual among Muqīms astrolabes in that it carries no floral tracery to connect the various star pointers. In the lower half, outside the ecliptic ring, the star pointers are joined to the mainframe by an X-shaped bridge straddling the meridian and by two nearly straight bars on either side. Inside the ecliptic ring, there is an interesting formation containing a quatrefoil. Unlike the retes in other Lahore astrolabes, there are large open spaces in this rete. The star pointers are shaped mostly like tiger's claws. There are several unnamed pointers placed for the sake of symmetry.

Table A028-1 Stars on the Rete

	Star Name	Identification
01	*Dhanab al-qayṭus J[anūbī]*	β Ceti
02	*Baṭn al-Ḥūt*	β Andromedae
03	*Rijl al-Musalsala*	γ Andromedae
04	*Fam al-Qayṭus*	γ Ceti
05	*Ṣadr al-Qayṭus*	π Ceti
06	*Ghūl*	β Persei
07	*Tālī Masāfat al-Nahr*	γ Eridani
08	*ᶜAyn [al-Thawr]*	α Tauri
09	*ᶜAyyūq*	α Aurigae
10	*Rijl Yusrā*	β Orionis
11	*Yad Yusrā*	γ Orionis
12	*Yad Yumnā*	α Orionis
13	*Rijl Yumnā*	κ Orionis

	Star Name	Identification
14	*[Shiᶜrā] Yamānī*	α Canis Majoris
15	*[Shiᶜrā] Shāmiya*	α Canis Minoris
16	*Mankhar Shujāᶜ*	σ Hydrae
17	*Qāᶜidat al-Bāṭiya*	α Crateris
18	*Janāḥ al-Ghurāb*	γ Corvi
19	*Simāk al-Aᶜzal*	α Virginis
20	*ᶜAnāq*	ξ Ursae Majoris
21	*Simāk Rāmiḥ*	α Bootis
22	*Nayyir Fakkah*	α Coronae Borealis
23	*ᶜUnuq al-Ḥayyah*	α Serpentis
24	?	
25	*Rās al-Jāthī*	α Herculis
26	*Rās al-Ḥawwā*	α Ophiuchi
27	*Yad [al-Ḥawwā]*	δ Ophiuchi
28	*Al-Wāqiᶜ*	α Lyrae
29	*Minqār [al-Dajājah]*	β Cygni
30	*Nasr Ṭā'ir*	α Aquilae
31	*Dhanab Dulfīn*	ε Delphini
32	*Dhanab Dajājah*	α Cygni
33	*Dhanab al-Jadī*	δ Capricorni
34	*Fam Faras*	ε Pegasi
35	*Sāq Sākib al-Mā'*	δ Aquarii
36	*Dhanab al-Qayṭus Sh[amālī]*	ι Ceti
37	*Mankib Faras*	β Pegasi

	Star Name	Identification
38	*Surrat Faras*	δ Pegasi
39	*Khaḍīb*	β Cassiopeiae

PLATES

At present there are four plates; there is space for one more plate which may have been lost. Altitude circles are drawn for every 3° and every fifth circle is highlighted by dots. Their labelling is not consistent. Azimuths are drawn below the horizon for every 10° and labelled. The horizontal and vertical diameters, the oblique horizon and prime meridian below the horizon are all dotted. The east and west points on the horizon are labelled *al-mashriq* and *al-maghrib* respectively.

Lines for seasonal hours are drawn. Dotted lines are for equal hours are drawn on some plates from the western horizon and from the eastern and western horizons on some other plates.

Table A028-2 Plates

	φ	Longest day
1a	22°	13;22 hours
1b	25°	13;35 hours
2a	27°	13;46 hours
2b	32°	14;8 hours
3a	36°	14;32 hours
3b	40°	14;54 hours
4a	Plate of ecliptic coordinates	
4b	Plate of horizons	

GEOGRAPHICAL GAZETTEER

The gazetteer is drawn in three concentric circles, listing 69 localities, roughly according to their longitudes in ascending order. In the outer circle, the letters are upside-down. Here the sequence of the entries is: latitude, locality, longitude. In the second and third circles, they are upright; here the sequence of the entries is: longitude, locality, latitude. In the table below, the entries are registered with a uniform sequence of locality, longitude and latitude.



Figure A028.3 – Geographical gazetteer (photo by S. R. Sarma)

Table A028-3 Geograhical Gezetteer

	Place Name	L	φ
	Outer Circle		
01	Qayrawān	41;0	30;40
02	Miṣr	63;20	30;20
03	ᶜAdan	76;0	11;0
04	Madīnat Ṭayyaba	75;20	25;0

	Place Name	L	φ
05	Makka Musharraf	77;10	21;40
06	Ṭā’īf	77;30	21;20
07	Bayt al-Maqdis	66;30	31;50[292]
08	Dimashq	70;0	33;15
09	Ḥalab	72;10	35;50
10	Mawṣil	77;0	30;30[293]
11	Nakhjawān	81;15	38;40
12	Tabrīz	82;0	38;0
13	Bardaᶜa	83;0	40;30
14	Kūfa	79;30	31;30
15	Madā’īn	72;0	33;10
16	Baghdād	80;0	33;25
17	Baṣra	84;0	30;0
18	Fīrūzābād	87;30	28;10
19	Shīrāz	88;0	29;36
20	Yazd	89;0	32;40
21	Hamadān	83;0	35;10
22	Sāwa	85;0	35;0
23	Qazwīn	85;0	36;0
24	Iṣfahān	86;40	34;25
25	Kāshān	86;0	34;0

[292] Here Muqīm engraved the latitude in the column for the longitudes and the longitude in the column of the latitudes.

[293] Here the engraver first engraved the longitude value; then erased it and engraved 30;30.

	Place Name	L	φ
26	Qum	85;40	34;45
27	Rayy	86;20	35;0
28	Astarābād	89;35	36;50
29	Bisṭām	89;30	36;10
30	Sabzawār	91;30	36;0
31	Nīshābūr	92;30	36;21
	Middle Circle		
32	Mashhad	92;30	37;0
33	Tūn	92;30	34;30
34	Qā'īn	93;20	33;40
35	Harāt	94;20	34;30
36	Marw	97;0	37;40
37	Balkh	101;0	36;41
38	Badakhshān	84;24	37;10
39	Bukhārā	97;30	39;50
40	Samarqand	99;16	39;37
41	Khujand	100;35	41;50
42	Kāshghar	106;30	44;0
43	Khutan	107;0	42;0
44	Hurmūz	92;0	25;0
45	Kirmān	91;30	30;5
46	Ghazna	104;20	33;35
47	Kābul	104;40	34;30
48	Tubbat	110;0	40;0

	Place Name	L	φ
49	Kashmīr	108;0	35;0
50	Qandahār	107;40	33;0
51	Tatta	102;30	25;10!
52	Bakar	105;0	27;40 (Mansura al-Sind)
53	Mūltān	107;35	29;40
54	Lāhūr	109;20	31;50
	Inner Circle		
55	Dihlī	113;35	28;39
56	Akbarābād	115;0	26;43
57	Qannawj	115;50	26;35
58	Banāras	117;20	26;55
59	Jawnpūr	119;6	26;30
60	Ajmīr	112;0	26;0
61	Jaddah	76;0	?
62	Ujjayn	110;50	23;30
63	Burhānpūr	113;0	20;30
64	Dawlatābād	111;0	20;30
65	Bijāpūr	105;30	16;20
66	Kolkanda	114;19	28;3 !
67	Aḥmadābād	108;40	23;15
68	Sarandīb	130;0	10;0
69	Kanbāyat	109;20	26;10



Figure A028.4 – Back of the astrolabe (photo by S. R. Sarma)

BACK

On the back, the rim of the two upper quadrants carries the two altitude scales, divided in 1° and 5° and labelled as 5—90; 90—5.

The upper left quadrant carries a sine-cosine grid with 30 horizontal and 30 vertical parallels, where each third is highlighted with dots. In the upper right quadrant, six declination arcs are drawn so that each zone between them represents two zodiac

signs, which are marked with their serial numbers (0 = Aries) along the two radii. Two graphs of the solar meridian altitudes for the latitudes 27° and 32° are superimposed on these quarter circles, with the labels *khaṭṭ niṣf al-nahār bi-ᶜarḍ 27; khaṭṭ niṣf al-nahār bi-ᶜarḍ 32* respectively.

The six declination arcs do not occupy the entire quadrant; some space is left near the apex where a table of six columns and six rows is engraved. It contains the table of triplicities; the table is the same as in A026, but without the four labels nārī (fiery), tarābī (earthy), hawā'ī (airy) and mā'ī (watery) which classify the signs according to the four elements.

A later hand tried to draw a crude shadow square on this quadrant with an angle greater than 90°!

In the lower half there are shadow squares, on the left for the base of 12 and on the right for 7. The vertical and horizontal scales are divided and numbered accordingly and are endowed with the following labels:
Vertical scale on the left: *ẓill sullam aṣābiᶜ maᶜkūs* (scale of reverse shadows in digits)
Horizontal scale on the left: *ẓill sullam aṣābiᶜ mustawī* (scale of direct shadows in digits)
Horizontal scale on the right: *ẓill sullam aqdām mustawī* (scale of direct shadows in feet)
Vertical scale on the right: *ẓill sullam aqdām maᶜkūs* (scale of reverse shadows in feet).

On the rim of the lower half are engraved the two corresponding cotangent tables. The scale on the left is divided in digits and bears a label to this effect at the end: (*al-aṣābiᶜ*). The unequal divisions are numbered 5, 10, 12, 15, 20, 25, 30, 36, 42, 48, 54 and 60. Each of these divisions are subdivided into 5 units each in the semi-circular band inside.

The scale on the right is divided in feet and bears a label to this effect at the end: *al-aqdām*. The unequal divisions are numbered 5, 7, 10, 15, 20, 25, 30, 36, 42, 48, 54 and 60. Each of these divisions are subdivided into 5 units each in the semi-circular band inside.

Below the scales of cotangents, there are three semi-circular rows containing the table of limits (*ḥudūd*).

Again, inside the shadow squares, there are four semi-circular rows. The first two are filled with the names of the 28 lunar mansions and the corresponding zodiac signs,

the latter in serial numbers from 0 to 11. The next two rows contain a table of decans (*wujūh*) and their regents.

Alidade

The alidade is plain without any scales; it appears to be a replacement.

Inscription

In the limited space between the horizontal diameter and the semi-circular rows is the maker's signature, engraved in two lines:

> *ṣanᶜat aḍᶜaf al-ᶜibād muḥammad muqīm ibn ᶜīsā*
> *ibn allāhdād asṭurlābī humāyūnī lāhūrī*
> 'The work of the weakest of the servant [of God], Muḥammad Muqīm, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn.'

The year of manufacture is engraved below the shadow squares: *fī sanah 1051 hijrī* (in the year 1051 Hijrī [= AD 1641-42]).

Provenance

Ex. Collection Nicolas Landau, Paris; ex. Collction J. A. Billmeir, Elstead, Surrey, UK.

Bibliography

Maddison 1957, No. 160, p. 22.

A029⊙ ASTROLABE BY MUḤAMMAD MUQĪM, 1051 AH (AD 1641-42)[294]

Diameter 134 mm

London, National Maritime Museum, Greenwich (# AST0579)

CCA 1054; Répertoire 14



Figure A029.1 – Front of the astrolabe (photo by S. R. Sarma)

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[294] This entry is based on personal examination in 1993 and on Charette 2005b.

COMPONENTS

Body with *kursī* (d. 134), shackle and ring, rete for 36 stars, 5 plates, alidade, pin and horse.

FRONT

The shackle and ring are replacements. The *kursī* is intricately pierced somewhat similar in style to that in the previous astrolabe, with three heart-shaped frames. The finial is trifoliate. The limb is divided in 1° and 5° and numbered in 5s from 5 to 360.

RETE

The Capricorn ring and ecliptic ring are joined by the equinoctial bar which has counter changes at its two intersections with the ecliptic ring. The solstitial bar is partly represented. The star pointers are not joined by a tracery vines and tendrils with leaves and flowers, but by unconnected segments. There are 36 stars pointers; many of them are curved like tiger's claws.

Table A029-1 Stars on the Rete

	Star Name	Identification
01	*Dhanab Qayṭus J[anūbī]*	β Ceti
02	*Baṭn Qayṭus*	ζ Ceti
03	*Rijl Musalsala*	γ Andromedae
04	*Ṣadr Qayṭus*	π Ceti
05	*Fam Qayṭus*	γ Cet
06	*Ghūl*	β Persei
07	*Tālī masāfat al-Nahr*	γ Eridani
08	*Dabarān*	α Tauri
09	*ᶜAyyūq*	α Aurigae
10	*Yad Yumnā*	α Orionis
11	*Rijl al-Jawjā' Yumnā*	κ Orionis
12	*Shiᶜrā Yamānī*	α Canis Majoris

	Star Name	Identification
13	*Shiᶜrā Shāmī*	α Canis Minoris
14	*Mankhar al-Shujāᶜ*	σ Hydrae
15	*Fard al-Shujāᶜ*	α Hydrae
16	*Qācidat al-Bāṭiya*	α Crateris
17	*Janāḥ al-Ghurāb*	γ Corvi
18	*Simāk Aᶜzal*	α Virginis
19	*Al-ᶜAnāq*	ζ Ursae Majoris
20	*Simāk Rāmiḥ*	α Bootis
21	*Nayyir Fakkah*	α Coronae Borealis
22	*ᶜUnuq al-Ḥayyah*	α Serpentis
23	*Rukbat [al-Ḥawwā] Yusrā*	ρ Ophiuchi
24	*Rās al-Jathī*	α Herculis
25	*Yad muqaddam*	δ Opiuchi
26	*Wāqiᶜ*	α Lyrae
27	*Minqār Dajājah*	β Cygni
28	*Nasr Ṭā'ir*	α Aquilae
29	*Dhanab al-Dulfīn*	ε Delphini
30	*Dhanab al-Dajājah*	α Cygni
31	*Dhanab al-Jadī*	δ Capricorni
32	*Fam al-Faras*	ε Pegasi
33	*Sāq Sākib a[l-Mā']*	δ Aquarii
34	*Dhanab Qayṭus Sh[amālī]*	ι Ceti
35	*Mankib Faras*	β Pegasi
36	*Khaḍīb*	β Cassiopeiae

Star Name	Identification

PLATES

There are five plates; altitude circles are drawn for every 6°; azmith arcs are traced for every 10° sometimes below the horizon, sometimes above, and some other times both above and below.

Table A029-2 Plates

	φ	Longest Day
1a	22°	13 hours
1b	25°	13 hours!
2a	27°	13;43 hours
2b	32°	14;8 hours
3a	36°	14 hours
3b	40°	14 hours
4a	0° + 90°	
4b	18° + 72°	
5a	Plate of ecliptic coordinates	
5b	Plate of horizons	

GEOGRAPHICAL GAZETTEER

On the inner side of the mater is engraved a geographical gazetteer in three concentric circles containing the names, longitudes and latitudes of 69 localities. The localities are arranged in ascending order of their longitudes. The writing proceeds clockwise in the outer circle and anticlockwise in the two inner circles.

Table A029-3 Geographical Gazetteer

	Place Name	L	φ
	Outer Circle (clockwise)		
01	Qayrawān	41;0	31;40
02	Miṣr	63;20	30;20
03	ᶜAdan	76;0	11;0
04	Madīnat Ṭayyaba	75;20	25;0
05	Makka Musharraf	77;0	21;40
06	Tā'if	77;30	21;20
07	Bayt al-Maqdis	66;30	31;50
08	Dimashq	70;0	33;15
09	Ḥalab	72;10	35;50
10	Mawṣil	77;0	34;30
11	Nakhjawān	81;15	38;40
12	Marāgha	82;0	37;20
13	Tabrīz	82;0	38;0
14	Bardaᶜa	83;0	40;30
15	Kufa	79;30	31;30
16	Baghdād	80;0	33;25
17	Baṣra	84;0	30;0
18	Fīrūzābād	87;30	28;10
19	Shīrāz	88;0	29;36
20	Yazd	89;0	32;0
21	Qazwīn	85;0	36;0
22	Iṣfahān	86;40	32;25
23	Kāshān	86;0	34;0

	Place Name	L	φ
24	Qum	85;40	34;45
25	Rayy	86;20	35;0
26	Astarābād	89;35	36;50
27	Biṣtām	89;30	36;10
28	Mashhad	92;30	36;0
29	Tūn	92;30	34;30
30	Harat	94;20	34;30
31	Marw	97;0	37;40
	Middle Circle (anticlockwise)		
32	Balkh	81;0	36;41
33	Badakhshān	84;24	37;10
34	Bukhārā	97;30	39;50
35	Samarqand	99;16	39;37
36	Khujand	100;35	41;55
37	Kāshghar	106;30	44;0
38	Khutan	107;0	42;0
39	Hurmūz	92;0	25;0
40	Kirmān	91;30!	30;5
41	Ghazna	104;20	33;35
42	Kābul	104;40	34;30
43	Tubbat	110;0	40;0
44	Kashmīr	108;0	35;0
45	Tana	102;30	25;10
46	Bakar	105;0	27;40 (Mansura al-Sind)

	Place Name	L	φ
47	Qandahār	107;40	33;0
48	Multān	107;35	29;40
49	Lāhūr	109;20	31;50
50	Sālkot	109;0	33;0
51	Pānīpata	113;20	28;52
52	Tānīsar	112;33	30;10
53	Haḍrat Dihlī[295]	113;35	28;39
54	Akbarābād	115;0	26;43
	Inner circle (anticlockwise from the top)		
55	Qannawhāj !	115;50	26;35
56	Banāras	117;20	25;55
57	Kawālīyar	115;0	26;29
58	Jawnpūr	119;0	26;36
59	Jidda	77;0	21;0
60	Ujjayn	110;50	23;30
61	Ajmīr	111;5	26;0
62	Saronj (?)	72;40	34;50
63	Aḥmadābād	108;40	23;15
64	Burhanpūr	103;0	20;30
65	Bījāpūr	105;30	16;20
66	Dawlatābād	110;0	20;30
67	Kalkanda	114;19	28;4 !

[295] Spelt wrongly as ‘Hadrab Dihlī’

	Place Name	L	φ
68	Sarandib	130;0	10;0
69	Kanbayāt	109;4	22;20



Figure A029.2 – Back of the astrolabe (photo by S. R. Sarma)

Back

The back of this astrolabe is designed almost exactly like the back of the astrolabe A028 which too was made in the same year. The rim on the upper half bears the two altitude scales, divided in 1° and 5°, and numbered in 5s as 5—90; 90—5.

In the upper left is the trigonometric quadrant which carries 30 vertical and 30 horizontal parallels where each fifth is dotted.

The solar quadrant in the upper right is divided by declination arcs into 6 zones, one for each pair of zodiac signs; the signs are labelled along the two radii; from *al-Saraṭān* to *al-Qaws* along the vertical radius and from *al-Jawjā'* to *al-Dalw* along the horizontal radius. Moreover, two sigmoid graphs of the solar altitude at midday are traced on this quadrant with the labels *khaṭṭ niṣf al-nahār bi-ᶜarḍ 27* and *khaṭṭ niṣf al-nahār bi-ᶜarḍ 32* respectively.

As astrolabe A029, here also the table of triplicities is engraved at the apex of the quadrant, without the labels *nārī, tarābī, hawā'ī* and *mā'ī.*

Shadow squares are drawn in the middle of the lower half. On the left these are drawn for a base of 12 digits; the horizontal and vertical scales are divided into 12 units each and numbered accordingly. They are labelled respectively as
ẓill sullam aṣābiᶜ mustawī (scale of the direct shadows in digits) and
ẓill sullam aṣābiᶜ maᶜkūs (scale of the reverse shadows in digits)

On the right the base is 7 feet; the horizontal and vertical scales are divided into 12 units each and numbered accordingly. They are labelled respectively as
ẓill sullam aqdām mustawī (scale of the direct shadows in feet) and
ẓill sullam aqdām maᶜkūs (scale of the reverse shadows in feet).

The rim of the lower half carries cotangent scales. Inside these scales, there are three semi-circular rows containing the table of limits (*ḥudūd*). Again, inside the shadow squares there are four semi-circular rows. The first two are filled with the names of the 28 lunar mansions and the corresponding zodiac signs, the latter in serial numbers from 0 to 11. The next two rows contain a table of decans (*wujūh*) and their regents.

Alidade

The alidade has ornate ends and an ornate centre-piece. The right half carries a sexagesimal scale which is divided every 6 and 2 units, and sundial markings for hours 1/12, 2/11, 3/10, and 4/9. On the left half is engraved the scale of solar longitude.

The wedge is a modern replacement; it bears a label ‘S.P.1970’.

Inscription

The maker’s signature is engraved upside down below the table of limits:

ṣanaᶜat bi-yad aḍaᶜaf al-ᶜibād muḥammad muqīm ibn ᶜīsā
ibn allāhdād asṭurlābī humāyūnī lāhūrī

‘Made by the hand of the least of the servants [of God], Muḥammad Muqīm, the son of ᶜĪsā, the son of Allāhadād of Lahore, the astrolabe maker to [the Emperor] Humāyūn.’

The year of manufacture is written in the space between the horizontal diameter and the semi-circular tables: *fī sanah 1051 hijrī* (in the year 1051 Hijrī [= AD 1641-42]).

Provenance

Presented by Captain R. K. Dickson on 29 August 1946.

Bibliography

Charette 2005b.

A030⊙ ASTROLABE BY MUḤAMMAD MUQĪM, 1053 AH (AD 1643-44)

Diameter 167 mm

Oxford, Museum of the History of Science (#43704)

CCA 72; Répertoire 15



Figure A030.1 – Front of the astrolabe (photo by S. R. Sarma)

Components

Body with *kursī* (d. 167, h.225, t. 9), shackle and ring, rete (d. 155) for 38 stars, 5 plates (d. 156), alidade, pin and horse.

Front

The ring has a diamond cross-section; the ends are not soldered together. The shackle also has a diamond cross-section; its form is more oval than trifoliate; the bases are trifoliate. The profiles of the *kursī* are made up of ogees at the base and top with a lobe in the middle. The finial is trifoliate. The *kursī* is finely pierced and the upper surface on the front and back is decorated with hatching.

The limb is divided in 1° and 5° and labelled in 5s from 5 to 360.



Figure A030.2 – Rete of the astrolabe (photo by S. R. Sarma)

RETE

The Capricorn ring and the ecliptic ring are held together by the equinoctial bar which has counter changes at its two intersections with the ecliptic ring. The latter is divided into 12 signs and labelled with their names; each sign is further subdivided into units of 6° and again into units of 2°. There are 38 star pointers, 17 outside the ecliptic and 21 inside. These are slightly curved with very sharp tips. These star pointers are joined to the main frame by a tracery of intersecting circles and triangles; this design matches nicely with that the *kursī.* There is a handle on the peripheral ring to the right of the north point.

Table A030-1 Stars on the Rete

	Star Name	Identification
01	*Dhanab al-Qayṭus J[anūbī]*	β Ceti
02	*Rijl Musalsala*	γ Andromedae
03	*Fam al-Qayṭus*	γ Ceti
04	*Ṣadr al-Qayṭus*	π Ceti
05	*Kaff al-Jadhmā'*	α Ceti
06	*Rās al-Ghūl*	β Persei
07	*Tālī Masāfat al-Nahr*	γ Eridani
08	*ᶜAyyūq*	α Aurigae
09	*Rijl al-Jawjā' Yusrā*	β Orionis
10	*Yad al-Jawjā' Yusrā*	γ Orionis
11	*Yad al-Jawjā' Yumnā*	α Orionis
12	*Rijl al-Jawjā' Yumnā*	κ Orionis
13	*Shiᶜrā Yamānī*	α Canis Majoris
14	*Shiᶜrā Shāmī*	α Canis Minoris
15	*Fard al-Shujāᶜ*	α Hydrae
16	*Ẓahr Dubb Akbar*	α Ursae Majoris

	Star Name	Identification
17	*Qāᶜidat al-Bāṭiya*	α Crateris
18	*Ẓahr al-Asad*	δ Leonis
19	*Janāḥ al-Ghurāb*	γ Corvi
21	*Simāk Aᶜzal*	α Virginis
20	*Al-ᶜAnāq*	ζ Ursae Majoris
22	*Simāk Rāmiḥ*	α Bootis
23	*Nayyir Fakkah*	α Coronae Borealis
24	*ᶜUnuq al-Ḥawwā*	α Serpentis
25	*Rās al-Jāthī*	α Herculis
26	*Rās al-Ḥawwā*	α Ophiuchi
27	*Nasr Wāqiᶜ*	α Virginis
28	*Nasr Ṭā'ir*	α Aquilae
29	*Minqār Dajājah*	β Cygni
30	*Dhanab Dulfīn*	ε Delphini
31	*Dhanab al-Dajājah*	α Cygni
32	*Fam Faras*	ε Pegasi
33	*Dhanab al-Jadī*	δ Capricorni
34	*Sāq Sākib al-Mā' J[anūbyya]*	α Aquarii
35	*Dhanab al-Qayṭus Sh[amālī]*	ι Ceti
36	*Mankib Faras*	β Pegasi
37	*Surrat al-Faras*	δ Pegasi
38	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are five plates with the following specifications:

Table A030-2 Plates

	φ	Longest Day
1a	22°	13;21 hours
1b	25°	13;25 hours
2a	27°	13;46 hours
2b	32°	14;8 hours
3a	36°	14;32 hours
3b	40°	14;52 hours
4a	23°	13;24 hours
4b	0° + 72° + 90°	
5a	Plate of ecliptic coordinates	
5b	Plate of horizons with notches at the four cardinal points	

On plates 1-4, altitude circles are drawn for every 2° with each fifth circle dotted. Azimuth arcs are traced for every 6° below the horizon; plain lines for seasonal hours and dotted lines from the western horizon for equal hours.

The plate of ecliptic coordinates and the plate of horizons have the usual projections, but no labels. Interestingly the plate has four notches at the pour points of the compass, so that all the four sets of horizons can be made use of. In theory all horizon plates should have four such notches in order to be functional, but very rarely they do.

Of special interest is 4b which has a composite projection for the three latitudes 0°, 72° and 90°.[296] The upper half carries the stereographic projections for the latitude 0°. Here the horizontal diameter is the horizon. Below the line of horizon in the west and in the east are the labels *lā ᶜarḍ lahu* (there is no latitude). The altitude circles are

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[296] See also A047; Sottas 1930, pp. 171-173.

drawn for each 3° and every fifth highlighted with dots. These are numbered on both sides of the meridian. Azimuth arcs are traced for every 10° above the horizon. They are drawn completely in the upper left quadrant and numbered along the horizon. In the upper right quadrant, they are drawn partially and make way for the projections of latitude 72°.

The stereographic projections for latitude 90° are drawn in the lower left quadrant. Here the equator constitutes the horizon; it is drawn as a full dotted circle. Altitude circles are drawn for every 3° both above and below the equator-horizon. Every fifth circle is highlighted with dots. The altitude circles above the equator-horizon are numbered from 3 to 90. The circle at 24° is drawn somewhat bold; it is the Tropic of Cancer. The altitude circles below the equator-horizon are numbered from 3 to 18. Below the line of equator-horizon is the label *ᶜarḍ tisᶜūn* (latitude 90 [degrees]).

The stereographic projections for latitude 72° (arctic circle) are traced in the lower right quadrant and partially also in the upper right quadrant. Here the horizon is represented by a dotted circle drawn eccentrically. Here also there are altitude circles for every 3°, numbered along the meridian up to a point slightly below the centre. From this point radiate the azimuth arcs at intervals of 10°; these are numbered above the horizon. Below the horizon is engraved the label *al-ᶜarḍ 72.*

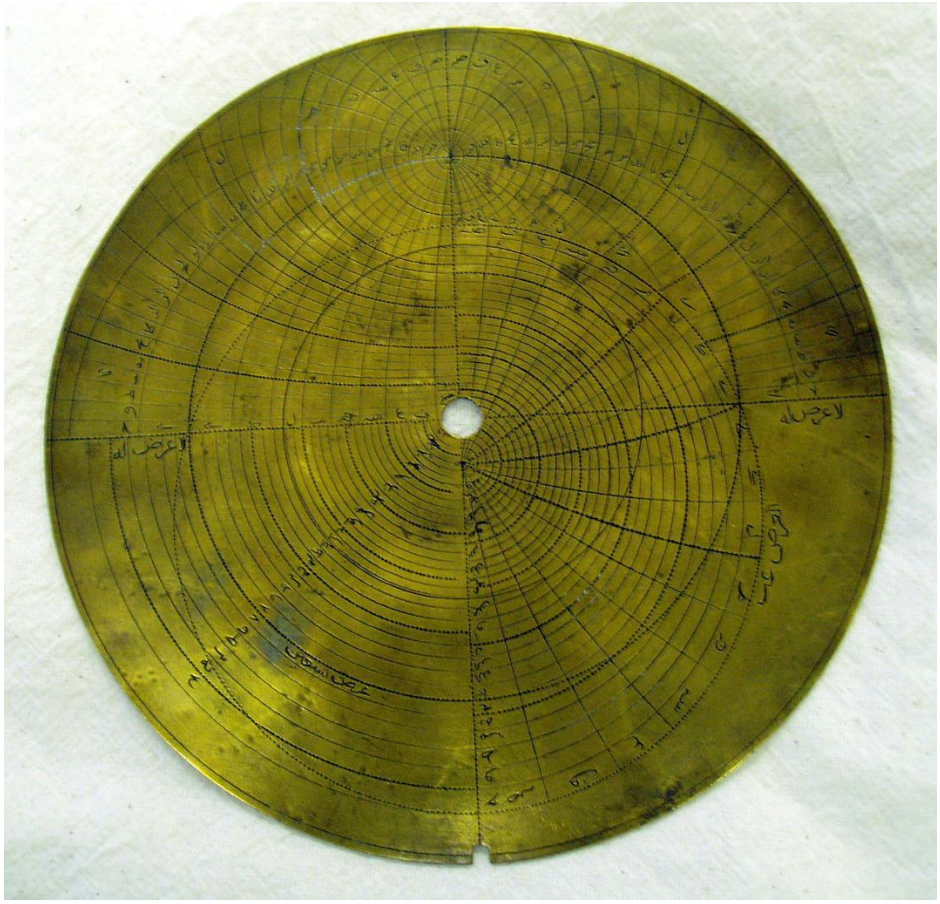


Figure A030.3 – Triple projection for latitudes 0°, 72° and 90°(photo by S. R. Sarma)

GEOGRAPHICAL GAZETTEER

The gazetteer is engraved in four circles for 116 localities arranged according to climates. The circles are separated by blank rows bounded by double lines on either side. The names of climates are engraved in the blank rows, not in elongated strokes as in other astrolabes, but in a compact form. The actual entries are in two lines, each separated from the next by two vertical strokes ‖. Again in each entry, the name of the locality is written in the first line; below that in the second line, the longitude and the latitude are written in the same row, separated by two vertical strokes ‖. Strangely, there are no arguments in the first cell of each row.



Figure A030.4 – Geographical Gazetteer (photo by S. R. Sarma)

Table A030-3 Geographical Gazetteer

	Place Name	L	φ
	Outer Circle		
[-I] *az khaṭṭ istiwā' tā iqlīm awwal* (from the line of equator up to the first climate)			
01	Sāḥil Baḥr Awqiyānūs[297]	11;0	0;0
02	Jazīra Qanbala	21;00	3;0

[297] Ocean coast of the Oceanus. Oceanus (Greek *Okeanos*) is said to be the divine personification of the sea that encircles world.

	Place Name	L	φ
03	Hadiya	66;0	7;0
04	ᶜAdan	76;0	11;0
05	Sarāndīb	130;0	10;0
06	Jamkūt	177;0	5;0
07	Kankandaz[298]	106;0	0;0
[I] *al-iqlīm al-awwal* (the first climate)			
08	Dunqula	63;0	60;0!
09	Jabil	75;0	13;30
10	Janad	75;6	14;30
11	Ṣanᶜān	77;0	14;30
12	Zītūn	114;0	17;0
13	Bījāpūr	105;30	17;20
[II] *al-iqlīm al-thānī* (the second climate)			
14	Madīnat Tayyaba	75;20	25;0
15	Makka Muᶜaẓẓama	77;10	21;40
16	Hurmūz	92;0	25;0
17	Qannwj	115;50	26;15
18	Banāras	117;20	26;15
19	Kawālīyar	114;0	26;29
20	Akbarābād	115;0	26;43
21	Kara wa Mānikpūr	118;10	26;19
22	Lakhnawti	114;13	26;30

[298] The name is so engraved; cf. Kennedy 1987a, s.v. Kang and Kangdezh, p. 171.

	Place Name	L	φ
23	Kūpāmāvū	116;10	26;43
24	Badāūn	119;59	27;32
25	Jawnbūr	119;6	26;36
26	Awadh	118;6	26;22
27	Ajmīr	111;5	26;0
28	Mandū	111;25	27;15!
29	Sārankbūr	112;30	23;20
30	Narwar	114;0	25;20
31	Patan	104;30	22;0
32	Bahrūj	109;45	21;20
33	Juyūl[299]	106;40	19;0
34	Tānah	114;5	19;20 Thane
35	Aḥmadābād	108;40	23;15
36	Burhānpūr	113;0	20;30
37	Dawlatābād	104;0	20;30
38	Kanbāyat	109;20	22;30
[III] *al-iqlīm al-thālith* (the third climate)			
39	Asfī	12;15	30;15
40	Qayrawān	41;15	31;15
41	Mahdiyya	92;15 !	32;30
42	Iskandariyya	61;54	30;18

[299] Kennedy 1987a, p. 167, says that this place is on the coast of India; the only authority he cites is al-Bīrūnī's *Al-Qānūn al-Masᶜūdī.* It is not mentioned in Abū'l-Faḍl's *Ā'īn-i Akbarī*, indexed in Kennedy 1987a, pp. 569-580. The place ought to be on the west coast of India, north of Mumbai, but I cannot identify it.

	Place Name	L	φ
43	Miṣr	63;15	30;20
44	Bayt al-Maqdis	66;30	31;50
45	ᶜAmmān	67;20	31;0
46	Dimashq	70;0	33;20
47	Ḥala	79;15	32;15
48	Kūfa	79;30	31;30
	Second Circle		
[III] *tatimma iqlīm thālith* (continuation of the third climate)			
49	Baghdād	80;15	33;20
50	Madā'īn	80;20	33;0
51	Bāb al-ᶜIrāq	80;15	33;0
52	Ḥalwān	84;55	34;0
53	Baṣra	84;0	30;0
54	Iṣfahān	87;40	32;25
55	Fīrūzābād	87;30	28;10
56	Shīrāz	88;0	29;30
57	Multān	107;25	29;40
58	Bakr	105;0	27;40
59	Kirmān	94;30	30;5
60	Parashwar	85;55	31;0
61	Qandahār	107;40	33;0
62	Sālkūt	109;0	33;0
63	Lāhūr	109;20	31;50
64	Dihlī	113;35	28;39

	Place Name	L	φ
65	Tānīsar	114;33	30;10
66	Samīr ?	85;40	32;15
67	Kolkanda	114;19	28;3
[IV] *al-iqlīm al-rābiᶜ* (the fourth climate)			
68	ᶜĀnah	75;30	38;45
69	Tūn	92;30	34;30
70	Harat	94;20	34;30
71	Qum	105;40!	34;45
72	Rayy	86;20	35;0
73	Sāwa	85;0	35;0
74	Kashmīr	108;0	35;0
75	Hamadān	83;0	35;10
76	Ḥalab	72;10	35;50
77	Mashhad	92;30	36;0
78	Sabzawār	91;30	36;5
79	Busṭām	89;30	36;10
80	Balkh	101;0	36;11
	Third Circle		
[IV] *tatimmah iqlīm rābi ᶜ* (continuation of the fourth climate)			
81	Nīshābūr	92;30	36;21
82	Ṭāliqān	85;45	36;10
83	Astarābād	89;35	36;50
84	Qazwīn	85;30	36;35
85	Badakhshān	104;24	37;10

	Place Name	L	φ
86	Marāgha	82;0	37;20
87	Marw	97;0	37;40
88	Tabrīz	82;0	38;0
89	Ardabīl	80;30	38;0
[V] *al-iqlīm al-khāmis* (the fifth climate)			
90	Nakhjawān	81;15	38;40
91	Samarqand	99;16	39;37
92	Bīkand	97;30	39;45
93	Bukhārā	97;30	39;50
94	Tubbat	110;0	40;0
95	Bardaᶜa	83;0	40;30
96	S[h]amākhī	84;30	40;50
97	Khujand	105;35	41;55
98	Khutan	107;0	42;0
99	Kāshān	101;35	42;0
100	Bāb al-Abwāb	85;0	43;0
101	Aylāq	99;10	43;20
[VI] *al-iqlīm al-sādis* (the sixth climate)			
102	Ḥalqiya	20;0 !	47;0
103	Yanbalūna	34;55	45;15
104	Bandqīya	42;0	44;0
	Fourth Circle		
[VI] *tatimma al-iqlīm sādis* (continuation of the sixth climate)			
105	Haraqla	67;20	46;30

	Place Name	L	φ
106	Fārāb	88;30	45;0
107	Kāshghar	106;30	44;0
108	Bīsh Bāligh	111;0	45;50
109	Khān Bāligh	134;0	46;0
[VII] *al-iqlīm al-sābiʿ* (the seventh climate)			
110	Aqjākirmān	65;0	50;0
111	Qirqir	65;30	50;0
112	Ṭirnū	67;30	50;15
113	Araq	85;0	48;0
114	Ṣarāy	86;0	48;0
115	Akla	88;0	49;0
[VII+] *khārij iqlīm haftum* (beyond the seventh climate)			
116	Mārīkirmān	65;45	50;40
117	Ṣūdāq	66;0	51;0
118	Jazāīr Rūd Hard	---	62;0
119	Jazāīr Qūlī	---	65;0
120	Nahāya Baḥr Awqiyānūs[300]	---	71;0

BACK

The rim on the back is wider than the limb in the front. The rim of the two upper quadrants carries the altitude scales, which are divided in 1° and 5° and labelled 5—90; 90—5.

[300] End (*nahāya*) of the encircling ocean called Oceanus cf. Kennedy 1987a, p. 248.

The upper left quadrant is occupied by a sine-cosine graph with 60 horizontal and 60 vertical parallels, each fifth of which is highlighted with dots. In the upper right quadrant are traced declination circles for each 5° of solar longitude. These are labelled by the names of the zodiac circles along the two radii. The names of the signs from summer solstice to winter solstice, viz. *al-Saraṭān* to *al-Qaws,* are written along the vertical radius from the centre up to the periphery and the names of the signs from winter solstice to summer solstice, viz. *al-Jadī* to *al-Jawzā',* along the horizontal radius from the periphery to up to the centre. Above or next to these names the subdivisions of signs are numbered from 6 to 30, separately for each sign. In addition, two sigmoid graphs of the midday altitude of the sun throught the year are plotted for the latitudes 27° and 32° with the labels *khaṭṭ niṣf al-nahār bi-ᶜarḍ 27* and *khaṭṭ niṣf al-nahār bi-ᶜarḍ 32* respectively.

In the lower half are shadow squares, on the left for a base of 12 and 60 and on the right for 7. The vertical and horizontal scales are drawn in three bands each. The inner band is divided in 12 units and numbered from the centre from 1 to 12 up to the end of horizontal scale and from 12 to 1 in the vertical scale. The middle band is divided in sexagesimal units. These are numbered in 5s in the outer band; from the centre onwards as 5, 10, 15, … 60 in the horizontal scale and again as 60, 55, 50, … 1 in the vertical scale. The horizontal scale of 12 is labelled as *ẓill sullam aṣābiᶜ mustawī* and the vertical scale *ẓill sullam aṣābiᶜ maᶜkūs.* The scale of 60 in the outer band has a new name; the horizontal scale is entitled *ẓill sittaynī mustawī* (sexagesimal direct shadow) and the vertical scale *ẓill sittaynī maᶜkūs* (sexagesimal reverse shadow). This sexagesimal scale occurs here for the first time on Lahore astrolabes.

The scale on the right has only a single band divided in 7 units and numbered accordingly. The labels are *ẓill sullam aqdām mustawī* for the horizontal scale and *ẓill sullam aqdām maᶜkūs* for the vertical scale. In an outer band adjoining the horizontal and vertical scales is engraved the maker's signature which will be discussed below.

Inside the shadow scales, there are 6 semi-circular rows, separated by double lines. In the first row (as counted from the outside) are engraved the names of the 28 lunar mansions and in the second row the names of the 12 corresponding zodiac signs. The next two rows contain the table of limits (*al-ḥudūd*) and the last two lines the decans (*al-wujūh*) and their regents as in A016 and A026.

These 6 semi-circular rows enclose the rectangular table of triplicities written upside down with the heading *arbāb muthallathāth laylī wa nahārī* (the regents of the triplicities at night and in the day). As in the two previous case (A026 and A027), the table avoids the four-fold classification according to the elements.

Finally, below the shadow squares, there is one more table entitled *faḍl al-dawr* (excess of revolution) as in A016 and A026.

ALIDADE ETC

The alidade and the wedge are plain and not original. The pin is original, its head is shaped like a lotus with 16 petals.



Figure A030.5 – Back of the astrolabe (photo by S. R. Sarma)

INSCRIPTION

The inscription is engraved in outer band outside a shadow square with the base of 7:

ṣanᶜat aḍᶜaf al-ᶜibād muḥammad muqīm ibn ᶜīsā ibn allāhdād asṭurlābī lāhūrī humāyūnī

> ‘The work of the least of the servants [of God], Muḥammad Muqīm, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn.’

To the right of the shadow squares is engraved the year of manufacture in both standard Arabic numerals and in *Abjad* notation: *fī 1053 sanah hijrī gh-n-j* (in the year 1053 Hijrī). To the left of the shadow squares the year is mentioned in a different era: *fī 1955 sanah sikandarī gh-ẓ-n-h* (in the year 1955 of Alexander, i.e. Rūmī era).

The Hijrī year 1053 lasts from 21 March 1643 to 9 March 1644 and the Rūmī year 1955 from 11 October 1643 to 10 October 1944. Therefore, the astrolabe was completed in the period from 11 October 1643 and 9 March 1644.

A little below the Hijrī year is engraved *fī 1221 sanah* (in the year 1221). This cannot be the year of manufacture in a third era. It is obviously added by a latter hand and may probably refer to the year in Hijri era when a new owner acquired it in 1806-07.

Provenance

Purchased by Lewis Evans in July 1909.

Bibliography

Gunther 1932, no. 72, pp. 197-200, figs. 98 (plate for lat. 23°, wrongly labelled as 22°), 99 (front view), pl. XLVII (back & gazetteer).

A031 ASTROLABE BY MUḤAMMAD MUQĪM, 1053 AH (AD 1643-44)[301]

Diameter 144 mm

Washington, National Museum of American History

CCA 86; Répertoire 16

COMPONENTS

Body with *kursī* (d. 144), shackle and ring, 5 plates, rete, alidade, pin and horse. Of these, the mater is original, the rete and the alidade are replacements, so also the plates serving the latitudes 31°-32° and 22°-25°.

FRONT

The ring is a corrugated circle and the shackle has the trifoliate shape. The *kursī* is covered on both sides with plates attached with rivets; apparently the fretwork is damaged. The limb is graduated in 1° and 5° and numbered 5—90; 5—90; 5—90; 5—90.

RETE

The rete is a crude replacement and non-functional.[302] The Capricorn ring is decorated with a pattern of a vine with leaves. The ecliptic is crudely divided and labelled with the names of the 12 signs. The name of only one star, *Qalb al-ᶜAqrab* (α Scorpii), is engraved near the tip of the Capricorn ring on the right.

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301 Entry based on Gibbs & Saliba 1984, pp. 129-132, where the gazetteer is not given. It is added here on the basis of a photo kindly provided by Dr Peggy Kidwell.

302 An astrolabe of 1659 by Muqīm's nephew Ḍiyā' al-Dīn (A076) is also equipped with a similar fake non-functional rete (cf. Gibbs & Saliba 1984, pp. 132-134; fig. 87).



Figure A031.1 – Rete of the astrolabe (© National Museum of American History, Washington, D.C.)

PLATES

There are 5 plates, each one notched at the north point.

Table A031-1 Plates

	φ	Longest Day
1a	Plate of horizons	
1b	Plate of ecliptic coordinates	
2a	36°	14 hours
2b	?	14 hours
3a	36°	14 hours
3b	40	14 hours
4a	31	14 hours
4b	32	14;8 hours
5a	25°	13 hours

	φ	Longest Day
5b	22°	13 hours

The first plate carries the plate of ecliptic coordinates with the label *ṣafīḥat mīzān al-ᶜanka[b]ūt* on one side and the plate of horizons on the other.

The other four plates are calibrated for different latitudes. Plate 3a is designed for latitude 36°, so is also plate 2a. The reverse side 2b carries no statement about the latitude. Strangely on all these plates, the duration of the longest day is given uniformly as 14 or 13 hours! For the latitude 32°, however, the correct value of 14;08 hours is given. It is also strange that there is no plate for the latitude of 27° (the Mughal imperial city of Agra) although a solar meridian altitude graph is drawn for this latitude on the back. Altitude circles are drawn for every 3° on some plates and for every 6° on some others; azimuth arcs for every 6° or 10°; similar variation occurs about the lines for equal hours.

Gibbs & Saliba opine that plates 4 and 5 are not original. But a closer examination is necessary to determine the original plates and the later additions.



Figure A031.2 – Geographical Gazetteer (© National Museum of American History, Washington, D.C.)

Geographical Gazetteer

The geographical gazetteer is engraved in three circles which are separated by blank rows with double lines on either side. It provides the names and coordinates of 77 localities, roughly according to increasing longitude. As in A026, the gazetteer here commences in the inner circle.

Table A031-2 Geographical Gazetteer

	Locality	L	φ
	Al-bilād	*al-ṭūl*	*al-ᶜarḍ*
	Inner Circle		

	Locality	L	φ
1	Qayrawān	41;0	31;40
2	Ṭāᶜif	77;30	21;20
3	Madīnat Tayyaba	75;20	25;0
4	Makka Muᶜaẓẓam	77;10	21;40
5	Bayt al-Maqdis	66;30	31;50
6	Dimashq	70;0	33;15
7	Ḥalab	72;10	35;50
8	Marāgha	82;0	37;20
9	Tabrīz	82;0	38;0
10	Kūfa	79;10	31;30
11	Baghdād	80;0	33;25
12	Baṣra	84;0	30;11
13	Fīrūzābād	87;30	28;0
14	Shīrāz	88;0	29;36
15	Yazd	89;0	32;0
	Middle Circle		
16	Qazwīn	85;0	36;0
17	Iṣfahān	87;40	32;25
18	Kāshān	86;0	34;0
19	Bisṭām	89;30	36;10
20	Sabzawār	91;30	36;10
21	Mashhad	92;30	36;0
22	Harāt	94;20	34;30
23	Balkh	81;0	36;0

	Locality	L	φ
24	Badakhshān	104;24	37;10
25	Bukhārā	97;30	39;50
26	Samarqand	99;16	39;37
27	Khujand	100;35	41;55
28	Kāsghar	106;30	44;0
29	Khutan	107;0	42;0
30	Hurmūz	92/94;0	25;0
31	Maymand	101;55	33;20
32	Kirmān	91;30	30;5
33	Ghazna	104;20	33;35
34	Kābul	104;40	34;30
35	Purshūr	105;55	31;0
36	Tubbat	110;0	40;0
37	Kashmīr	108;0	35;0
38	Qandahār	107;40	33;0
39	Daybal	102;30	25;10
40	Bakar	105;0	27;40
41	Multān	107;35	29;40
42	Sālkūt	109;30	33;0
	Outer Circle		
43	Lāhūr	109;20	31;50
44	Tānīsar	112;33	30;10
45	Pānīpaht	113;20	28;52
46	Dihlī	113;35	28;39

	Locality	L	φ
47	Sanbhal	115;20	28;18
48	Sunām	112;25	30;30
49	Hānsī	112;25	29;45
50	Badāwan	114;59	27;32
51	Kūl wa Jalālī	114;19	28;4
52	Akbarābād	115;0	26;43
53	Kawāliyar	114;0	26;29
54	Qannawj	115;50	26;35
55	Karah wa Mānikbūr	118;10	29;49
56	Banāras	117;20	26;55
57	Jawnbūr	119;6	26;36
58	Kūpāmaū’	116;33	26;45
59	Barūj	111;5	21;20
60	Kālpī	116.45	26;55
61	Sarūj	72;40	34;50
62	Ajmīr	111;5	26;26
63	Ujjayn	110;50	23;30
64	Jidda	76;0	21;0
65	Awadh	118;6	27;22
66	Laknnaw	114;4	26;30
67	Narwar	114;0	25;20
68	Mandū	111;25	22;15
69	Burhānbūr	113;0	20;30
70	Ahmadābād	108;40	23;15

	Locality	L	φ
71	Kanbāyat	109;20	26;20
72	Dawlatābād	111;0	20;30
73	Juyūl	106;40	19;0
74	Sarāndīb	130;0	10;0
75	Sulṭānkūt	115;0	28;30
76	Bījāpūr	105;30	17;20
77	Kūlkanda	114;20	28;4!

BACK

On the back, the upper half of the rim carries the two altitude scales, divided in 1° and 5° and numbered as 5—90; 90—5 and the lower half of the rim the cotangent scales in feet and digits.

In the upper left quadrant is engraved a sine-cosine grid with 30 horizontal and 30 vertical parallels, every third line being highlighted. The upper right quadrant carries six declination arcs. Two graphs of solar meridian altitude are plotted on this quadrant for the latitudes 27° and 32° with the usual labels.



Figure A031.3 – Back of the astrolabe (© National Museum of American History, Washington, D.C.)

In the lower half, there are two shadow squares. The left one is divided in 12 digits and the right one in 7 feet, with appropriately numbered divisions and labels. Inside the area bounded by these two squares are semi-circles, the outer one contains the names of the 12 zodiac signs and the inner one the names of the 28 lunar mansions.

Alidade

The alidade is plain without any scales; it may also be a replacement.

Inscription

Above the semi-circle containing the names of the lunar mansions is engraved the name of the astrolabe maker. The date of production is written below the shadow squares.

> *ṣanaᶜahu muḥammad muqīm ibn ᶜīsā ibn allāhdād asṭurlābī humāyūnī lāhūrī fī sanah 1053 hijrī*
>
> 'Made by Muḥammad Muqīm, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Empror] Humāyūn, in the year 1053 AH.'

Bibliography

Gunther 1932, no. 86, p. 216.

Gibbs & Saliba 1984, pp. 129-132.

A032⊙ ASTROLABE BY MUḤAMMAD MUQĪM, 1070 AH (AD 1659-60)

Diameter 142 mm

London, British Museum (#1893,0616.4)

CCA 78; Répertoire 18



Figure A032.1 – Front of the astrolabe (© Trustees of the British Museum)

The inscription on the lower rim on the back of this astrolabe proclaims that this astrolabe is made by Muḥammad Muqīm in AH 1070 (AD 1659-60). Even so, it raises some problems.

(i) There is a large gap of 17 years between Muqīm's last dated astrolabe of AH 1053 and this one. This can, of course, be explained away by saying that Muqīm continued making astrolabes but was not particular enough to put dates on the astrolabes.

(ii) The *kursī* is very low and not worked *à jour* as in all other astrolabes by Muqīm.

(iii) The inner side of the mater where the gazetteer is engraved and three plates have silver finish which is unusual.

(iv) On the rete the equinoctial and the solstitial bars are graduated.

(v) The most problematic is the geographical gazetteer. The symbol used here for zero, resembling a pair of small scissors (see Figure A032.5), is unlike the symbol in all other astrolabes by Muqīm. His nephew Ḍiyā' al-Dīn uses this symbol most frequently. Did Ḍiyā' al-Dīn then engrave the gazetteer? As in Muqīm's astrolabes A024 and A030, the gazetteer is arranged here according to climates. After the end of the seventh climate, five places are listed under the heading *iqlīm khāriz,* 'beyond climate,' implying 'beyond the seventh climate'. These are Allahabad, Surat, (?), Dhaka and Patna, i.e., Indian cities which should have been mentioned in the second climate. Furthermore, in the headings *iqlīm* and *iqlīmhā* are used indiscriminately.

Components

Body with *kursī* (d.142, h. 176, t. 6), shackle and ring, rete, 4 plates, alidade, pin and horse. One plate is a replacement, so too are the alidade, pin and horse.

Front

The ring is large and the shackle has a trifoliate shape. The *kursī* is very low and solid. The profiles are made up of many lobes and decorative holes. The surface is engraved with a floral motif in bas relief. The finial is trifoliate.

The limb is divided in 1° and 5° and labelled 5—90; 5—90; 5—90; 5—90.



Figure A032.2 – Rete of the astrolabe (© Trustees of the British Museum)

RETE

The two rings of the Tropic of Capricorn and ecliptic are held together by complete equinoctial and solstitial bars without any counter change. The left edge of the solstitial bar and the upper edge of the equinoctial bar constitute the vertical and horizontal diameters respectively. Like the edge of the ecliptic circle, these edges are also sloping; they are also graduated, into certain number of units and labelled with *Abjad* numbers. Each division is subdivided into 3 parts. The star pointers are joined by a fine floral tracery.

There is handle at 45° off the meridian in NW. On the back of the rete is engraved *ṣāḥib* (صاحبه) upside down at the bottom of the ecliptic ring. Is this an incomplete attempt to engrave the name of the owner?

PLATES

There are four plates, all with silver finish. The last one is made of a lighter metal and the projections on it are not complete; it must be a replacement.

Table A032-1 Plates

	φ	Longest Day
1a	25°	13;25 hours
1b	27°	13;43 hours
2a	29°	13;52 hours
2b	32	14;8 hours
3a	Plate of ecliptic coordinates	
3b	Plate of horizons	
4a	9°	---
4b	11°	12;20 hours

On plates 2 and 3 altitude circles are drawn for every 2°; every second one is labelled as 4, 8, …, on both sides.

On 2a, there are no azimuth curves; on 2b, 3a-b, azimuth curves are drawn for every 6° below the horizon, numbered in a straight line below the Tropic of Cancer.

On plates 2 and 3, lines for seasonal hours and dotted lines for equal hours from the western horizon are drawn; both sets are numbered jointly from 1 to 12 from the western horizon onwards.

Plate 2a has an additional feature: here plain lines are drawn for *ghaṭīs* from the western horizon and counted from 1 to 31 in standard Arabic/Persian numerals.

Plate 3a is inscribed with the Plate of ecliptic coordinates and carries the label *ṣafīḥat mīzān al-ᶜankabūt.* Latitude circles are drawn for every 3°; they are labelled on alternate sides of the vertical diameter from the centre to the north point. Every fifth line (15°) is dotted. Longitude circles are traced for every 6°; the circles for every 30°, being the boundaries of the signs, are dotted. In the lower half the sign names and numbers of the divisions (6, 12, … 30) are inscribed below the ecliptic circle; but in the upper half, these are not written below the upper half of the ecliptic but (much below) just above the equator circle. Under the east west diameter are written *al-mashriq* in the east and *al- maghrib* in the west.

Plate 3b carries the plate of horizons and has the label *ṣafīḥa āfāqiyq*. It carries four sets of half horizons for each degree of latitude, from 10° to 66° (the last one repeated in all the sets), but each alternate latitude numbered at both extremities.

11	19	27	35	43	51	59	66
12	20	28	36	44	52	60	66
13	21	29	37	45	53	59	66
14	22	30	38	46	54	60	66

Declination scales along the four radiallines; these are divided into 2 and 6 units and labelled as 6, 12, 18, 24.

The fourth plate, which appears to be a later addition, is calibrated for latitude 9°. Here are drawn altitude circles for every 5°, and labelled on both sides. There are no azimuth arcs. The reverse side, 4b, is made for the latitude 11°. Here also altitude circles are traced for every 5° and labelled on both sides. There are no azimuth arcs, nor lines for seasonal hours. Lines for equal hours are drawn from the western horizon and numbered from 1 to 12.



Figure A032.3 – Geographical gazetteer (© Trustees of the British Museum)

GEOGRAPHICAL GAZETTEER

The gazetteer is engraved in three circles with three rows in each to provide the coordinates of 93 localities arranged according to climates. The writing in upside down, but the enumeration begins in the outer circle.

Table A032-2 Geographical Gazetteer

	Place Name	**L**	**φ**
	asmā' al-buldān	***al-ṭūl***	***al-ᶜarḍ***
	Outer Circle		
[-I] *iqlīm* (!) *az khaṭṭ istiwā' tā iqlīm awwal* (from the line of equator up to the first climate)			
01	(Sāhil Bahr Awqiyānus)	11;0	0;0
02	(Jazīrat Qanbala)	----	3;0
03	Jamkūt	177;0	5;0
04	Shallā	170;0	5;0
05	Kūkūh	54;10	10;0
06	ᶜAdan	76;0	11;0
07	?	10;0	14;0
08	Dabal	74;20	14;10
09	?	77;30	14;30
10	Jind	75;30	14;30
[I] *al-iqlīm awwal* (the first climate)			
11	Sawmnāt	104;0	17;0
12	Zaitūn?	114;0	17;15
13	Bijāpūr	105;30	17;20
14	Burhānpūr	103;0	20;30
[II] *iqlīmhā* (!) *al-iqlīm dūyam* (the second climate)			

	Place Name ***asmā' al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
15	Dawlatābād	111;0	20;30
16	Jidda	77;0	21;0
17	Ṭāᶜif	77;30	21;20
18	Makka Muᶜẓẓum	77;10	21;40
19	Kanbayāt	109;20	22;20
20	Khaybar	75;20	24;20
21	Madīnat Musharrafa 75;20	25;0	
22	Hurmūz	92;0 !	25;0
23	Ajmīr Haḍrat Khwājā	111;0	26;0
24	Kawālīyar	114;0	26;29
25	Lahknūtī	114;33	26;30
26	Qannawj	115;50	26;35
27	Jawnpūr	119;6	26;36
28	Akbarābād dār al-Mulk Hind	114;0	26;43
29	Kūbāmaū'	116;33	26;45
30	Karah wa Mānikpūr	118;10	26;49
31	Awdah	118;6	27;22
32	Badāwan	119;19	27;22
[III] *iqlīmhā* (!) *al-iqlīm siwum* (the third climate)			
33	Kūlkanda	114;19	18;4
34	Fīrūzābād	106;30	28;20
35	Shāhjahānābād	113;35	28;39

	Place Name ***asmā' al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
36	Shīrāz	108;0	29;36
37	Multān	107;35	29;40
38	Baṣra	84;0	30;0
39	Miṣr	66;20	30;20
	Middle Circle		
[III] *tatimma iqlīm siwum* (continuation of the third climate)			
40	Kūfa	79;30	31;30
41	Bayt al-Maqdis?	66;30	31;30
42	Lāhūr dār al-Saltanat	109;20	31;50
43	Yazd	89;0	32;0
44	Iṣfahān	87;40	32;25
45	Qandahār	104;40	33;0
46	Sālkūt	109;0	33;0
47	Madā'in	72;0	33;0
48	Dimashq	70;0	33;55
49	Baghdād	72;0	33;25
[IV] *iqlīm chahārum* (fourth climate)			
50	Kāshān	86;0	34;0
51	Mawṣil	77;0	34;30
52	Tūn	92;30	34;30
53	Harāt	94;30	34;30
54	Kābul	104;40	34;30
55	Rayy	86;20	35;20

	Place Name ***asmā' al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
56	Kashmīr ?	108;0	35;0
57	Hamadān	83;0	35;10
58	Ḥalab	72;10	35;50
59	Mashhad Maqdis	92;30	36;0
60	Sabzawār	91;30	36;?
61	Balkh	101;0	36;41
62	Badakhshān	84;24	37;10
63	Tabrīz	82;0	38;0
64	Ardabīl	82;0	38;0
65	Nakhajwān	81;15	38;40
[V] *iqlīmha* (!) *al-iqlīm panjum* (the fifth climate)			
66	Samarqand	99;16	39;37
67	Bukhārā	97;30	39;50
68	Tubbat	110;0	40;0
69	Bardaᶜa	83;0	40;30
70	Samākhī	84;30	40;50
	Inner Circle		
[V] *tatimma iqlīm panjum* (continuation of the fifth climate)			
71	--	66;30	41;0
72	Khujand	105;35	41;55
73	Khutan	107;0	42;0
74	Kāshān	101;35	42;0
75	Farghāna	102;0	42;20

	Place Name	**L**	**φ**
	asmā' al-buldān	***al-ṭūl***	***al-ᶜarḍ***
[VI] *iqlīm shashum* (sixth climate)			
76	Kāshghar	106;30	44;0
77	--	92;0	44;0
78	Balkh		
79	Ṭarāz		
80	Bīsh Bāligh	46;0 ?	
81	Khān Bāligh		
82	Harat		
[VII] *iqlīm haftum* (seventh climate)			
83	Arq	105	70;0
84	Bulghār	60;0	?;30
85	?		
86	Qirqir	64;30	50;40
87	Kirmān Mārī	65;45	50;45
88	Ṣūdaq	66;0	51;0
[VII+] *iqlīm khāriz* (beyond climate)			
89	Allāhābād	115;34	26;50
90	Sūrat	108;50	13;15 ?
91			
92	Dhāka Bankāla	130;0	?
93	Patna	120;?	

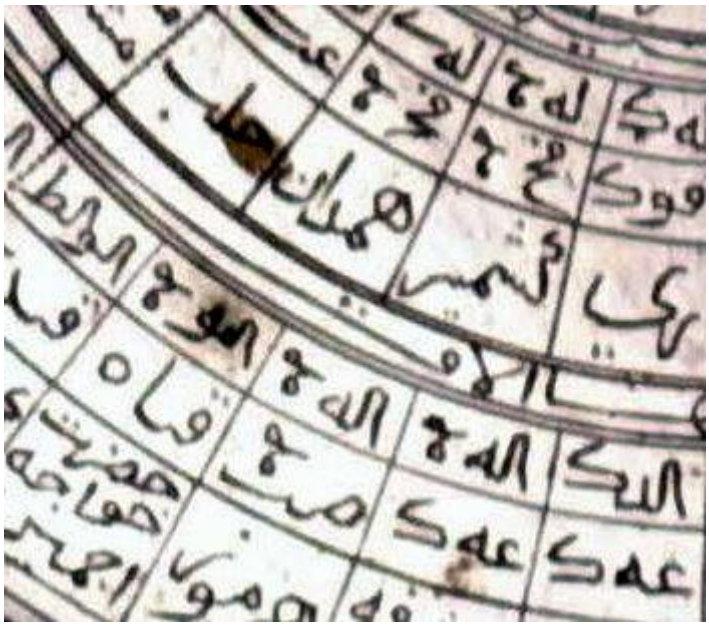


Figure A032.4 – Detail of Figure A032.3 showing the zero symbols



Figure A032.5 – Back of the astrolabe (@ Trustees of the British Museum)

BACK

On the back, the upper half of the rim carries altitude scales, divided in 1° and 5° and labelled 5—90; 90—5.

In the upper left is the trigonometric quadrant with 60 horizontal parallels. The solar quadrant in the upper right divided into 18 zones by the declination curves. Along the two radii are engraved the names of the corresponding signs and the degrees of their subdivisions (10°, 20°, 30°). Four sigmoid curves are drawn here to represent the midday altitude of the sun throughout the yeat at four latitudes 27° (Agra), 29° (Delhi), 32° (Lahore), 36° (Samarqand). The uppermost curve carries the label *khaṭṭ niṣf al-nahār bi-ʿarḍ 27.* For the others, just the numerical value of the latitude is engraved below on the right hand side. In all other astrolabes Muqīm drew just two curves for the latitudes of 27° (Agra) and 32° (Lahore). In this astrolabe a curve was added for the latitude 29° (Delhi), presumably because in 1648 Shah Jahan shifted the Mughl capital from Agra to Delhi and renamed the latter as Shāhjahānābād.[303]

In the lower half of the back are shadow squares, on the left for the base of 12 digits and on the right for the base of 7 feet, with the usual labels.

Inside the shadow squares, there are two rectangular tables. On the right is the table of multiples of the differences between the approximately correct length of the tropical year and 365 days (*faḍl al-dawr*). On the left is the table of the triplicities and their regents of the night and of the day with the heading *jadwal arbāb muthallathāt laylī wa nahārī.* This table differs slightly from the tables in other astrolabes.

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[303] Muqīm's nephew Ḍiyā' al-Dīn drew two curves for the latitudes of 27° and 32° in his astrolabes made before 1648 and three curves for 27°, 29° and 32° in the astrolabes produced after 1648.

Table A032-3 Triplicities and Regents

Night Regent	Sign	Day Regent		Night Regent	Sign	Day Regent
Jupiter	Aries	Sun		Mercury	Gemini	Saturn
Sun	Leo	Jupiter		Saturn	Libra	Mercury
Saturn	Sagittarius	Saturn		Jupiter	Aquarius	Jupiter
Moon	Taurus	Venus		Venus[304]	Cancer	Venus
Venus	Virgo	Moon		Mars[305]	Scorpio	Mars
Mars	Capricorn	Mars		Saturn[306]	Pisces	Saturn[307]

Outside the shadow squares are six semi-circular rows; the first two outer ones display the relation between the 28 lunar mansions and 12 signs of the zodiac. The next two rows contain the tables of limits (*ḥudūd*) and the last two the decans (*wuẓūh*) and their regents.

The rim of the lower half contains cotangent scales in digits and feet respectively. On the middle of this row is engraved the maker's signature and date.

Alidade

The alidade is plain and uninscribed. It appears to be a replacement added later.

Inscription

It appears that while designing the back, no plan was made for the location of the inscription. After the back has been completely engraved, including the cotangent scales and the numbers of the division on them, the inscription was engraved there as an afterthought. In the cotangent tables, the first cells on either side of the meridian line are

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304 Elsewhere Mars.

305 Eslewhere Venus.

306 Elsewhere Moon.

307 Elsewhere Moon.

rather long with just the numerical value 6 (و) engraved there. The inscription was placed here, with the numerical value 6 (و) punctuating it on both sides of the meridian:

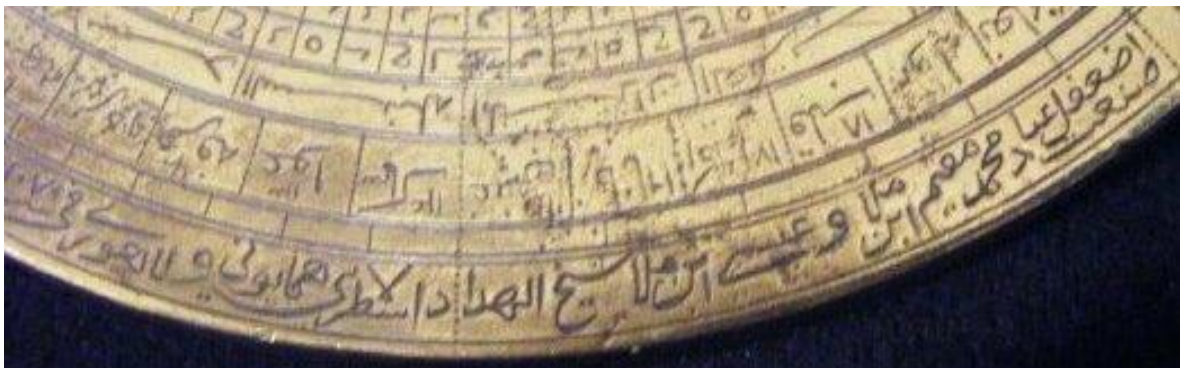


Figure A032.5 – Signature of the astrolabe maker (detail of Figure A032.4)

ṣanᶜat aḍᶜaf al-ᶜibād muḥammad muqīm ibn mullā [و] ᶜīsā ibn mullā shaykh allāhdād asṭurlābī humāyūnī [و] lāhūrī fī sanah 1070 hijrī

‘Made by the weakest of the servants [of God], Muḥammad Muqīm, son of Mullā cĪsā, son of Mullā Shaykh Allāhdād of Lahore, astrolabe maker to [the Emperor] Humāyūn in 1070 Hijrī [= 1659-60].’

BIBLIOGRAPHY

Gunther 1932, pp. 210-211, no. 78.

A033 ASTROLABE BY MUḤAMMAD MUQĪM, NOT DATED[308]

Diameter 270 mm

Paris, PC (Georges Charliat)

CCA 3504; Répertoire 23

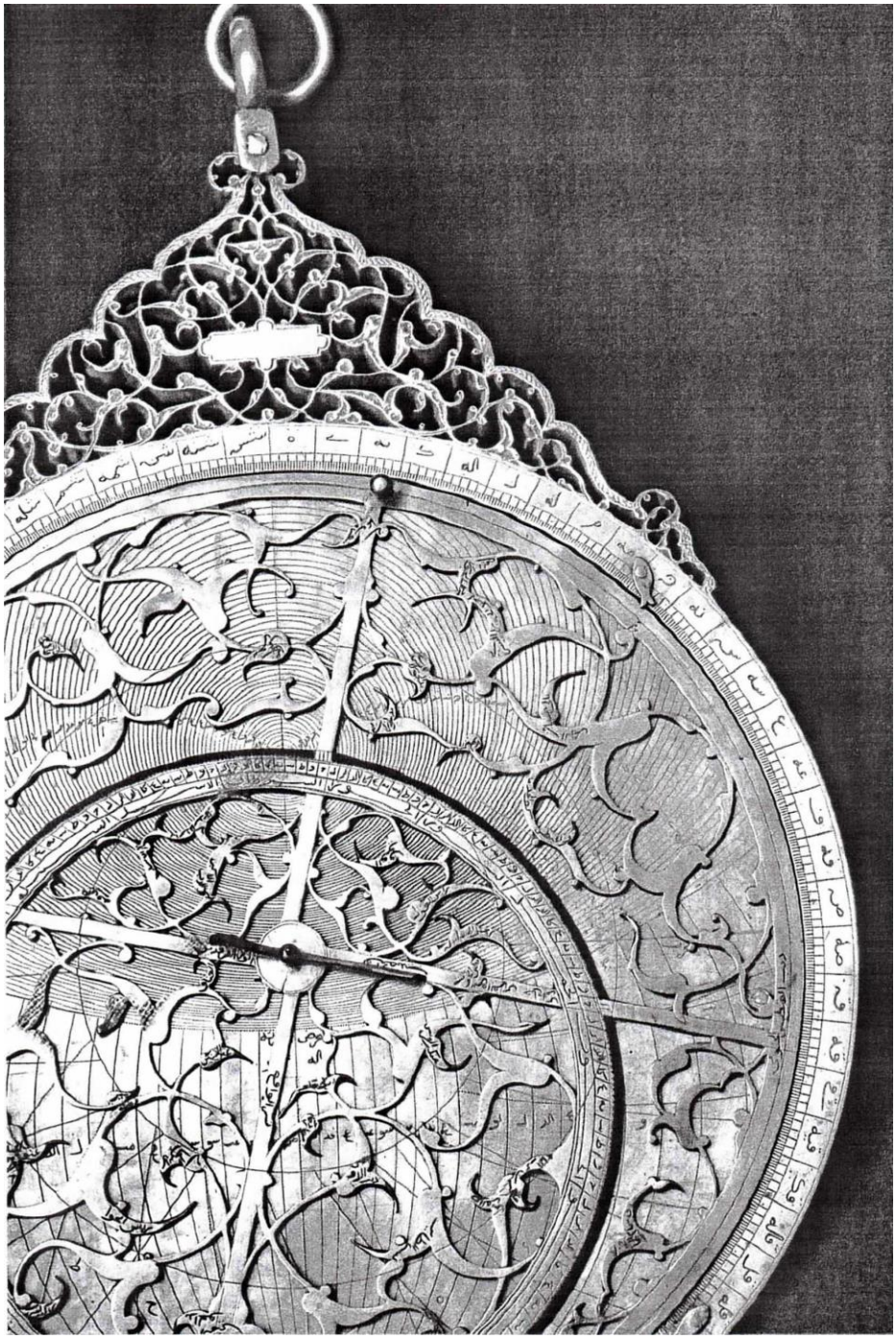


Figure A033.1 – Front of the astrolabe (photo from Guye & Michel 1971)

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308 Entry based on the Répertoire (23) and a partial photo in Guye & Michel 1971, fig. 211.

From the partial image published in Guye & Michel, the astrolabe appears to be a large and splendidly crafted piece. According to the Répertoire, it is one of the rare astrolabes to have an eccentric zodiac calendar on its back.[309]

COMPONENTS

Body with *kursī,* shackle and ring, rete for 44 stars, pin and wedge; no information is available on the number of the plates and on the alidade.

FRONT

The very delicately fretted *kursī* looks like filigree work, with the motif of the tulip with flared petals is repeated often. The profiles, with lobes between ogees above and below are engraved with a pattern on the surface. The trifoliate finial is also fretted. There is a cartouche in the centre of the *kursī.*

The limb is divided in 0;20°, 1° and 5° and labelled from 5 to 360. The inner edge of the limb is not straight, but is rather irregular which is surprising.

RETE

The Capricorn ring and the ecliptic ring are held together by the complete equinoctial and solstitial bars, each with a counter change at the centre. The ecliptic ring is divided into the 12 zodiac signs and labelled with their names. Each sign is further subdivided into units of 3° and numbered accordingly. The star pointers are joined by a delicate floral tracery where once again the motif of tulip flowers two flared petals dominates. There is a handle at the north point. On the limb, at 50° and 140° can be seen two small fish-shaped rotatable lugs to hold the rete in place. Presumably there are two more such clips at 230° and 320°, that it at an interval of 90°.[310]

PLATES

It is not known how many plates there are. In the only available photo, beneath the rete can be seen a plate carrying stereographic projections for latitude 25°. Here altitude circles are drawn for every 1° and azimuth arcs for every 6° below the horizon. There

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309 Qā'im Muḥammad's astrolabe of 1635 (A013) also has a such a calendar on the back.

310 Similar clips can be seen in an astrolabe (A104) attributable to Ḍiyā' al-Dīn Muḥammad at the Adler Planetarium, Chicago.

are two sets of hour lines, one for seasonal hours and the other for equal hours since sunset and before sunrise.

Geographical Gazetteer

A geographical gazetteer is engraved on the inner side of the mater.

Back

On the back, the upper half of the rim carries the two altitude scales divided in 1° and 5° and labelled 1— 90; 90— 1. There is an eccentric zodiac calendar divided in 12 x 30 units and also a calendar of Syrian months divided in 28, 30, 31 days. There are the usual trigonometric quadrant in the upper left, the solar quadrant in the upper right, shadow squares in the lower half, besides a table of triplicities and other astrological tables.

Inscription

> *ʿamal bi-yad aḍʿaf al-ʿibād muḥammad muqīm ibn mullā ʿīsā ibn shaykh allāhdād asṭurlābī humāyūnī lāhūrī*
>
> 'Made by the hand of the weakest of the servants [of God], Muḥammad Muqīm, son of Mullā ʿĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn.'

Bibliography

Guye & Michel 1971, pp. 226, 228, fig. 211, where a partial image of the front is published.

A034 ASTROLABE BY MUḤAMMAD MUQĪM, NOT DATED

Diameter 206 mm

Paris, PC

CCA 3828; Répertoire 22

The only information available is from the Répertoire. According to this source, the astrolabe consists of the body, rete for 40 stars and 5 plates. A geographical gazetteer is engraved on the inner side of the mater.

On the back, the rim of the upper half carries two altitude scales. On the upper left there is a trigonometric quadrant and on the upper right a solar quadrant with curves for the midday altitude of the sun at latitudes 27° and 32°. In the lower half, shadow squares, table of triplicities and other astrological tables.

INSCRIPTION

aḍaᶜf al-ᶜibād muḥammad muqīm ibn ᶜīsā ibn allāhdād

asṭurlābī humāyūnī lāhūrī

'[Made by] the weakest of the servants [of God], Muḥammad Muqīm, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn.'

PROVENANCE

The astrolabe was previously in the collection of Nicholas Landau, Paris.

A035 ASTROLABE BY MUḤAMMAD MUQĪM, NOT DATED[311]

Diameter 204 mm

Paris, PC

CCA 3829

COMPONENTS

Body, rete for 43 stars, 4 plates; no information on alidade, pin and horse.

FRONT

The limb is divided in 1° and 5° and numbered from 5° to 360°.

RETE

The following 46 stars named on the pointers in the rete

Table A035-1 Stars on the Rete

	Star Name	Identification
01	*Dhanab Qayṭus J[anūbī]*	β Ceti
02	*Baṭn*	β Andromedae
03	*Dhanab al-Ḥūt*	α Piscium
04	*Rijl al-Musalsala*	γ Andromedae
05	*Ṣadr al-Qayṭus*	π Ceti
06	*Ghūl*	β Persei
07	*Kaff al-Jadhmā'*	α Ceti
08	*Tālī Musāfat al-Nahr*	γ Eridani
09	*ᶜAyn al-Thawr*	α Tauri
10	*Al-ᶜAyyūq*	α Aurigae
11	*Rijl Yusrā*	β Orionis
12	*Yad al-Jawjā' Yusrā*	γ Orionis

[311] Entry based on an unpublished description kindly provided by Professor David King.

	Star Name	Identification
13	*Yad al-Jawzā' Yumnā*	α Orionis
14	*Rijl al-Jawzā' Yumnā*	κ Orionis
15	*Shiᶜrā Yamānī*	α Canis Majoris
16	*Shiᶜrā Shāmī*	α Canis Minoris
17	*Ṭarfat al-Safīnā*	ρ Puppis
18	*Mankhar al-Shujāᶜ*	σ Hydrae
19	*Fard al-Shujāᶜ*	α Hydrae
20	*Qā'idat al-Bāṭiya*	α Crateris
21	*Ẓahr al-Dubb al-Akbar*	α Ursae Majoris
22	*Janāḥ al-Ghurāb*	γ Corvi
23	*Al-ᶜAnāq*	ζ Ursae Majoris
24	*Simāk Aᶜzal*	α Virginis
25	*Simāk Rāmiḥ*	α Bootis
26	*ᶜUnuq al-Ḥayyah*	α Serpentis
27	*Qalb al-ᶜAqrab*	α Scorpii
28	*Rukbat al-Ḥawwā Yusrā*	ζ Ophiuchi
29	*Rās al-Jāthī*	α Herculis
30	*Rās al-Ḥawwā*	α Ophiuchi
31	*ᶜAyn al-Tinnīn*	γ Draconis
32	*Yad al-Ḥawwā Yumnā Muqaddam*	δ Ophiuchi
33	*Nasr al-Wāqiᶜ*	α Lyrae
34	*Minqār al-Dajājah*	β Cygni
35	*Nasr Ṭā'ir*	α Aquilae
36	*Dhanab al-Dulfīn*	ε Delphini

	Star Name	Identification
37	*Ridf*	α Cygni
38	*Dhanab al-Jadī*	δ Capricorni
39	*Fam al-Faras*	ε Pegasi
40	*Sāq-i Sākib al-Mā' J[anūbī]*	δ Aquarii
41	*Mankib al-Faras*	β Pegasi
42	*Kaff al-Khaḍīb*	β Cassiopeiae
43	*Surrat al-Faras*	δ Pegasi

PLATES

There are four plates with the following specifications:

Table A035-2 Plates

	φ	Longest Day
1a	18°	13;9 hours
1b	22°	13;-- hours
2a	23;30°	13;30 hours
2b	25°	13;-- hours
3a	45°	15;-- hours
3b	0° + 72°	
4a	Plate of horizons	
4b	Plate of ecliptic coordinates	

On plates 1-3a, altitude circles are drawn for each 2° and azimuth arcs for each 6° above or below the horizon as well as curves for the hours since sunset or hours before

sunrise. On plate 3b, altitude circles are for every 3° and azimuth arcs for every 6°. Two original plates are missing; one of them was replaced by 4.

Geographical Gazetteer

There is a geographical gazetteer engraved inside the mater.

Back

On the back, the rim of the upper half carries two altitude scales divided in 1° and 5° and marked 5 — 90; 90 — 5. On the upper left is a trigonometric quadrant and on the upper right a solar quadrant with curves for the midday altitude of the sun at latitudes 27° and 32°.

Provenance

The astrolabe was previously in the collection of Nicholas Landau, Paris.

A036 ASTROLABE BY MUḤAMMAD MUQĪM, NOT DATED[312]

Diameter 160 mm

Lahore, Lahore Museum (#M.44-1)

Répertoire 19



Figure A036.1 – Front of the astrolabe (photo courtesy Dr Naseem Naqvi)

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312 Entry based on photos kindly provided by Dr Naseem Naqvi, London, and photos and detailed information kindy sent by Mubashir Ul-Haq Abbasi, Islamabad. Mubashir Ul-Haq Abbasi will be publishing a full-length description shortly.

Components

Body with *kursī* (d. 160, h. 205, t. 12), rete for 31 stars and 5 plates. The ring, shackle, alidade, pin and wedge are missing. The ensemble is held together by a modern bolt and nut.

Front

The *kursī* is not pierced; its surface on both sides is decorated with a very fine design of intertwining creepers and flowers in low relief. The trifoliate finial is pierced with a small hole at the base on each side, as is done in Kufic astrolabes and also in Muqīm's own astrolabes A047 and A048. The degree scale on the rete is divided in 1° and 5° and numbered from 5 to 360.



Figure A036.2 – Rete of the Astrolabe (photo by Mubashir Ul-Haq Abbasi)

Rete

The rete in this astrolabe resembles the same in the astrolabe of 1567 by Allāhdād (A001) and in the astrolabe attributable to Allāhdād (A004); thus it does not follow the characteristic style of the Lahore astrolabes. The Capricorn ring and the ecliptic ring are

held together by the equinoctial bar and the complete solstitial bar, both of which are counter-changed at the centre. Large arcs of the circle representing the equator are shown both within and below the ecliptic. There are 31 star pointers on the rete which exhibit an archaic form of tiger's claws. A handle affixed in the Capricorn ring, to the right of the north point, is now lost; just a hole remains there.

Table A036-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus J[anūbī]*	β Ceti
2	*Baṭn al-Ḥūt*	β Andromedae
3	*Rijl al-Musalsala*	γ Andromedae
4	*Fam al-Qayṭus*	γ Ceti
5	*Ghūl*	β Persei
6	*ᶜAyn al-Thawr*	α Tauri
7	*ᶜAyyūq*	α Aurigae
8	*Rijl al-Jawzā' Yusrā*	β Orionis
9	*Yad al-Jawzā' Yumnā*	α Orionis
10	[*Shiᶜrā Yamānī*][313]	α Canis Majoris
11	*Shiᶜrā Shāmī*	α Canis Minoris
12	*Mankhar Shujāᶜ* (?)	σ Hydrae
13	*Fard Shujāᶜ*	α Hydrae
14	*Qalb al-Asad*	α Leonis
15	*Ẓahr al-Asad*	δ Leonis
16	*Ṣarfa*	β Leonis
17	*Janāḥ al-Ghurāb*	γ Corvi

313 A curved star pointer was made but not labelled.

	Star Name	Identification
18	*Al-ᶜAnāq*	ζ Ursae Majoris
19	*Simāk Aᶜzal*	α Virginis
20	*Simāk Rāmiḥ*	α Bootis
21	*Nayyir Fakkah*	α Coronae Borealis
22	*ᶜUnuq al-Ḥayyah*	α Serpentis
23	*Al-Jāthī*	α Herculis
24	*Nasr Wāqiᶜ*	α Lyrae
25	*Miqār [Da]jāja*	β Cygni
26	*Nasr Tā'ir*	α Aquilae
27	*Dhanab al-Dālfīn* (!)	ε Delphini
28	*Dhanab al-Jadī*	δ Capricorni
29	*Mankib Faras*	β Pegasi
30	*Sāq Sākib al-Mā J[anūbī]*	δ Aquarii
31	*Kaff al-Khaḍīb*	β Cassiopeiae

Plates

There are five plates in the astrolabe.

Table A036-2 Plates

	φ	Longest day
1a	21;40°	13 hours
1b	24°	13 hours
2a	27°	13;43 hours
2b	31;50°	14;7 hours
3a	36°	14;00

	φ	Longest day
3b	40°	14;00
4a	45°	--
4b	34;20°	14;00
5a	Plate of ecliptic coordinates	
5b	Plate of horizons	

On all these plates (except 5a), altitude circles are drawn for each 3° with every fifth circle dotted, azimuth arcs for each 10° below the horizon, and plain lines for seasonal hours and dotted lines for equal hours drawn from the western and eastern horizons. All these sets of lines are numbered. On the plate for 45°, the duration of the longest day is not mentioned.

On the plate of ecliptic coordinates, latitude circles are drawn for each 6° and longitude circles for each 10°, with every third circle which forms the boundary between the signs being dotted. The two sets of circles are numbered. The names of the signs are written along the ecliptic. Plates 1 to 4 have notches at the north point. Plate 5 has notches at all the four compass points. This is one of the few cases where four notches are made, although every plate containing the plate of horizons ought to have them, so that the four sets of half horizons can be made use of.



Figure A036.3 – Geographical gazetteer (photo by Mubashir Ul-Haq Abbasi)

Geographical Gazetteer

On the inner surface of the mater is engraved a geographical gazetteer in two circles, with much empty space in between, for 70 places arranged roughly according to increasing longitude, starting from Qayrawān in modern Tunisia and proceeding eastwards. In the upper row of each circle are given the longitudes, in the middle row the place names and in the lower row the latitudes. In reproducing the data in the following table, we follow a uniform order of place name first and longitude and latitude thereafter.

Table A036-3 Geographocal Gazetteer

	Place Name ***al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
	First Circle		
1	Qayrawān	41;0	31;40
2	Mahdiyya	42;0	32;0
3	Miṣr	63;20	20;20
4	ᶜAdan	76;0	11;0
5	Madīnaat Tayyaba	75;20	25;0
6	Makka Munajjam	77;10	21;40
7	Ṭā'īf	77;30	21;20
8	Bayt al-Maqdis	66;30	31;50
9	Dimashq	70;0	33;15
10	Ḥalab	72;10	35;50
11	Qūniya	66;30	41;0
12	Raqqah	73;15	36;0
13	ᶜĀna	76;30	34;0
14	Tabrīz	82;0	38;0
15	Bardaᶜa	83;0	40;30
16	Kūfa	79;30	31;30
17	Madā'īn	72;0	33;10
18	Baghdād	80;0	33;25
19	Baṣra	84;0	30;0
20	Fīrūzābād	87;30	28;10
21	Shīrāz	83;0	29;36
22	Yazd	89;0	34;40

	Place Name ***al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
23	Hamadān	83;0	35;10
24	Sāwa	85;0	35;0
25	Qazwīn	85;0	36;0
26	Iṣfahān	86;40	32;25
27	Kāshān	86;0	34;0
28	Qumm	85;40	34;45
29	Rayy	86;20	35;0
30	Astarābād	89;35	36;50
31	Sabzawār	91;30	36;0
32	Nayshābūr	92;30	36;21
33	Mashhad	92;30	36;0
34	Tūn	92;30	34;30
35	Qā’īn	93;20	33;40
36	Harāt	94;20	34;30
37	Marw	97;0	37;40
38	Balkh	101;0	36;41
39	Badakhshān	104;27	37;10
40	Bukhārā	97;30	39;50
41	Samarqand	99;16	39;37
42	Khujand	100;35	41;15
43	Kashghar	106;30	44;0
44	Khutan	107;0	42;0
45	Hurmūz	92;0	25;0
46	Kirmān	91;30	30;0

	Place Name ***al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
47	Ghazna	104;20	33;35
	Second Circle		
48	Kābul	104;40	34;30
49	Daybul	102;30	25;10
50	Bakar	105;0	37;40
51	Qandahār	107;40	33;0
52	Tubbat	110;0	40;0
53	Kashmīr	108;0	35;0
54	Multān	107;35	29;40
55	Lāhūr	109;20	31;50
56	Tānīsar	112;33	30;10
57	Haḍrat Dihlī	113;25	28;39
58	Akbarābād	115;4	26;43
59	Qannawj	115;50	36;35
60	Banāras	1[1]7;20	26;55
61	Kawāliyar	114;0	26;29
62	Jawnbūr	119;50	26;36
63	Ajmīr	111;5	26;0
64	Jadda	77;0	21;0
65	Ujjayn	1[1]2;0	22;30
66	Burhanbūr	1[1]3;0	20;30
67	Bījābūr	105;30	16;20
68	Kūlkanda	114;19	18;4
69	Kanbāyat	109;4	22;20

	Place Name ***al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
70	Sarāndīb	130;0 (!)	10;0

BACK

The upper half of the rim on the back carries the altitude scales which are divided in 1° and 5° and numbered 5—90; 90— 5. In the upper left is the trigonometric quadrant with 60 horizontal parallels, with each fifth highlighted with dots. Opposite to it is the solar quadrant with declination arcs, one for each 10° of solar longitude. Here each third circle, which forms the boundary between two signs, is dotted. The names of the related signs are engraved along the two radii, together with the degrees of each decan as 10, 20, 30, marked separately for each sign. Two graphs solar meridian altitude at the latitudes of 27° and 32° are plotted in this quadrant along with the labels *khaṭṭ niṣf al-nahār bi-ᶜarḍ 27* and *khaṭṭ niṣf al-nahār bi-ᶜarḍ* 32 respectively.

In the lower half are the shadow squares, on the left for a base of 7 feet and on the right for a base of 12 digits. The vertical and horizontal scales are divided and numbered accordingly. On the two lower corners there is a label each reading *ẓill sullam,* (the scale of shadows). The 4 scales are accompanied by the following labels:
Vertical scale on the left: *ẓill aṣābiᶜ maᶜkūs*
Horizontal scale on the left: *ẓill aṣābiᶜ mustawī*
Horizontal scale on the right: *ẓill aqdām mustawī*
Vertical scale on the right: *ẓill aqdām maᶜkūs.*

The space inside the shadow squares is occupied by 7 concentric semi-circular rows. The first and the outermost row carries the names of the 28 lunar mansions and the second row the names of the 12 corresponding zodiac signs. Rows 2, 3, 4 constitute a table of the decans (*wujūh*) and their regents. Rows 2, 5, 6, 7 form a table of the triplicities and their diurnal and nocturnal regents.

The shadow squares are encircled by 5 concentric semi-circular rows. The first and the outermost row on the rim carry the cotangent scales, on the left in feet and on the right in digits as in the shadow squares. The unequal divisions on the scale on the left are numbered, starting from the south-north line, as 5, 7, 10, 15, 20, 25, 30, 36, 42,

48, 54, 60, followed by the label *al-aqdām* (feet). The unequal divisions on the scale on the right are numbered, also from the south-north line, as 5, 10, 12, 15, 20, 25, 30, 36, 42, 48, 54, 60, followed by the label *al-aṣābiʿ* (digits). These divisions are subdivided into 5 in the following semi-circular row.

Rows 3, 4, 5 contain a table of limits (*ḥudūd*), with the names of the signs in the fifth row.

INSCRIPTION[314]

Immediately below these 5 semi-circular rows is the astrolabe maker's signature, inscribed on both sides of the south-north line:

ṣanaʿahu muḥammad muqīm ibn ʿīsā ibn allāhdād

asṭurlābī humāyūnī lāhūrī

'Made by Muḥammad Muqīm, son of ʿĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn.'

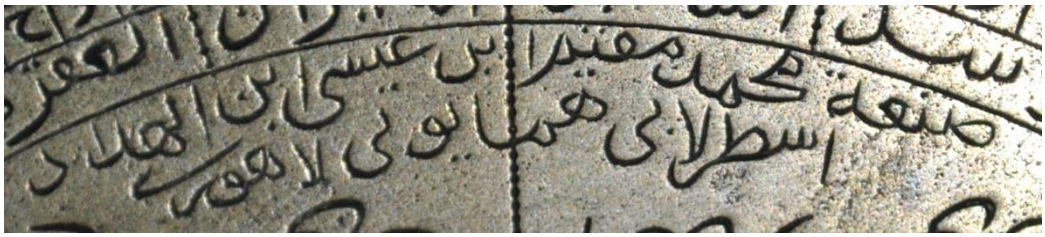


Figure A036.4 – Signature of the astrolabe maker (photo by Mubashir Ul-Haq Abbasi)

On the edge of the mater, there is yet another inscription, this time providing the name of an owner, which reads:

mālik aqall al-ʿibād muḥammad hāshim ibn muḥammad bāqir tabrīzī

'Owner, the weakest of the servants [of God], Muḥammad Hāshim, son of Muḥammad Bāqir, of Tabrīz.

PROVENANCE

Donated to the Museum by Masud Ilahi in memory of his father Shaikh Mahbub Ali, an agricultural engineer from Faisalbad and a former member of the Constituent Assembly, India.

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314 The Répertoire does not give the text, but only the translation which is somewhat off the mark: 'Made by Muḥammad Muqīm, son of ʿĪsā, son of Allāhdād, in the reign of the emperor Shāh ad-Dīn[!] Shāh Jahān[!].

BIBLIOGRAPHY

Dar 1994, pp. 169-172, pls. II-V.

A037 ASTROLABE BY MUḤAMMAD MUQĪM, NOT DATED[315]

Diameter 146

PLU: ex-Canada, Don Mills, Ontario Science Centre (#68.165.1)

CCA 3827; Répertoire 25



Figure A037.1 – Front of the astrolabe (photo courtesy Ontario Science Centre)

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315 This entry is based on a full set of photocopies made directly from the astrolabe parts and an unpublished description of the astrolabe by Professor E. Birnbaum, Department of Middle East & Islamic Studies, University of Toronto, which the Ontario Science Centre has kindly sent me on 2 March 1993.

COMPONENTS

Body with *kursī* (d. 146, t. 9), shackle and ring, rete, 5 plates, alidade, pin, washer and horse.

FRONT

The ring has circular cross-section; its two ends are not joined together. The shackle has trifoliate form; this shape is not repeated in its two bases which are roundish. The *kursī* is lobed with a trifoliate finial; is finely worked *à jour,* with a triangular piece at the centre and surface decorations on both sides. The limb divided in 0;30°, 1° and 5° and numbered 5—360.



Figure A037.2 – Rete of the Astrolabe (photo courtesy Ontario Science Centre)

RETE

The two rings of the Tropic of Capricorn and the ecliptic are held together by the equinoctial bar which has a counter change at the centre. About 49 star pointers, 28 inside the ecliptic circle and 21 outside, are joined by an almost symmetric floriated tracery. The ecliptic circle is divided into 12 zodiac signs and labelled with their names, each sign is divided into groups of 6° and numbered accordingly, and each of the units are divided into two halves to represent 3°. There are about 40 star pointers, but it was not possible to decipher the names in the available photos, especially those inside the ecliptic circle. Most of the stars outside the ecliptic are enumerated below.

Table A037-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus Janūbī*	β Ceti
2	*Fam al-Qayṭus*	γ Ceti
3	*Ṣadr al-Qayṭus*	π Ceti
4	*ᶜAyn al-Thawr*	α Tauri
5	*ᶜAyyūq*	α Aurigae
6	*Rijl al-Jawjā' al-Yusrā*	β Orionis
7	*Yad al-Jawjā' al-Yusrā*	γ Orionis
8	*Yad al-Jawjā' al-Yumnā*	α Orionis
9	*Rijl al-Jawjā' al-Yumnā*	κ Orionis
10	*Shiᶜrā Yamānī*	α Canis Majoris
11	*Shiᶜrā Shāmī*	α Canis Minoris
12	?	
13	*Fard al-Shujāᶜ*	α Hydrae
14	*Qāᶜidāt al-Bāṭiya*	α Crateris
15	*Janāḥ al-Ghurāb*	γ Corvi
16	*Simāk al-Aᶜzal*	α Virginis
17	*Qalb al-ᶜAqrab*	α Scorpii
19	*Nasr Wāqiᶜ ?*	α Lyrae
20	*Nasr al-Tāir*	α Aquilae
21	*Dhanab al-Jadī*	δ Capricorni

PLATES

There are five plates in the astrolabe. Of the 10 photos, it is not possible to determine which two plate faces belong to the same plate. Therefore, these are numbered below serially from 1 to 10. None seem to carry labels about the latitude for

which the plate is calibrated and the duration of the longest day at that latitude. Plate face 1 is engraved with multiple horizons and seems to be genuine. All the others appear to be spurious: latitude 30° is repeated in two, lat. 60° is repeated in two other plate faces. On all plate faces from 2 to 9, altitude circles are drawn for every 6° and numbered; azimuths are traced below the horizon and numbered; lines for seasonal hours are marked and numbered.

1. Plate of horizons, appears to be genuine.
2. Blank.
3. Made for the latitude of 30°.
4. Also made for 30°.
5. Calibrated for the latitude of 60° which is most unusual.
6. Also calibrated for 60°.
7. Latitude 24°.
8. Latitude 27°.
9. Latitude 21°. The notch is at the west point and not at the north point as in others.
10. Latitude 36°? Altitude circles for 3°, not drawn uniformly, nor numbered. There are no azimuths; there are lines for seasonal hours, but not numbered.



Figure A037.3 – Geographical Gazetteer (photo courtesy of Ontario Science Centre)

GEOGRAPHICAL GAZETTEER

On the inner surface of the mater is engraved a geographical gazetteer of 85 localities with their longitudes and latitudes in four concentric circles which are separated from one another by an empty band.

Table A037-2 Geographical Gazetteer

	Place Name ***asmā al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
	First Circle		
1	Qayrawān	41;0	31;40
2	Miṣr	63;20	30;20
3	ᶜAdan	76;0	11;0

	Place Name ***asmā al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
4	Madīnat al-Rasūl	75;20	25;0
5	Makka Muᶜaẓẓam	77;10	21;40
6	Hajar Baḥrayn	83;0	25;15
7	Bayt al-Maqdis	66;30	31;50
8	Dimashq	70;0	33;15
9	Ḥalab	72;0	35;50
10	Iṣṭanbul	59;50	45;0
11	Raqqa	73;45	36;1
12	Mawṣil	77;0	34;30
13	Nakhjavān	81;55	38;40
14	Marāgha	82;0	37;20
15	Tabrīz	82;0	38;0
16	Bardaᶜa	83;0	40;30
17	Pākūya	84;30	39;30
18	Bāb al-Abwāb	85;0	43;0
19	Bulghār	90;0	49;30
20	Kūfa	79;30	31;30
21	Baghdād	80;0	38;25
22	Baṣrah	84;0	30;11
23	Rām Hurmūz	85;45	31;0
24	Fīrūzābād	87;30	28;10
25	Yazd	89;0	32;0
26	Shīrāz	88;0	29;36
27	Hamadān	88;0	25;10

	Place Name ***asmā al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
28	Qazwīn	85;0	36;0
29	Iṣfahān	86;40	32;25
30	Kāshān	86;0	34;0
31	Qumm	85;40	34;45
32	Rayy	86;20	35;0
33	Ṭālīqān	85;45	36;10
34	Astarābād	89;35	36;50
35	Samnān	88;0	36;0
36	Bisṭām	89;30	36;31
37	Sabzawār	91;30	36;5
38	Harāt	94;20	34;30
39	Marw	87;0 (sic!)	37;40
	Second Circle		
40	Balkh	101;0	36;41
41	Qabādhiyān	102;0	37;45
42	Badakhshān	104;24	37;10
43	Andarāb	103;45	36;0
44	Bukhārā	107;30	39;50
45	Samarqand	109;36	39;37
46	Hazār Āsf	105;0	41;0
47	Khujand	100;36	41;50
48	Kāshghar	106;30	44;0
49	Khutan	107;0	42;0
50	Qarāqūrūm	115;0	46;0

	Place Name ***asmā al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
51	Hurmūz	102;0	26;50
52	Ghazna	104;20	33;35
53	Kābul	104;40	34;30
54	Ribāṭ Amīr	105;0	34;0
55	Peshāwar	107;10	33;25
56	Dabīl	102;30	25;10
57	Bakr	105;0	27;40
58	Somnāt	106;0	17;0
59	Qandahār	107;40	33;0
60	Awadh	106;20	28;40
61	Mūltān	107;35	29;40
62	Lahāwar	109;20	31;50
63	Siālkot	109;4	38;0
64	Tubbat	110;0	40;0
65	Kashmīr	108;0	35;0
66	Sarāndīb	130;0	10;0
	Third Circle		
67	Qannawj	115;50	26;35
68	Banarasi	117;20	26;55
69	Haḍrat Dihlī	113;35	28;55
70	Tānīsar	112;13	30;10
71	Sambhal	105;0	28;4
72	Akra	114;0	27;13
73	Kawāliyār	115;0	26;29

	Place Name ***asmā al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
74	Jawnpūr	109;6	26;37
75	Mānakpūr	108;10	26;49
76	Barūj	111;5	21;20
77	Dhārmā Qaṣba Lū?	110;15	24;0
78	Ajmīr	112;24	26;0
79	Ujjayn	102;0	22;30
80	Aḥmadābād	108;40	23;15
81	Burhānpūr	103;0	21;30
	Fourth Circle		
82	Dawlatābād	111;0	20;30
83	Lankā[316]	110;50	0;0
84	Khanbhāyat	109;20	24;30
85	Bījāpūr	105;30	17;20

BACK

On the back, the rim of the upper half carries the altitude scales, divided in 0;30°, 1°, 5° and numbered 5—90; 90—5.

In the upper left quadrant are drawn 60 horizontal parallels with each fifth line highlighted with dots. The upper right quadrant bears 30 declination arcs, one for each 6° of solar longitude. Along the two radii are engraved the names of the corresponding signs and the degrees of their parts (as 6, 12, …30). Upon these quarter circles are

316 Lankā at 0;0 lat, 110;50 long, reflects the notional point of Sanskrit astronomy of zero meridian and zero longitude. This place name does not occur in any other astrolabe. It is different from the actual Sri Lanka, listed under no. 66 as *Sarāndīb.*

plotted two sigmoid graphs of the solar meridian altitude for the latitudes of 27° and 32° (representing the two imperial cities Agra and Lahore) with the usual legends.

In the lower half are two shadow squares; on the left for a base of 12, on the right for a base of 7. The vertical and horizontal scales on the left and on the right are divided and numbered accordingly. These scales bear the following labels:

Vertical scale on the left: *ẓill sullam aṣābiʿ maʿkūs*

Horizontal scale on the left: *ẓill sullam aṣābiʿ mustawī*

Horizontal scale on the right: *ẓill sullam aqdām mustawī*

Vertical scale on the right: *ẓill sullam aqdām maʿkūs*

Two rectangular tables are engraved inside these shadow squares. The one on the left carries the heading *faḍl al-dawr* (excess of revolution) and shows the multiples of the difference between the length of the tropical year and 365 Days. The table on the right is entitled *arbāb muthallathāt laylī wa yawmī* (the regents of the triplicitities at night and in the day) and shows the signs and the regents (represented by the last consonant of their names in Arabic) without, however, classifying them according to the four elements, as is done on some astrolabes described before.

Below the shadow squares are several concentric semi-circular rows; their configuration is somewhat unusual. The outermost rim, corresponding to the altitude scale in the upper half is blank. The cotangent scales which are usually inscribed here is placed further inside. The semi-circles following the blank rim successively display the following data.

Row 1. The quarter circle on the left is divided into unequal divisions and numbered from the horizontal diameter to the vertical, serially from 1 to 23 and 24 (?); the purpose of this scale is not clear. The quarter circle on the right is divided into 18 equal divisions of 5° each and numbered in 5s from 5 to 90.

Row 2. Blank.

Rows 3-4. In row 4 are marked the cotangent scales, labelled on the left *al-aṣābiʿ* (digits) and on the right *al-aqdām* (feet). On both sides there are unequal divisions which are numbered in 5s from 5 to 60. On row 3, fractions of the divisions in row 3 are marked; but this done only on the right; the quarter circle on the left is blank.

Row 5. Blank.

Rows 6-7. Names of the 28 lunar mansions and the names of the 12 corresponding zodiac signs.

Rows 7, 8, 9. Table of the limits.

Rows 7, 10, 11. Table of faces.

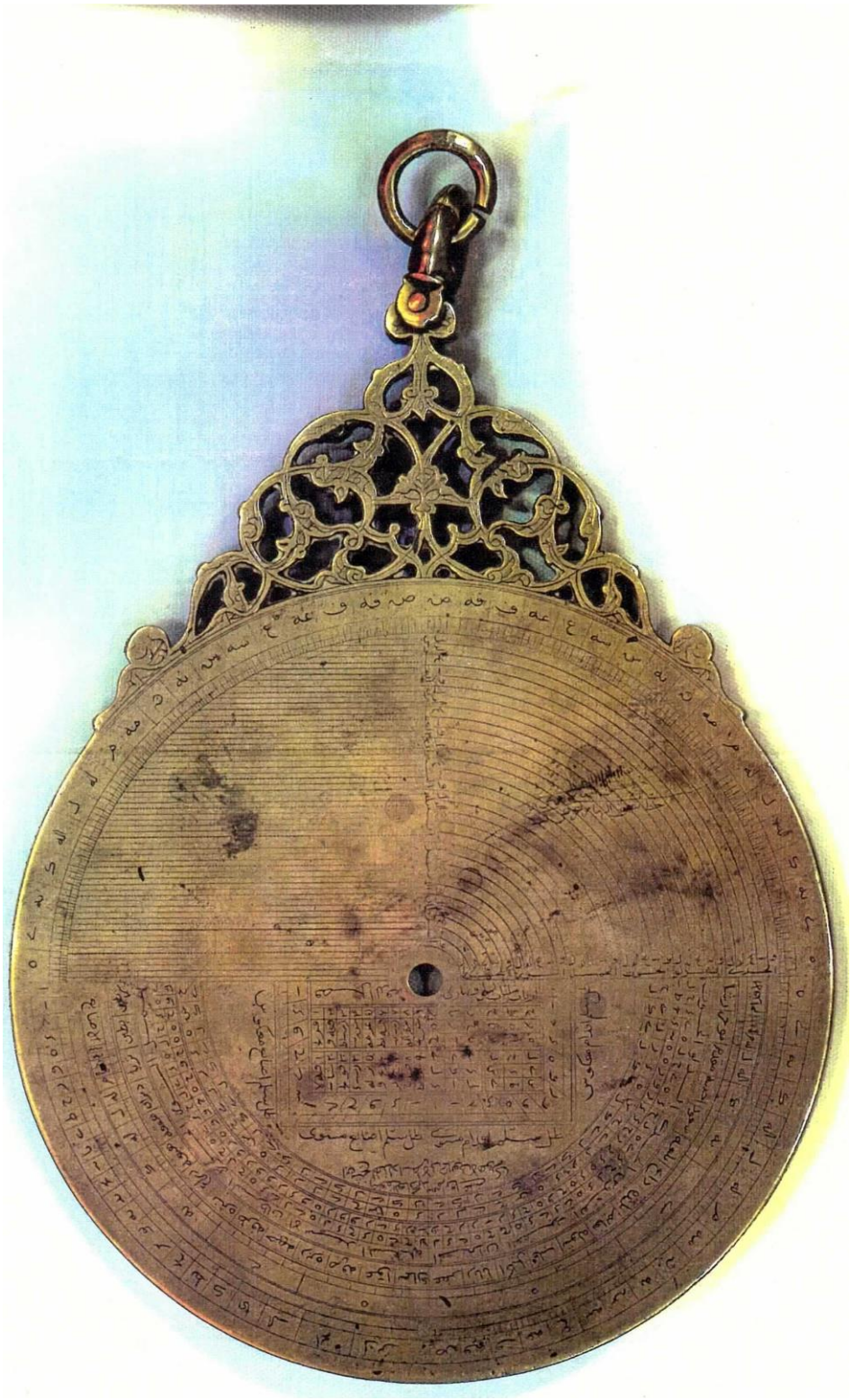


Figure A037.4 – Back of the astrolabe (photo courtesy Ontario Science Centre)

ALIDADE ETC.

Straight bar alidade with a simple centre piece, but with ornate ends. The photo shows the back of the alidade; it is not known whether the front is calibrated. Simple pin. In the wedge, the horse's head is moulded nicely showing the ears, eyes and mouth.

INSCRIPTION

In two lines, between the shadow squares and the semi-circular tables, written upside down.

> *aḍ^{c}af al-^{c}ibād muḥammad muqīm ibn mullā ^{c}īsā*
> *ibn shaykh allāhdād asṭurlābī humāyūnī lāhūrī*
> '[The work of] the weakest of the servants [of God], Muḥammad Muqīm, son of Mullā ^{c}Īsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn.'

PROVENANCE

The Ontario Science Centre informed me in November 2012 that the astrolabe has been missing since 2000.

A038 ASTROLABE BY MUḤAMMAD MUQĪM, NOT DATED

Diameter 140 mm

PLU, ex. Sotheby's

CCA 2609, Répertoire 26

Components

Body with *kursī* (d. 140), shackle and ring, rete for 37? stars, 5 plates, alidade, pin and horse.

Back

Trigonometric quadrant; solar quadrant with curves of the midday altitude of the sun at latitudes 27° and 32°; shadow squares and astrological tables.

Inscription

ᶜamal muḥammad muqīm ibn ᶜīsā ibn allāhdād asṭurlābī humāyūnī lāhūrī

'The work of Muḥammad Muqīm, son of Mullā ᶜĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn.'

Bibliography

Sotheby's catalogue of 26 February 1968, lot 14.

A039⊙ ASTROLABE BY MUḤAMMAD MUQĪM, NOT DATED

Diameter 134 mm

New Haven, Yale University, Harvey Cushing/John Hay Whitney Medical Library, Edward Clark Streeter Collection of Weights & Measures

CCA 3807; Répertoire 30



Figure A039.1 – Geographical Gazetteer
(photo courtesy of Harvey Cushing/John Hay Whitney Medical Library)

Components

Only the mater with *kursī* (d. 134, h. 161, t. 5) is extant. The limb is made separately and joined to the back plate by means of five rivets.

Front

The *kursī* has lobed profiles. The trifoliate finial which is a common feature in Muqīm's astrolabes is missing here; instead, there is a circular hole at the apex of the *kursī.* Whether this hole was originally intended for the shackle or whether the finial is broken is not certain. The *kursī* is elegantly pierced with decorative engravings on the surface. The limb is divided in 1° and 6° and numbered 6—360.

Geographical Gazetteer

On the inner side of the mater, there is a small peg at the north point to hold the plates in position. The surface carries a geographical gazetteer inscribed in three concentric circles, which are separated from one another by double lines. The gazetteer contains the names, longitudes and latitudes of 69 localities. In the outer circle, the data is engraved upside-down, but it is straight in the other two circles.

Table A039-1 Geographical Gazetteer

	Place Name *al-bilād*	**L** *al-ṭūl*	**φ** *al-ᶜarḍ*
	Outer Circle		
1	Miṣr	63;20	30;20
2	ᶜAdan	76;0	11;0
3	Madīnat Ṭayyaba	75;20	25;0
4	Makka Muᶜaẓẓam	77;10	21;40
5	Bayt al-Maqdis	66;30	31;50
6	Dimashq	70;0	33;15
7	Ḥalab	72;10	35;50
8	Marāgha	82;0	37;20
9	Tabrīz	82;0	38;0

	Place Name ***al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
10	Kūfa	79;30	31;30
11	Baghdād	80.0	33;25
12	Baṣrah	84;0	30;0
13	Fīrūzābād	87;30	28;10
14	Shīrāz	88;0	29;36
15	Yazd	89;0	32;40
16	Qazwīn	85;0	36;0
17	Iṣfahān	86;40	32;35
18	Kāshān	86;0	34;0
19	Qum	85;40	34;45
20	Rayy	86;20	35;0
21	Astarābād	89;35	36;50
22	Bisṭām	89;30	36;10
23	Sabzawār	91;30	36;5
24	Mashhad	92;30	36;0
25	Harāt	94;20	34;30
26	Balkh	101;0	36;41
27	Badakhshān	104;24	37;10
28	Bukhārā	97;30	39;50
29	Samarqand	99;36	39;37
30	Khujand	100;35	41;55
31	Kāshghar	106;30	44;0
	Middle Circle		
32	Khutan	107;0	42;0

	Place Name ***al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
33	Hurmūz	92;0	25;0
34	Kirmān	91;30	30;0
35	Ghazna	104;20	33;35
36	Kābul	104;40	34;30
37	Daybul	102;30	25;10
38	Qandahār	107;40	33;0
39	Tubbat	110;0	40;0
40	Kashmīr	108;0	35;0
41	Parshūr	105;15	31;0
42	Mūltān	107;35	29;40
43	Sālkot	109;0	33;0
44	Lāhūr	109;20	31;50
45	Tānīsar	112;33	30;10
46	Pānīpahtah	113;20	28;52
47	Hadhrat Dihlī	113;35	28;39
48	Akra	115;0	26;43
49	Qanūj	115;50	26;35
50	Kawālīyar	114;0	26;29
51	Banāras	117;20	26;55
52	Lakhnawtī	114;13	26;30
53	Kopāmāyū	116;33	26;45
54	Jawnpūr	119;6	26;36
	Inner Circle		
55	Kara	118;10	29;49

	Place Name *al-bilād*	**L** *al-ṭūl*	**φ** *al-ᶜarḍ*
56	Jadda	77;0	21;0
57	Ujjayn	102;0	22;30
58	Ajmīr	111;5	26;0
59	Baran	114;0	28;48
60	Kol	114;19	28;4
61	Badāūn	114;19	27;12
62	Sarūj	72;40	34;50
63	Nawshahar	78;20	38;10
64	Jamkūt	177;0	5;0
65	Farmal	104;35	32;55
66	Burhānpūr	103;0	20;30
67	Dawlatābād	101;0	20;30
68	Bījāpūr	105;30	16;20
69	Kanbāyat	109;20	26;20

BACK

The rim of the upper quadrant carries the altitude scales divided in 1° and in 6° and labelled 6—90; 90—6. The rim of the lower half carries the cotangent scales, on the left *al-aṣābiᶜ* (digits) and on the right *al-aqdām* (feet).



Figure A039.2 – Back of the astrolabe (photo courtesy Harvey Cushing/John Hay Whitney Medical Library

The upper left quadrant is engraved with 30 horizontal parallels, where every third line is highlighted with dots.

The upper right quadrant carries six declination arcs, one for each pair of zodiac signs which are marked with their serial numbers on the two radii. Two graphs of the solar meridian altitude for the latitudes 27° and 32° are plotted with the usual labels.

In the lower half there are shadow squares, on the left for the base of 12 and on the right for the base of 7, with the usual divisions and labels.

Inside the shadow squares are two concentric semi-circles carrying the names of the 12 zodiac signs and those of the 28 lunar mansions.

Inscription

Inside the two semi-circles is the maker's signature in three lines written upside-down:

sanaᶜat muḥammad muqīm ibn ᶜīsā
ibn allāhdād asṭurlābī humāyūnī
lāhūrī
‘Made by Muḥammad Muqīm, son of ᶜĪsā, son of Allāhdād of Lahore, astrolabe maker to [the Emperor] Humāyūn.’

A040⊙ ASTROLABE BY MUḤAMMAD MUQĪM, NOT DATED

Diameter 129 mm

Oxford, Museum of the History of Science (#37530)

CCA 1013; Répertoire 20

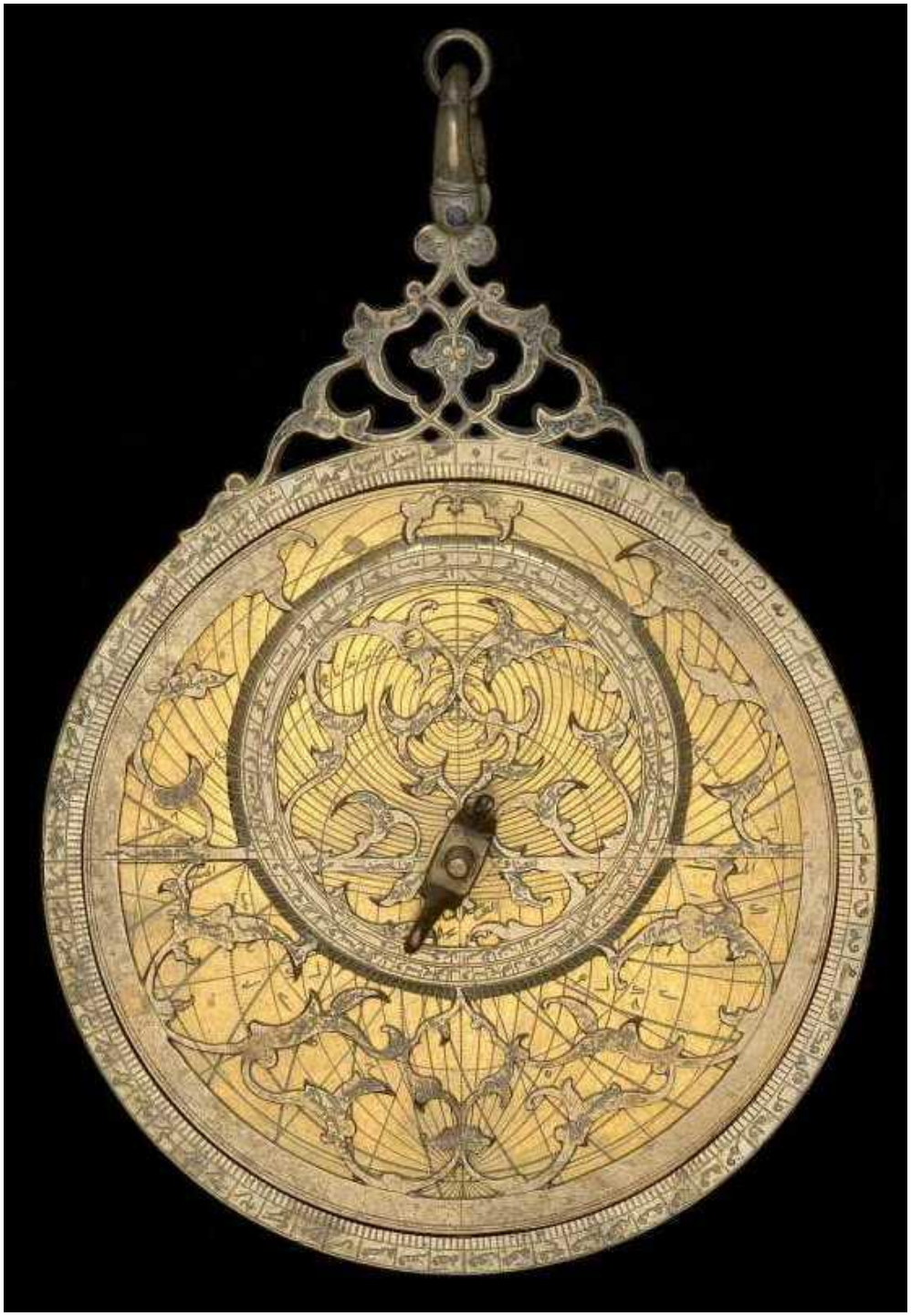


Figure A040.1 – Front of the astrolabe
(© Museum for the History of Science, Oxford)

It is an elegantly crafted astrolabe with some innovations not found elsewhere. In the solar quadrant on the back, besides the sigmoid graph for the midday altitude of the sun at latitude 27°, there are two other graphs to show the beginning and end of the mid-afternoon prayer *al-ᶜasr* throught the year. Second, on the latitude plate 2, which is calibrated for 27° (Agra) on one side and for 32° (Lahore) on the other, there are crepuscular prayer lines below the eastern and western horizons. There are also *ghaṭī* lines on these two sides. Third, on the plate 4b containing a triple projection for the latitudes 0° + 72° + 90°, there are declination scales.

Components

Body with *kursī* (d. 129, h. 166, t. 8), shackle and ring, rete (d. 117) for 41 stars, 5 plates (d. 117). Alidade, pin and horse are missing. The ensemble is held together by a modern bolt and nut.

Front

The ring is very small; the two ends are welded together. The shackle has trifoliate shape and diamond cross-section. The *kursī* has an interesting profile with lobes and sharp projections, topped by a trifoliate finial. It is pierced with just 8 perforations but has a pleasing design with a diamond-shaped motif in the middle, which repeats itself twice in the rete below. Decorative engravings on the surface on both sides.

The limb is divided in 1° and 5° and labelled 5—360.

Rete

The broad Capricorn ring and the equally broad ecliptic ring are joined by the equinoctial bar with counter changes. The inner edge of the Capricorn constitutes the Tropic of Capricorn and not the outer circle as is the usual case. Consequently, the first point of Capricorn in the ecliptic ring is far removed from the degree scale on the limb. This gap is bridged by an ornate arch set upon the ecliptic ring and this arch functions as the Capricorn index (*al-muri*).

The ecliptic circle is divided into 12 signs and labelled with their names. Each sign is divided into five units which are numbered as 6, 12, 18, 24, 30. Divisions of 3° are marked on the sloping edge of the ecliptic ring. Originally there was a handle in a part of the tracery inside the ecliptic ring which is now lost; only the hole remains.

There are a very large number of stars on this small astrolabe. Their names are engraved in miniscule letters but still very clearly written.

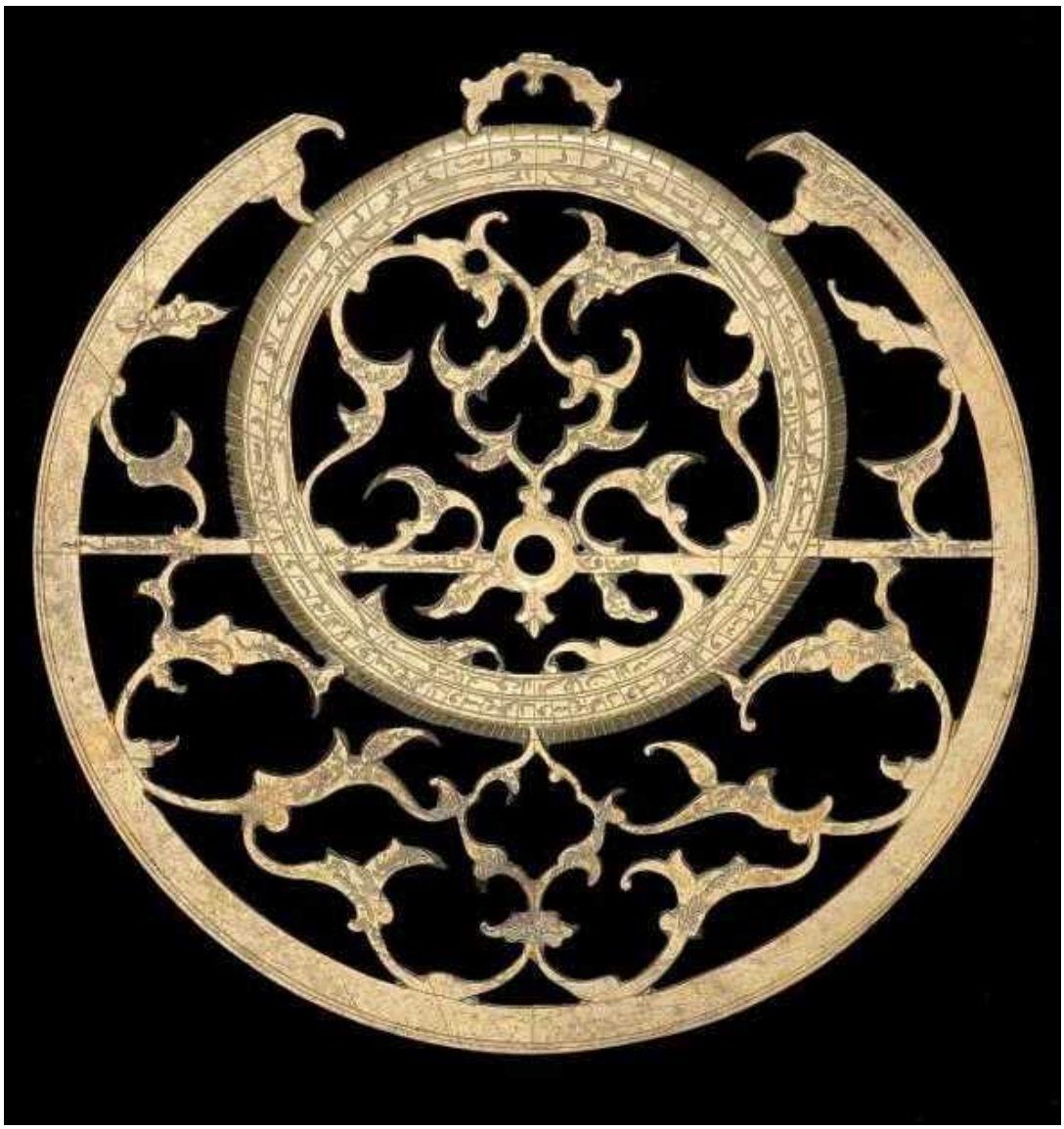


Figure A040.2 – Rete of the Astrolabe (© Museum of the History of Science, Oxford)

Table A040-1 Stars on the Rete

	Star Name	Identification
01	*Dhanab al-Qayṭus J[anūbī]*	β Ceti
02	*Baṭn [al-Ḥūt]*	β Andromedae
03	*Rijl al-Musalsala*	γ Andromedae
04	*Fam al-Qayṭus*	γ Ceti
05	*Kaff al-Jadhmā'*	α Ceti

	Star Name	Identification
06	*[Rās al-] Ghūl*	β Persei
07	*Tālī Masāfat al-Nahr*	γ Eridani
08	*ᶜAyn al-Thawr*	α Tauri
09	*ᶜAyyūq*	α Aurigae
10	*Rijl Yusrā*	β Orionis
11	*Yad Yusrā*	γ Orionis
12	*Rijl Jawjā' [Yumnā]*	κ Orionis
13	*Yad Yumnā*	α Orionis
14	*Shiᶜrā Yamānī*	α Canis Majoris
15	*Shiᶜrā Shāmī*	α Canis Minoris
16	*Ṭarfat al-Safīna*	ρ Puppis
17	*Fard al-Shujāᶜ*	α Hydrae
18	*Qalb al-Asad*	α Leonis
19	*Ẓahr Dubb Akbar*	α Ursae Majoris
20	*Qāᶜidat al-Bāṭiya*	α Crateris
21	*Al-ᶜAnāq*	ξ Ursae Majoris
22	*Janāḥ al-Ghurāb*	γ Corvi
23	*Simāk al-Aᶜzal*	α Virginis
24	*Simāk Rāmiᶜ*	α Bootis
25	*Nayyir Fakkah*	α Coronae Borealis
26	*ᶜUnuq al-Ḥayyah*	α Serpentis
27	*Qalb al-ᶜAqrab*	α Scorpii
28	*Rās al-Ḥawwā*	α Ophiuchi
29	*Yad al-Ḥawwā al-Yamīnī al-Muqaddam*	δ Ophiuchi

	Star Name	Identification
30	?	
31	*Nasr Wāqi*^{c}	α Lyrae
32	*Minqār Dajājah*	β Cygni
33	*Dhanab al-Dūlfīn*	ε Delphini
34	*Dhanab Dajājah*	α Cygni
35	*Fam al-Faras*	ε Pegasi
36	*Dhanab al-Jadī*	δ Capricorni
37	*Mankib Sākib al-Mā'*	α Aquarii
38	*Sāq Sākib al Mā' J[anūbī]*	δ Aquarii
39	*Dhanab al-Qayṭus Sh[amālī]*	ι Ceti
40	*Surrat Faras*	δ Pegasi
41	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are five plates with the following specifications.

Table A040-2 Plates

	φ	Longest Day
1a	22°	13;22 hours
1b	25°	13;25 hours
2a	27°	13;43 hours
2b	32°	14;8 hours
3a	36°	14;32 hours
3b	18° + 30°	

	φ	Longest Day
4a	40°	14;54 hours
4b	0° + 72° + 90°	
5a	Plate of ecliptic coordinates	
5b	Plate of horizons	

In all plates (except 5b) altitude circles are traced for every 3° and every fifth of these (15°) is highlighted by dots; the circles are numbered on both sides. Azimuth arcs drawn below the horizon for every 10°. The prime meridian is dotted. Lines are drawn for seasonal hours and for equal hours from the western horizon. The east and west points labelled.

On the two sides of plate 2 serving the latitudes 27° and 32°, dotted lines are drawn for equal *ghaṭīs* from the western horizon. There are also crepuscular prayer lines below the eastern and western horizons.

On 3b which has the double projection for 30° and 18° altitude circles are drawn for3° and labelled; plain lines for seasonal hours and dotted lines for equal hours counted from both eastern and western horizons, but no azimuth arcs.

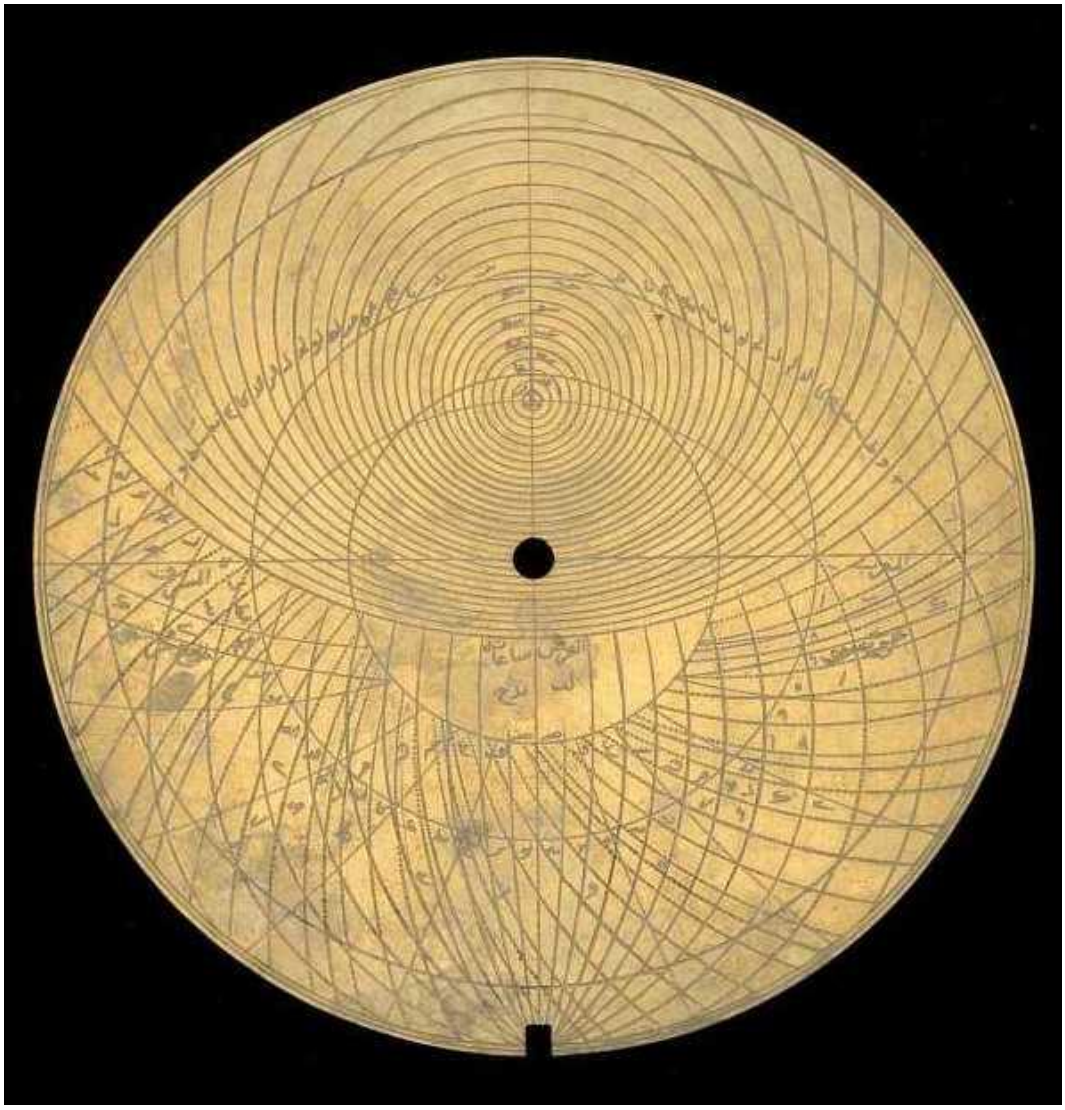


Figure A040.3 – Plate for the latitude of Lahore at 32°
(© Museum of the History of Science, Oxford)

4b. The triple projection of 0°, 72° and 90° is as in the astrolabe of 1643 (A030), but an innovation is made here by introducing declination scales between the Capricorn circle and equatorial circle at the eastern and western horizons, and at the lower meridian that separates the projections for 90° and 72°.

5a. In the plate of ecliptic coordinates, circles of latitudes are drawn for each 3° and circles of latitudes for each 10° and numbered. The names of the signs are written along the ecliptic circle, but there is no label for the plate itself.

5b. In the plate of horizons, half horizons are drawn for latitudes with even number of degrees from 6° to 68°; in four sets, with intervals of 8° in each set.

6	14	22	…	62
8	16	24	…	64
10	18	26	…	66
12	20	28	…	68

There are declination scales divided in 2° and labelled 6, 12, 18, 23;30. There is no label for the plate.

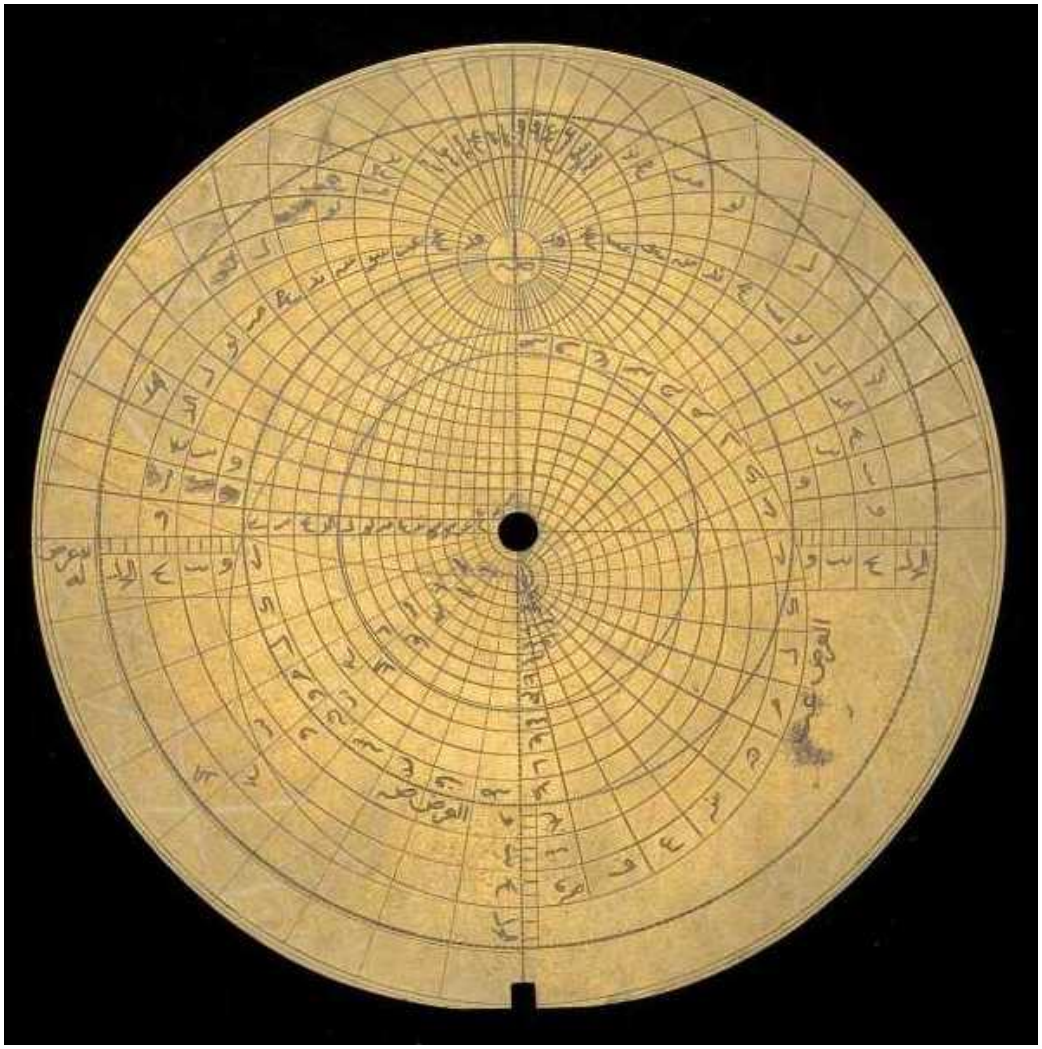


Figure A040.4 – Projections for the latitudes 0°, 72° and 90°
(© Museum of the History of Science, Oxford)

A rectangular peg is affixed at the north point inside the limb in order hold the plates in position. Accordingly, the plates have notches at the north point. However, plate 3 has two notches at the north point and at 90° from it. If the two projections for 18° and 30° on 3b were to be made use of, there ought to be notches at north and south points. In the plate of horizons there is only one notch at the north point, although it needs notches at all the four points of compass so that the four sets of half-horizons can be made use of.



Figure A040.5 – Geographical gazetteer
(© Museum of the History of Science, Oxford)

GEOGRAPHICAL GAZETTEER

The gazetteer is inscribed in three circles with the names, longitudes and latitudes of 77 localities. The letters are written upside-down, i.e., the tops of the letters are towards the centre of the astrolabe. The enumeration begins at the top of the inner circle and proceeds from right to left, roughly according to increasing longitude.

Table A040-3 Geographical Gazetteer

	Place Name ***al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
	Inner Circle		

	Place Name ***al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
01	Miṣr	63;20	30;20
02	ᶜAdan	76;0	11;0
03	Madinat Rasūl ᶜAlayhi al-Salām 75;20	25;0	
04	Makka Muᶜaẓẓam	77;10	21;40
05	Tā'īf	77;30	21;20
06	Bayt al-Maqdis	66;30	31;50
07	Dimashq	70;0	33;15
08	Ḥalab	72;10	35;50
09	Qūnya	66;30	41;0
10	Raqqa	73;15	36;0
11	ᶜĀna	76;30	34;0
12	Mawṣil	77;0	34;30
13	Nakhajwān	81;15	38;40
14	Tabrīz	82;0	38;0
15	Bardaᶜa	83;0	40;30
	Middle Circle		
16	Bāb al-Abwāb	85;0	43;0
17	Bulghār	90;0	49;30
18	Kūfa	79;30	31;30
19	Madā'īn	72;0	33;10
20	Baghdād	80;0	33;25
21	Baṣra	84;0	30;0
22	Arjān	86;30	35;30

	Place Name ***al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
23	Fīrūzābād	87;30	28;10
24	Shīrāz	88;0	29;36
25	Yazd	89;0	32;40
26	Abhar	84;30	36;45
27	Hamadān	83;0	35;10
28	Karaj	84;45	32;0
29	Sāwa	85;0	35;0
30	Qazwīn	85;0	36;0
31	Iṣfahān	86;40	32;25
32	Kāshān	86;0	34;0
33	Qum	85;40	34;45
34	Rayy	86;20	35;0
35	Khuwār	87;10	35;40
36	Ṭāliqān	85;45	36;10
37	Astarābād	89;35	36;50
38	Jarjān	90;0	36;50
	Outer Circle		
39	Busṭām	89;30	36;10
40	Sabzawār	91;30	36;5
41	Nīshābūr	92;30	36;21
42	Ṭūs	92;30	37;0
43	Tūn	92;30	34;30
44	Harāt	94;20	34;30
45	Marw	97;0	37;40

	Place Name ***al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
46	Balkh	100;0 !	36;41
47	Badakhshān	104;24	37;10
48	Bukhārā	97;30	39;50
49	Samarqand	99;16	39;37
50	Khujand	100;35	41;55
51	Kāshghar	106;30	44;0
52	Khutan	107;0	42;0
53	Hurmūz	92;0	35;0
54	Maymand	104;40	35;0
55	Dabīl	102;30	25;2
56	Mūltān	107;35	29;40
57	Qandahār	107;40	33;0
58	Kābul	104;40	35;0
59	Kashmīr	108;0	35;0
60	Tubbat	110;0	40;0
61	Lahāwar	109;20	31;50
62	Tānīsar	112;25	30;10
63	Dihlī Haḍrat	113;35	28;0 !
64	Akra	115;0	26;46
65	Qannawj	115;50	106;35 !
66	Bānārasī	117;20	26;55
67	Sarāndīb	130;0	10;0
68	Kawāliyār	115;0	26;29
69	Ajmīr	112;5	26;0

	Place Name *al-bilād*	**L** *al-ṭūl*	**φ** *al-ᶜarḍ*
70	Ujjayn	112;0	22;30
71	Badāwan	119;29	27;42
72	Sanbhal	115;0	28;18
73	Aḥmadābād	108;40	23;15
74	Bījāpūr	108;30	17;20
75	Mandū	111;25	22;15
76	Jadda	76;0	21;0
77	Kanbāyat	109;20	22;20

BACK

The rim of the upper two quadrants carries altitude scales which are divided in 1° and 5° and labelled 5—90; 90—5. In the upper left quadrant are drawn 60 horizontal parallels, with every fifth dotted. In the upper right quadrant, declination circles are traced for every 10° of solar longitude. Along the vertical radius the signs from the summer solstice to the winter solstice, i.e., from *al-Saraṭān* (Cancer) to *al-Qaws* (Sagittarius) with their divisions are written from the centre to the periphery. Along the horizontal radius the signs from the winter solstice to the summer solstice, i.e., *al-Jadī* (Capricorn) to *al-Jawzā'* (Gemini) with their divisions are written from the periphery up to the centre.

Superimposed on these are three graphs; the upper one represents the solar meridian altitude throughout the year at the latitude of 27° and carries the label *khaṭṭ niṣf al-nahār al-ᶜarḍ 27.* The other two lines are the graphs of the beginning and end of the mid-afternoon prayer *al- ᶜaṣr,* with the labels *awwal ᶜaṣr* and *ākhir ᶜaṣr.*

In the lower half, there are shadow squares, on the left for the base of 12 and on the right for the base of 7. The vertical and horizontal scales on the left and right divided and numbered accordingly. These scales carry the following labels:

Vertical scale on the left: *ẓill sullam aṣābiᶜ maᶜkūs*

Horizontal scale on the left: *ẓill sullam aṣābiʿ mustawī*

Horizontal scale on the right: *ẓill sullam aqdām mustawī*

Vertical scale on the right: *ẓill sullam aqadām maʿkūs*



Figure A040.6 – Back of the astrolabe
(© Museum of the History of Science, Oxford)

Inside these shadow squares are engraved two rectangular tables. The table on the left is entitled *faḍl al-dawr* (excess of revolution) and contains multiples of the difference between the true and nominal years. The table on the right bears the heading *arbāb al-muthallathāt* (regents of the triplicities) and arranges the signs and their diurnal and nocturnal regents according to the four elements *nārī* (fiery), *tatāmi* (earthy), *hawā'ī* (airy) and *mā'ī* (watery).

Table A040-4 Triplicities and their Regents

nārī (fiery)				*tarābī* (earthy)		
Sun	Jupiter	Saturn		Venus	Moon	Mars
Aries	Leo	Sagittarius		Taurus	Virgo	Capricorn
Jupiter	Sun	Saturn		Moon	Venus	Mars
hawā'ī (airy)				*mā'ī* (watery)		
Saturn	Mercury	Jupiter		Venus	Mars	Moon
Gemini	Libra	Aquarius		Cancer	Scorpio	Pisces
Mercury	Saturn	Jupiter		Mars	Venus	Mon

The rim of the lower half bears the two cotangent scales, on the left in digits (*al-aṣābiʿ*) and on the right in feet (*al-aqdām*). The divisions in these scales are subdivided into 5 parts each in the immediately following semi-circular row. This is followed by 6 semi-circular rows. The first two rows contain the names of the 28 lunar mansions and the names of the 12 corresponding zodiac signs The next two rows form the table of limits (*ḥudūd*) and the last two the decans (*wujūh*) and their regents.

INSCRIPTION

Beneath the shadow squares, along the curve of the semi-circular table is inscribed the signature of the maker, but no date:

> *ʿamal aḍʿaf al-ʿibād muḥammad muqīm ibn mullā ʿīsā ibn shaykh allāhdād [a]sṭurlābī humāyūnī lāhūrī.*
>
> 'The work of the weakest of the servants [of God], Muḥammad Muqīm, son of Mullā ʿĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn.'

PROVENANCE

Formerly in the Henri Michel Collection, Brussels.

J. A. Billmeir Collection

BIBLIOGRAPHY

Michel 1947, Plate XXI: front and back, Fig. 22: gazetteer. The caption under the gazetteer states ‘Table of Qibla azimuths’, but these are only longitudes and latitudes.

A041⊙ ASTROLABE BY MUḤAMMAD MUQĪM, NOT DATED

Diameter 107 mm

PLU, ex-Antwerp, PC



Figure A041.1 – Front of the astrolabe (photo by S. R. Sarma)

In this astrolabe, on both sides of the five plates (including the plate of ecliptic coordinates and the plate of horizons), there are two concentric circles on the rim. In the inner circle are engraved the names of 16 places whose latitudes are close to the latitude

for which the plate is calibrated. In the outer rim are given the longitudes and latitudes of these 16 places in 32 cells. There is only one more specimen among the Lahore astrolabes which exhibits this feature, but only partially (A014). I regret very much that when I examined this astrolabe briefly in 1996, I did not appreciate the importance of this feature and did not photograph all the plates. I have photocopies of two pages where the obverse and reverse sides of all the components of the astrolabe are illustrated. The pages are apparently from an unidentified catalogue of Christie's with the serial numbers K 39564 and K39565. I tried to enlarge the images of the individual plates and to copy the gazetteers on the rim, but these images were trimmed around, cutting off the lower part of the *Abjad* numerals denoting the longitudes and latitudes.

Since the rims of the plates are covered by this gazetteer, the circle of the Tropic of Capricorn lies several mm inside on the plates as well as on the rete. Consequently, the upper part of the ecliptic ring is far away from the degree scale on the rim. In order to bridge this gap, a trifoliate arch is attached to the topmost point of the ecliptic ring to function as the Capricorn index (*al-mūri*), as is done in A014 and also in A038.

Components

Body with *kursī* (d. 107, h. 142, t. 8) and shackle, rete for 27 stars, 5 plates, alidade, pin and horse. The ring is missing.

Front

There is a fine shackle which has trifoliate outline and an oval cross-section and ornate bases. The *kursī* is worked à jour and has a trifoliate finial.

The limb is divided into 1° and 5° and groups of 5° are numbered from 5 to 360°. But at the back the altitude scale is divided in 1° and 6°.

Rete

The Capricorn ring and the much broader ecliptic ring are held together by the equinoctial bar which has counter changes at its two intersections with the ecliptic ring. The tracery joining the star pointers is quite symmetrical. Inside the ecliptic ring, it forms a heart-shaped frame around the star pointer of Vega. The ecliptic ring is divided into the 12 signs, labelled with their names; further subdivided into 6° and labelled. These divisions are marked on the beveled edge. There are 27 named star pointers. The

rete is broken at three places and mended. There is a handle on the Capricorn ring, to the right of the north point.



Figure A041.2 – Rete of the Astrolabe (photo by S. R. Sarma)

PLATES

There are five plates.

Table A041-1 Plates

	φ	Longest Day
1a	22°	13 hours!
1b	25°	13 hours!
2a	27°	13;43 hours
2b	32°	14;8 hours
3a	36°	14;32 hours

	φ	Longest Day
3b	40°	14 hours !
4a	42°	14 hours
4b	0°+72°+90°	
5a	Tablet of ecliptic co-ordinates	
5b	Plate of horizons	

On plates 1-4 altitude circles are drawn for every 6° and labelled on both sides. Azimuth arcs are drawn for 10° below the horizon. On 3b for 40°, however, they are drawn above and below the horizon. Lines for seasonal hours are drawn on all latitude plates. On plate 3a-b (36°-40°), lines are drawn for equal hours from the western horizon; on the rest they are drawn from the western as well as the eastern horizon up to the meridian. The duration of the longest day is erratic in several cases.

As mentioned above, the rims of all plates are engraved with gazetteers of 16 places. As an example, the gazetteer engraved on the rim of the plate 2a for latitude 27° will be reproduced below, as much as it was possible to decipher. The gazetteer starts from the north point and proceeds clockwise.

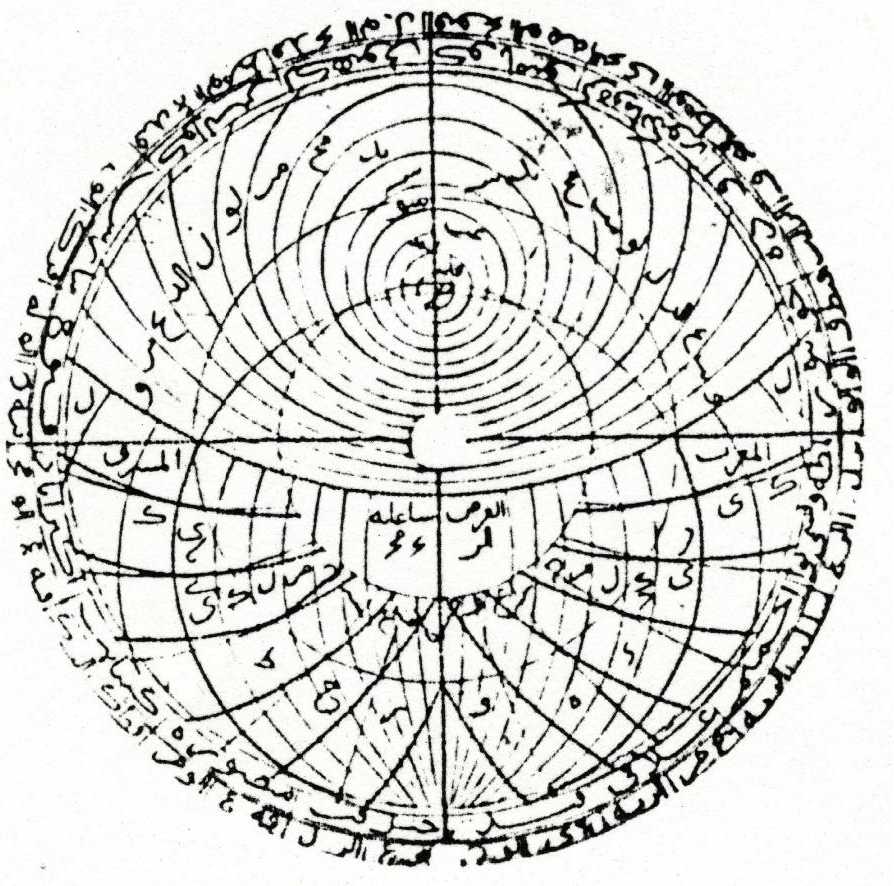


Figure A041.3 – Plate for latitude 27° (from Christie's catalogue)

Table A041-2 Gazetteer on Plate 2a

	Place Name	L	φ
01	---	---	27;30
02	Mansūrah	105;0	27;40
03	---	59;20	27;20
04	Akbarābād	115;-	26;43
05	Qannawj	115;50	26;45
06	Banāras	107;20	26; ?
07	Kowaliyar	114;0	26;49
08	Lakhnauti	114;13	26;30
09	Kopāmāū	116;13	26;45
10	Karah wa Manikpūr	113;10	26;49
11	Awadh	113;6	27;22

	Place Name	L	φ
12	Jawnbūr	119;6	26;26
13	---	---	27;0
14	Ajmīr	-;30	26;15
15	Allāqī	68;40	27;15
16	Fayd	---	26;50

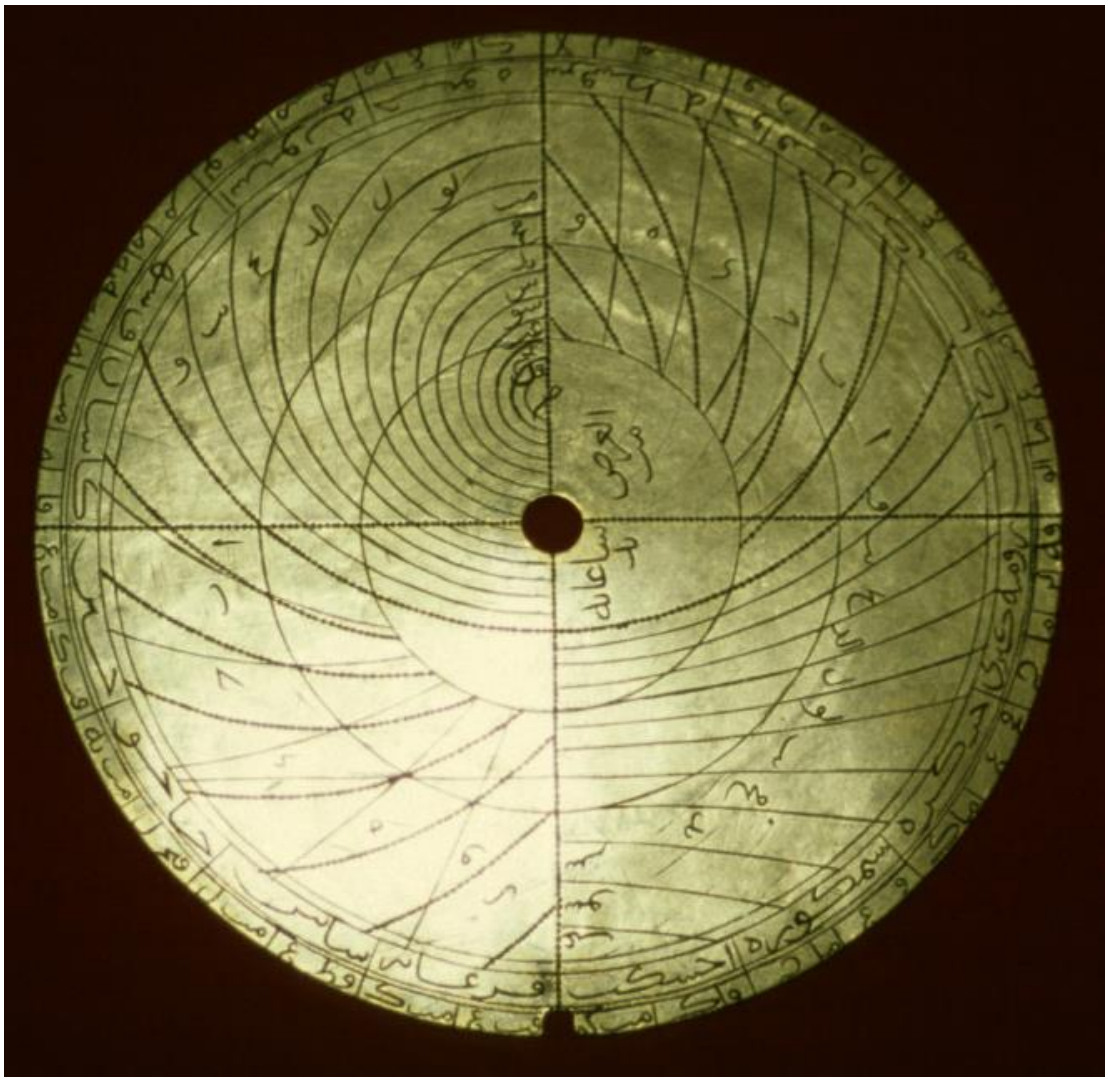


Figure A041.4 – Plate for the latitude of 42° (photo by S. R. Sarma)

On plate 4a for the latitude of 42°, the astrolabe maker shows off his virtuosity by interchanging the upper and the lower quadrants on the right. Here also the rim carries a gazetteer of 16 places that are stuated near the latitude of 42° such as Farghāna,

Rūmiyya Kabīrī (Rome), Khutan, Jenowa (Genoa) and so on. On the reverse side of the plate is a combined projection for the three latitudes of 0° + 72° +90°. On the rim, however, are listed 16 localities close to the equator.

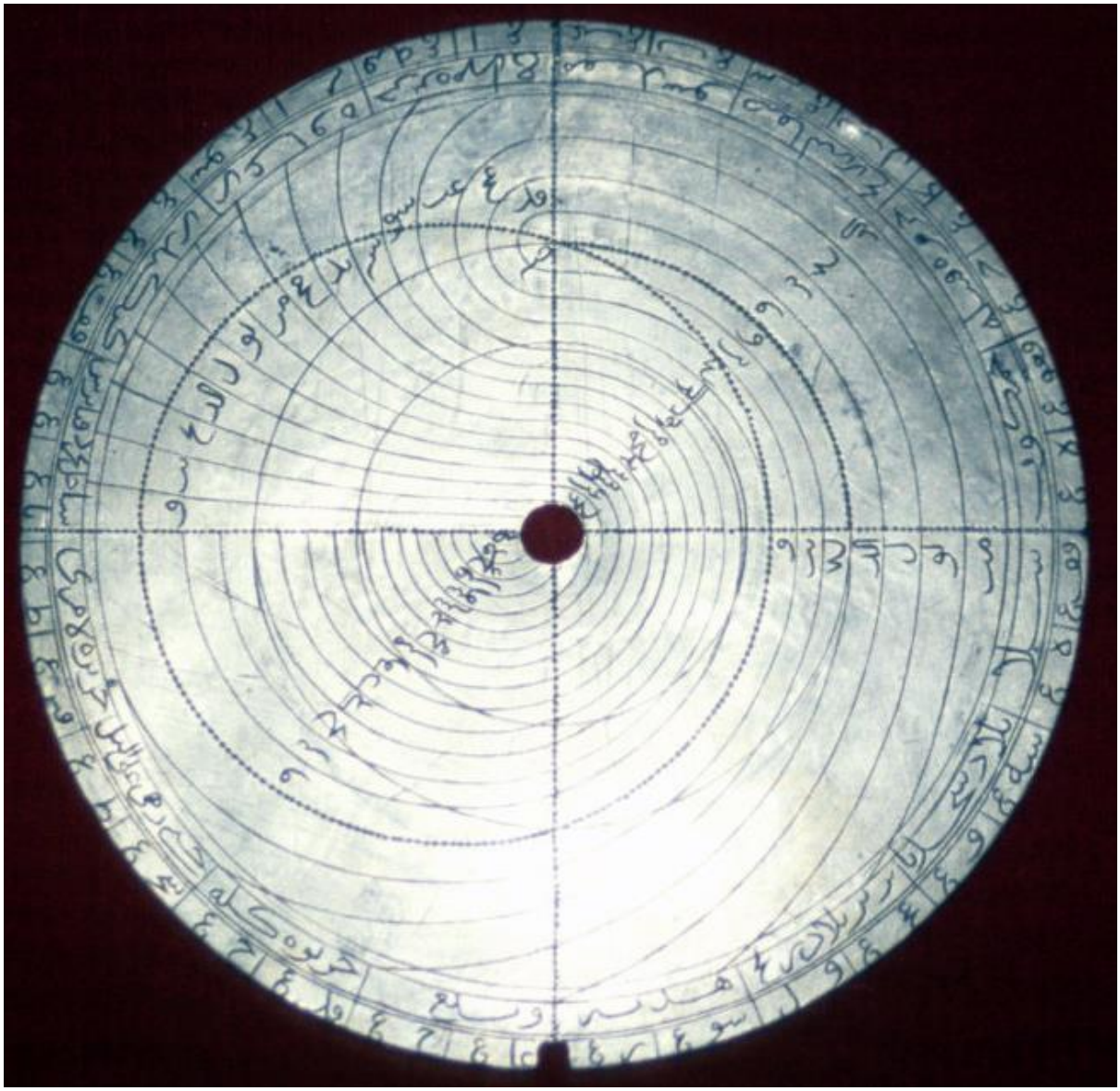


Figure A041.5 – Combined projection of latitudes 0° + 72° + 90° (photo by S. R. Sarma)

GEOGRAPHICAL GAZETTEER

On the inner side of the mater, a geographical gazetteer of 69 localities is engraved in a spiral form. The order of arrangement is: place name (*al-bilād*), latitude (*al-ʿarḍ*) and longitude (*al-ṭūl*). There is a peg at the north point to prevent the plates from rotating freely around the centre.

BACK

The rim of the upper half carries two altitude scales, divided in 1° and 6° and numbered as 6—90; 90—6, while the rim of the lower half has scales of cotangents.

The upper left quadrant carries a sine-cosine grid with 30 horizontal and 30 vertical parallels, where each third line is highlighted by a dotted line.

In the upper right quadrant are drawn six declination circles; the serial numbers of the related signs are marked along the two radii. On these arcs, two graphs are drawn for the solar meridian altitude for the latitudes of 27° and 32°.

In the lower half are shadow squares, on the left for the base of 12 digits and on the right for the base of 7, with the scales divided and numbered accordingly. The scales are accompanied by the following labels:

Vertical scale on the left: *ẓill sullam aṣābiʿ maʿkūs*

Horizontal scale on the left: *ẓill sullam aṣābiʿ mustawī*

Horizontal scale on the right: *ẓill sullam aqdām mustawī*

Vertical scale on the right: *ẓill sullam aqdām maʿkūs*



Figure A041.6 – Back of the astrolabe (photo by S. R. Sarma)

Within the shadow squares is a table of climates, displaying the latitudes and the hours of the maximum daylight at the beginning and the middle of the seven climates.[317]

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317 This table occurs also in A024 and A051, but in different arrangements. See also Kaye 1918, p. 132

Here the first column shows the climates, the second the latitude at the beginning (*mabdā'*) of the climate and the third the latitude at the middle (*wasaṭ*) of the climate. In the fourth column are mentioned the maximum hours of daylight at the beginning of the climate and in the fifth column the same at the middle of the climate. For the seventh climate, the second column shows both the latitudes at the beginning and end of the climate; likewise, the fourth column displays maximum hours at the beginning and end of the climate.

Table A041-3 Climates

Aqālīm **(climates)**	***ᶜarūd*** **(latitudes)**		***sāᶜāt*** **(hours)**	
	beginning	middle	beginning	middle
1	12;43	16;47	12;45	13;0
2	20;31	24;10	13;15	13;30
3	27;34[318]	30;46	13;45	14;0
4	33;43	36;28	14;15	14;30
5	39;1	41;21	14;45	15;0
6	43;30	45;39	15;15	15;30
7	47;18 50;31	48;59	15;45 16;15	16;0

ALIDADE

The alidade is 98 mm long with ornate ends and an ornate centre piece. The pin and the horse are replacements.

INSCRIPTION

Immediately below the horizontal diameter is the maker's signature which reads

ṣanᶜat aḍᶜaf al-ᶜibād muḥammad muqīm ibn 'īsā ibn allāhdād lāhūrī [asṭurlābī] humāyūnī

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[318] Inscribed wrongly as 24;34.

‘The work of the weakest of the servants [of God], Muḥammad Muqīm, son of ‘Īsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn.’

BIBLIOGRAPHY

The astrolabe was shown on the cover page of Christie’s Catalogue, *Engineering and Scientific Works of Art and Instruments*, London 21 March 1991, but was not described inside, nor was it included in the auction. But it came up for auction at some other time: I have two sheets from a catalogue, showing all parts front and back, with numbers K 39564 and K 39565.

A042⊙ ASTROLABE BY MUḤAMMAD MUQĪM, NOT DATED

Diameter 105 mm

Paris, Institut du Monde Arabe (#AI 86-25)

CCA 3537



Figure A042.1 – Front of the astrolabe (photo courtesy Institut du Monde Arabe)

This small astrolabe has an unusual *kursī.* It is solid and plain, yet it is striking with its extravagant profiles having lobed protuberances. On the back, instead of the usual two graphs of the midday altitude of the sun at the latitudes of the Mughal Imperial cities Agra (27°) and Lahore (32°), there is only one graph for 32°.

COMPONENTS

Body with *kursī* (d. 105, h. 141, t. 7), shackle and ring, rete for 37 stars, 5 plates (d. 89), alidade, pin and washer. Original horse is missing; a pin is used a substitute.

FRONT

The ring has a diamond cross section. The shackle has trifoliate shape but simple round bases. The *kursī* is solid without any fretwork or surface decorations; but is endowed with unusual profiles with three tri-lobed protuberances.

The limb is divided in 1° and 6° and numbered in 6s from 6 —360.

RETE

The Capricorn ring and the ecliptic ring are held together by the equinoctial bar counter-changed once at the centre; the spaces between the two rings and inside the ecliptic circle are filled with a floral tracery of continuous flow of vines and tendrils, with the recurring motif of tulips with flared petals. Particularly impressive is the spiral form of the tracery inside the ecliptic ring. A large handle is attached to the Capricorn ring at NW. The ecliptic circle is divided into 12 signs of zodiac and labelled with their names; each sign is divided into five units of 6° each and numbered accordingly. There are 37 star pointers.



Figure A042.2 – Rete of the astrolabe (photo by S. R. Sarma)

Table A042-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab Qayṭus Janūbī*	β Ceti
2	*Baṭn Ḥūt*	β Andromedae
3	*Fam Qayṭus*	γ Ceti
4	*Ṣadr Qayṭus*	π Ceti
5	*Ghūl*	β Persei
6	*Masāfat al-Nahr*	γ Eridani
7	*ᶜAyn Thawr*	α Tauri

	Star Name	Identification
8	*ᶜAyyūq*	α Aurigae
9	*Rijl Jawzā' Yusrā*	β Orionis
10	*Yad Jawzā' Yusrā*	γ Orionis
11	*Yad Jawzā' Yumnā*	α Orionis
12	[*Shiᶜrā*] *Yamānī*	α Canis Majoris
13	[*Shiᶜrā*] *Shāmī*	α Canis Minoris
14	*Fard Shujāᶜ*	α Hydrae
15	*Qā'idāt Bāṭiya*	α Crateris
16	*Janāḥ Ghurāb*	γ Corvi
17	*Ẓahr Dubb Akbar*	α Ursae Majoris
18	*Simāk Aᶜzal*	α Virginis
19	*ᶜAnāq*	ζ Ursae Majoris
20	*Simāk Rāmiḥ*	α Bootis
21	*Fakkah*	α Coronae Borealis
22	*ᶜUnuq Ḥayyah*	α Serpentis
23	*Qalb ᶜAqrab*	α Scorpii
24	?	ρ Ophiuchi
25	*Jāthī*	α Herculis
26	?	δ Ophiuchi
27	*Nasr Wāqiᶜ*	α Lyrae
28	*Minqār Dajājah*	β Cygni
29	*Nasr Ṭā'ir*	α Aquilae
30	*Dhanab al-Dajājah*	α Cygni
31	*Fam Faras*	ε Pegasi

	Star Name	Identification
32	*Dhanab Jadī*	α Capricorni
33	*Mankib Sākib Mā'*	α Aquarii
34	*Sāq Sākib Mā' Janūbiyya*	δ Aquarii
35	*Mankib Faras*	β Pegasi
36	?	?
37	*Khadīb*	β Cassiopeiae

PLATES

There are five plates with the following specifications.

Table A042-2 Plates

	φ	Longest Day
1a	22°	13;22 hours
1b	25°	13;25 hours
2a	27°	13;43 hours
2b	32°	14;8 hours
3a	36°	14;28 hours
3b	40°	14;52 hours
4a	18°+70° double projection	
4b	0°+90° double projection	
5a	Plate of ecliptic coordinates	
5b	Plate of horizons	

Altitude circles are drawn at every 6°; azimuth arcs for 10° sometimes above and sometimes below the horizon. There are lines for seasonal hours and for equal hours. Each plate has a rectangular notch at the north point.

GEOGRAPHICAL GAZETTEER

A gazetteer of 58 localities is engraved on the inner surface of the mater in two circles which are separated by a blank circle bounded on either side by double lines. A similar black circle also separates the first circle from the inner edge of the limb.

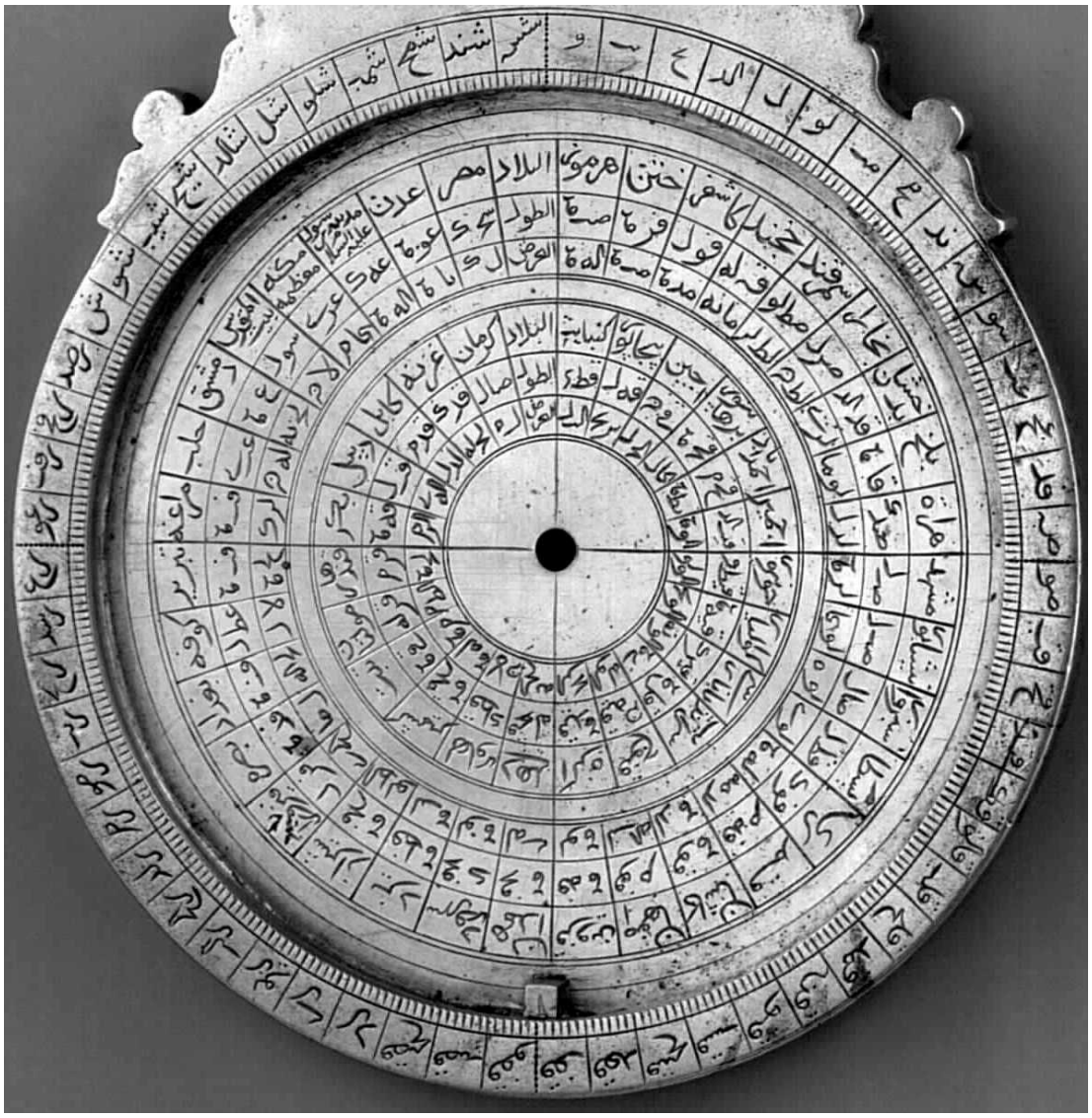


Figure A042.3 – Geographical Gazetteer (photo courtesy Institut du Monde Arabe)

Table A042-3 Geographical Gazetteer

	Place Name ***al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
	Outer Circle		
1	Miṣr	63;20	30;20
2	ᶜAdan	76;0	11;0

	Place Name ***al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
3	Madīnat Rasūl ᶜAlayhi al-Salām	75;20	25;0
4	Makka Muᶜaẓẓam	77;10	21;40
5	Bayt al-Maqdis	66;30	31;50
6	Dimashq	70;0	33;15
7	Ḥalab	72;10	35;50
8	Marāgha	82;0	37;20
9	Tabrīz	82;0	38;0
10	Kūfa	79;30	31;30
11	Baghdād	80.0	33;25
12	Baṣrah	84;0	30;41
13	Fīrūzābād	87;30	28;10
14	Shīrāz	88;0	29;36
15	Yazd	89;0	32;0
16	Suhraward	83;20	36;0
17	Hamadān	83;0	35;10
18	Qazwīn	85;0	36;0
19	Iṣfahān	86;40	32;25
20	Kāshān	86;0	34;0
21	Qumm	85;40	34;45
22	Rayy	86;20	35;0
23	Bisṭām	89;30	36;10
24	Sabzawār	91;30	36;5
25	Nīshābūr	92;30	36;21

	Place Name ***al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
26	Mashhad	92;30	37;0
27	Harāt	94;20	37;30
28	Balkh	101;0	36;41
29	Badakhshān	104;24	37;10
30	Bukhārā	97;30	39;50
31	Samarqand	99;36	39;37
32	Khujand	100;35	41;55
33	Kāshghar	106;30	44;0
34	Khutan	107;0	42;0
35	Hurmūz	92;0	25;0
	Inner Circle		
36	Kirmān	91;30	30;5
37	Ghazna	104;20	33;35
38	Kābul	104;40	34;30
39	Dabīl	102;30	25;10
40	Bakr	105;0	27;40
41	Qandahār	107;40	33;0
42	Mūltān	107;35	29;40
43	Tubbat	110;0	40;0
44	Kashmīr	108;0	35;0
45	Lahāwar	109;20	31;50
46	Dihlī	113;35	28;15
47	Akra	114;0	27;13
48	Qannawz	115;50	26;35

	Place Name ***al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
49	Sarāndīp	130;0	10;0
50	Bānārasī	117;20	26;55
51	Kawāliyār	115;0	26;13
52	Jawnbūr	119;6	27;37
53	Ajmīr	112;24	26;0
54	Aḥmadābād	108;40	19;0
55	Burhānpūr	103;0	21;30
56	Ujjayn	110;50	23;30
57	Bījāpūr	105;30	17;13
58	Kanbāyat	109;4	22;30

BACK

The rim of the upper half carries altitude scales divided in 1° and 6° and labelled in 6s as 6—90; 90—6. On the upper left is a trigonometric quadrant with 30 horizontal parallels, with every third line highlighted by dots.

In the upper right, a universal horary quadrant is superimposed on the solar quadrant. In the solar quadrant, six declination arcs are drawn and the related signs are marked by their serial numbers along the two radii. Instead of the usual two, only a single graph of the solar meridian altitude is drawn for the latitude 32° with the label *khaṭṭ niṣf al-nahār bi-ᶜarḍ 32*. Six lines of seasonal hours are drawn in the same quadrant and numbered from 1 to 6.



Figure A042.4 – Back of the astrolabe (photo courtesy Institut du Monde Arabe)

In the lower half are drawn the shadow squares in the lower half; on the left for 7 feet with the two scales divided in 7 units and numbered serially; on the right for 12 digits with the two scales divided in 6/12 units and numbered in 2's as 2, 4, …12. The labels are:

Vertical scale on the left: *ẓill sullam aqdām maᶜkūs*

Horizontal scale on the left: *ẓill sullam aqdām mustawī*
Horizontal scale on the right: *ẓill sullam aṣābiʿ mustawī*
Vertical scale on the right: *ẓill sullam aṣābiʿ maʿkūs*

Outside the shadow squares, but inside the rim, are two semi-circular rows with the names of the 12 zodiac signs engraved in one and the names of 28 lunar mansions engraved in the other.

The rim on the lower half carries cotangent scales. The scale on the left is marked with 6, 12, 18, 24, 30, 36, … 60, *al-aqdām.* The scale on the right is marked with the same numbers followed by *al-aṣābiʿ*.

Alidade

Straight bar alidade with unusual ornate ends and an ornate centre-piece; the edge of the right half is graduated in divisions corresponding to the distances between the horizontal parallels in the sine quadrant, which are numbered on the surface, in 6s, from 6, 12…60. There are also sundial markings for hours 1/12, 2/11, 3/10, 4/9 and 8. On the left half is engraved the scale of solar longitude with curves matching the pairs of signs in the upper right quadrant together with their serial numbers.

Inscription

Within the shadow squares is engraved the maker's signature in three lines upside-down:

> *aḍaʿaf al-ʿibād muḥammad muqīm ibn mullā*
> *ʿīsā ibn shaykh allāhdād [a]sṭurlābī*
> *humāyūnī lahūrī.*
> '[Made by] the weakest of the servants [of God], Muḥammad Muqīm, the son of Mullā ʿĪsā, the son of Shaykh Allāhdād of Lahore, the astrolabe-maker to [the Emperor] Humāyūn.'

Provenance

Formerly in the M. Distombes Collection

Bibliography

Mouliérac 1989, pp. 102-104.

A043 ASTROLABE BY MUḤAMMAD MUQĪM, NOT DATED

Diameter 96 mm

Cannes, PC

Répertoire 34

The Répertoire gives the following information about this astrolabe.

RETE

The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names; 22 named star pointer.

GEOGRAPHICAL GAZETTEER

Names, longitudes and latitutides of (?) localities.

BACK

Upper half of the rim carries the altitude scales divided in 2° and 5° and the lower half cotangent scales. Upper left quadrant carries a sign graph; upper right quadrant bears arcs of declination and two curves for the midday altitude of the sun at latitudes 27° and 32°. Lower half has shadow squares and astrological tables.

INSCRIPTION

sanacahu muḥammad muqīm ibn cīsā ibn allāhdā[d] aṣ[ṭ]urlābī humāyūnī lāhūrī.

'Made by Muḥammad Muqīm, son of cĪsā, son of Allāhdā[d] of Lahore, astrolabe maker to [the Emperor] Humāyūn.'

PROVENANCE

Private collection at Cannes; formerly of the private collection of Palmö, Bombay.

A044 ASTROLABE BY MUḤAMMAD MUQĪM, NOT DATED[319]

Diameter 92 mm

PLU



Figure A044.1 – Front of the astrolabe (photo from Linton 1980)

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[319] Entry based on Linton 1980, no. 223, p. 175.

In this astrolabe, the workmanship appears to be good, but not the quality of engraving. In the degree scales on the front and on the back, the divisions of 1° are very irregular. The Linton Catalogue remarks: 'Not one of Muḥammad Muqīm's best astrolabes! The engraving of the Arabic is often crude and done without understanding, but this instrument does not appear to be modern, fake. Possible apprentice work from the Lahore workshop.'

Components

Body with *kursī* (d. 92), shackle and ring, rete for 16 stars, 5 plates, alidade, washer, pin and wedge.

Front

The *kursī* is heavily reticulated. From the available photos, it is not clear whether there is trifoliate finial. The limb is divided in 1° and 6° and numbered from 6 to 90, separately in each quadrant.

Rete

The rings of the Capricorn and ecliptic are held together by the horizontal bar which has no counter-change and by an indifferent tracery which connects the star pointers to the main frame.

Plates

There are 5 plates serving latitudes 18°+30° and 25°; 20°and 30°; 0°+72°+90°and 29°; 36°and 40°; plate of ecliptic coordinates and plate of horizons. Azimuth arcs are sometimes engraved below the horizon. There are lines for seasonal hours and for equal hours drawn from the western horizon. Curves for the midday altitude of the sun at latitudes of 27° (Agra) and 32° (Lahore) are drawn on the back, but surprisingly there are no plates for these latitudes.

Geographical Gazetteer

The geographical gazetteer provides the names, longitudes and latitudes of 42 localities.

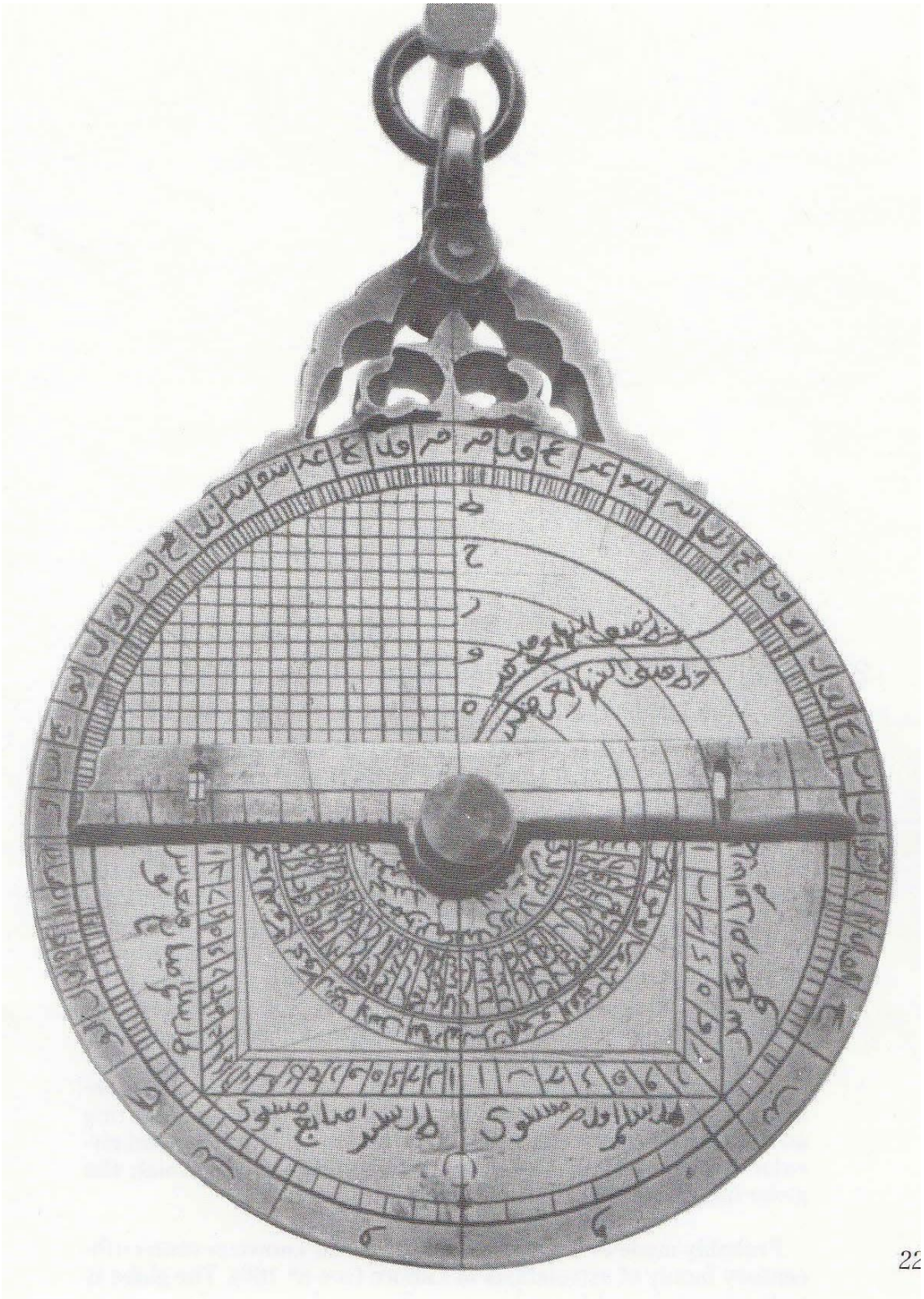


Figure A044.2 – Back of the astrolabe (photo from Linton 1980)

BACK

The upper half of the rim carries altitude scales divided in 1° and 6° and numbered in 6s as 6—90 and the lower half the cotangent scales, on the left in digits and on the right in feet. Trigonometric quadrant in the upper left with 20 horizontal and 20 parallel

lines. Solar quadrant in the upper right with declination arcs for each 30° of solar longitude, the vertical and horizontal radii marked with the serial numbers of the signs, and two sigmoid graphs of the sun's meridian altitude at the latitudes 27° and 32° with the usual labels.

In the lower half shadow squares, on the left for a base of 12 and on the right for a base of 7. The vertical and horizontal scales are divided and numbered accordingly and accompanied by the usual labels.

Within the shadow squares, two semi-circular rows showing the relation between the 12 zodiac signs and the 28 lunar mansions.

INSCRIPTION

The maker's signature is engraved in the space between the horizontal diameter and the semi-circular rows.

> *sanaᶜahu muḥammad muqīm ibn ᶜīsā ibn allāhdād asṭurlābī lāhūrī humāyūnī*
> 'Made by Muḥammad Muqīm, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn.'

PROVENANCE

Formerly in some private collection. Came up for auction at Nouveau Drouot, Paris, on 9 and 10 October 1980.

BIBLIOGRAPHY

Linton 1980, no. 233, p. 175.

A045 ASTROLABE BY MUḤAMMAD MUQĪM, NOT DATED

Diameter 92 mm

Fontenay-le-Comte, PC

Répertoire 35

RETE

The rete carries 16 named star pointers; there are five plates. The inscription on the back reads:

> *sanᶜat muḥammad muqīm [ibn ᶜīsā] ibn allāhdād asṭurlābī lāhūrī humāyūnī*
> '[Made by], Muḥammad Muqīm, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn.'

In the Arabic/Persian version cited in the Répertoire, the words 'ibn Isa', are missing, but not in the translation!

A046 ASTROLABE BY MUḤAMMAD MUQĪM, NOT DATED

Diameter 90 mm

PLU

Répertoire 28

RETE

The rete has 37 named star pointers; there are 6 plates. The inscription on the back reads:

> *aḍᶜaf al-ᶜibād muḥammad muqīm ibn mullā ᶜīsā*
> *ibn shaykh allāhdād asṭurlābī*
> *lāhūrī humāyūnī*
> '[Made by] the weakest of the servants [of God], Muḥammad Muqīm, son of Mullā cĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn.'

A047 ASTROLABE BY MUḤAMMAD MUQĪM, NOT DATED[320]

Diameter 90 mm

PLU, Ex-Paris, Sottas

CCA 1119; Répertoire 24

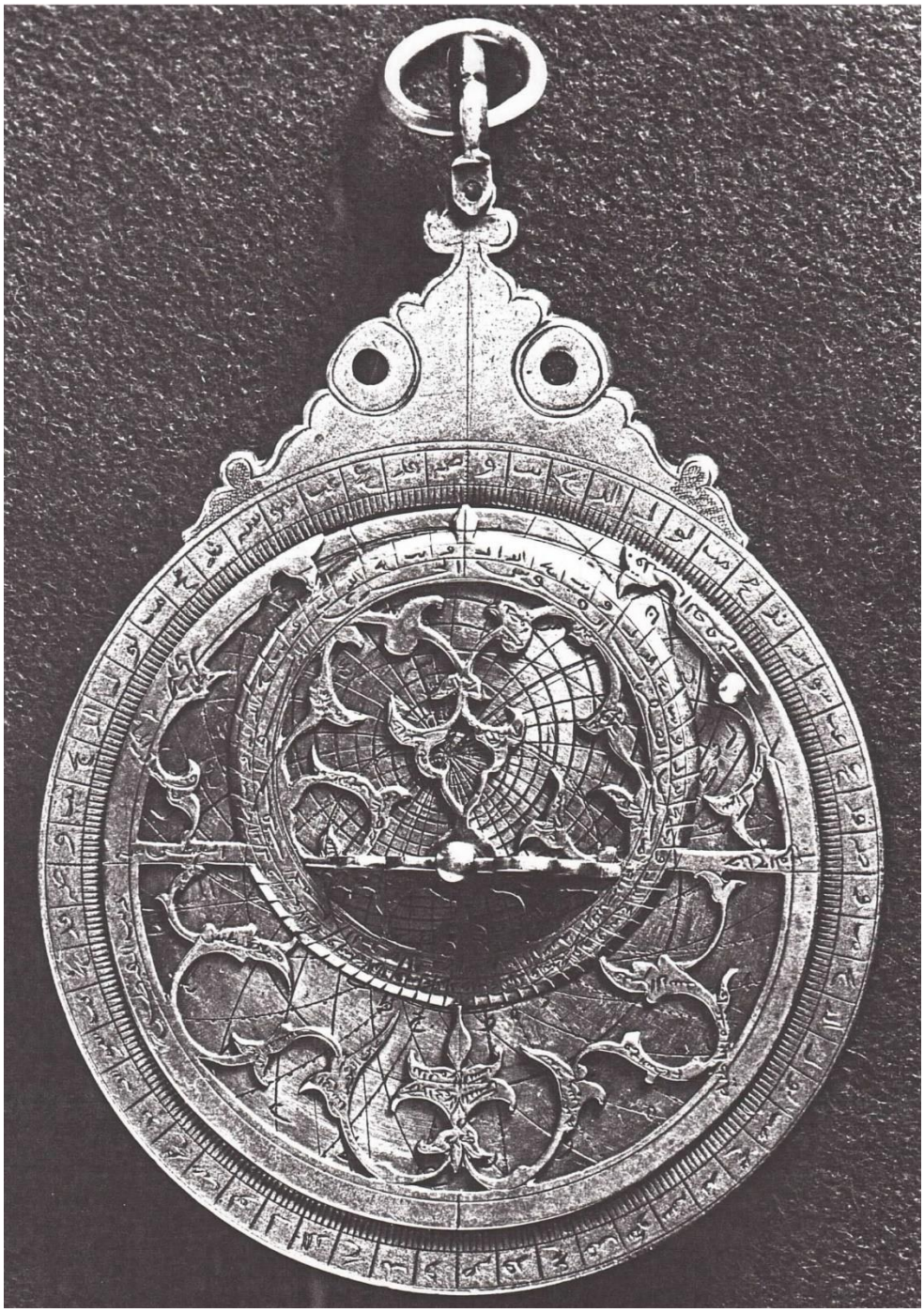


Figure A047.1 – Front of the astrolabe (photo courtesy Professor David King)

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[320] Entry based on Sottas 1930.

In designing the *kursī* of this astrolabe, Muqīm makes a departure from the characteristic style of his family and opts for a very plain surface with two prominent eyelets as in the Kufic astrolabes of the Middle East. But the rete retains its ornate character. There are plates with composite projections for latitudes 0° + 72° + 90° and for 18° + 72 ° to be found in other astrolabes as well, but this is perhaps the only astrolabe which contains a plate with projections for latitude 72°. In the plate for 32°, lines of equal hours are drawn also above the line of horizon, which is unusual.

COMPONENTS

Body with *kursī* (d. 90, t. 7), shackle and ring, rete for 37stars, 6 plates, alidade, pin and horse.

FRONT

The astrolabe has a large ring and a shackle, both with a diamond cross section. The shackle seems to have a trifoliate form. The *kursī* has lobed profiles and terminates in a trifoliate finial. A line runs all along the sides, emphasizing the eyelets.

The limb carries a scale of degrees divided in 1° and 6° and numbered from 6 to 90 separately in each quadrant.

RETE

The Capricorn ring and the ecliptic ring are held in position by the equinoctial bar with counterchanges at its two intersections with the ecliptic ring. A segment of the solstitial bar running between the two circles in the lower half is the base for a number of star pointers; from these arise two creepers to the left and to the right and then upwards, filling the space between the two rings. Inside the ecliptic ring, the two creepers start off from the centre, branch off and then join to create an empty space in the form of a stylized quatrefoil and then branch off to the left and right. These two creepers, almost symmetric, carry the 37 star pointers in the form of leaves or stylized tulip petals. The ecliptic circle is divided into 12 zodiac signs and labelled with their names. Each sign is divided into 5 units of 6° and numbered accordingly.

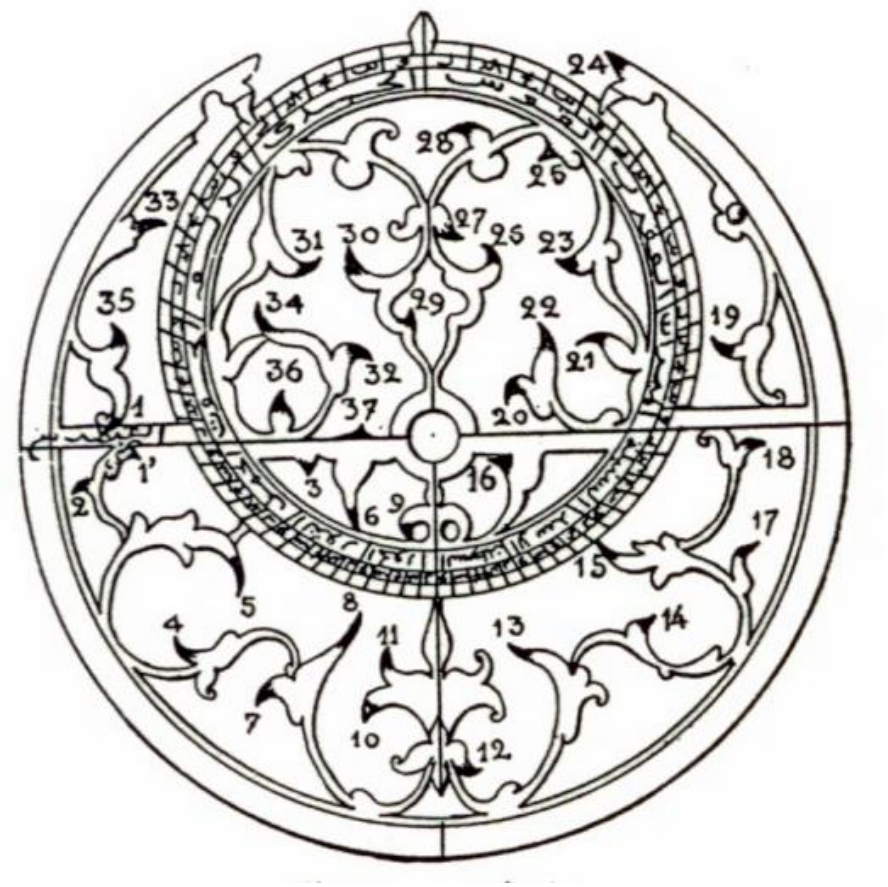


Figure A047.2 – Rete of the astrolabe (drawing from Sottas 1930)

There are 37 named star pointers in the rete. The names are difficult to read in the available photos. In his list, Dorn does not give the Arabic names, but only their French translation together with their identification. A summary of his star list is given in the following table

Table A047-1 Stars on the Rete

	Translation of the Arabic Name	Identification
1	The tail of the whale, northern	ι Ceti
2	The tail of the whale, southern	β Ceti
3	The belly of the fish	β Andromedae

	Translation of the Arabic Name	Identification
4	The breast of the whale	π Ceti[321]
5	The mouth of the whale	γ Ceti[322]
6	Algol	β Persei
7	The boatman of the interval of the river	γ Eridani
8	The eye of the bull	α Tauri
9	Goat ?	α Aurigae
10	The left foot of the giant	β Orionis
11	The left hand of the giant	γ Orionis
12	Sirius of Yemen	α Canis Majoris
13	Sirius of Syria	α Canis Minoris
14	The neck of the serpent	α Hydrae
15	The heart of the lion	α Leonis
16	The back of the Great Bear	α Ursae Majoris
17	The base of the bowl	α Crateris
18	The right wing of the raven	γ Corvi
19	The neglected support	α Virginis
20	The young goat	ζ Ursae Majoris
21	The support of the lancer	α Bootis
22	The radiant one of the crown	α Coronae Borealis
23	The neck of the serpent	α Serpentis

321 Sottas 1930 identifies it as γ Ceti.

322 Sottas 1930 identifies it as α Ceti.

	Translation of the Arabic Name	Identification
24	The heart of the scorpion	α Scorpii
25	The knee of the serpent charmer	ζ Ophiuchi
26	The head of the kneeling one	α Herculis
27	The head of the serpent charmer	α Ophiuchi
28	The right hand of the serpent charmer	ν Ophiuchi
29	The falling [eagle]	α Lyrae
30	The flying [eagle]	α Aquilae
31	The tail of the dolphin	ε Delphini
32	The tail of the chicken	α Cygni
33	The tail of Capricorn	δ Capricorni
34	The mouth of the horse	ε Pegasi
35	The leg of Aquarius	δ Aquarii
36	The shoulder of the horse	β Pegasi
37	The coloured hand	β Cassiopeiae

Plates

There are six plates with the following specifications as provided by Sottas.

Table A047-2 Plates

	φ	Longest day
1a	27°	13;46 hours
1b	32°	14;8 hours

	φ	Longest day
2a	28°	13;48 hours
2b	36°	14;24 hours
3a	21;12°	13;16 hours
3b	35°	14;22 hours
4a	40°	14;54 hours
4b	0°+72°+ 90°	
5a	72°	24 hrs
5b	23;12°	13;24,22 hrs
6a	Plate of ecliptic coordinates	
6b	Plate of horizons	

Of the plates calibrated to different latitudes, Sottas provides detailed descriptions and drawings of only 3 plates for the latitudes 28°, 32° and 40°. On all the plates the labels *al-mashriq* (east) and *al-maghrib* (west) are inscribed below the horizon in the east and west respectively.

On 1b for 32° are drawn altitude circles for every 6° azimuth arcs for every 10° below the horizon and the lines of seasonal hours. Lines of equal hours are drawn from the western horizon as usual below the line of horizon. In addition, lines of equal hours are drawn above the line horizon starting from the eastern horizon, which is very unusual. Both these sets are numbered from 1 to 12.

On 2a for 28° are drawn altitude circles for every 6°, azimuth arcs for every 10° above the horizon, lines of seasonal hours and lines of equal hours from the western horizon.

On 4a for 40° are drawn altitude circles for every 6°, azimuth arcs for every 10° below the horizon, lines of seasonal hours and lines of equal hours from the western horizon.

Therefore, it may be assumed that probably on all plates altitude circles are drawn for every 6°, azimuth arcs for every 10° sometimes below the horizon and sometimes

above the horizon and that all plates carried lines of seasonal hours and lines of equal hours drawn from the western horizon.

It is strange that the latitudes on plates 3a (21;12°) and 5a (23;12°) have precisely the same additional fraction of 12 minutes. Sottas does not make any comment on this peculiarity.

The plate of ecliptic coordinates (Sottas, fig. 5) has latitude circles inscribed for every 6° and longitude circles for every 10°. The names of the zodiac signs are inscribed along the ecliptic. There is the label *mīzān ʿankabū,*

On the plate of horizons (Sottas, fig. 4) half horizons are drawn for latitudes ranging from 6° to 68° in four sets as follows:

6	14	22	…	62
8	16	24	…	64
10	18	26	…	66
12	20	28	…	68

Declination scales are drawn between the equator and the tropics at their four intersections with the horizontal and vertical diameters. They are divided in 2° and labelled in 6s as 6, 12, 18, 24. Below the scales drawn along the horizontal diameter between the equator and the Tropic of Capricorn is inscribed *mayl kullī janūbī* (maximum declination south). Below the scales drawn along the vertical diameter between the equator and the Tropic of Cancer is the label *mayl kullī shamālī* (maximum declination north).

Plate 4b (Sottas, fig. 6) carries combined projections for the three latitudes 0°, 72° and 90°.

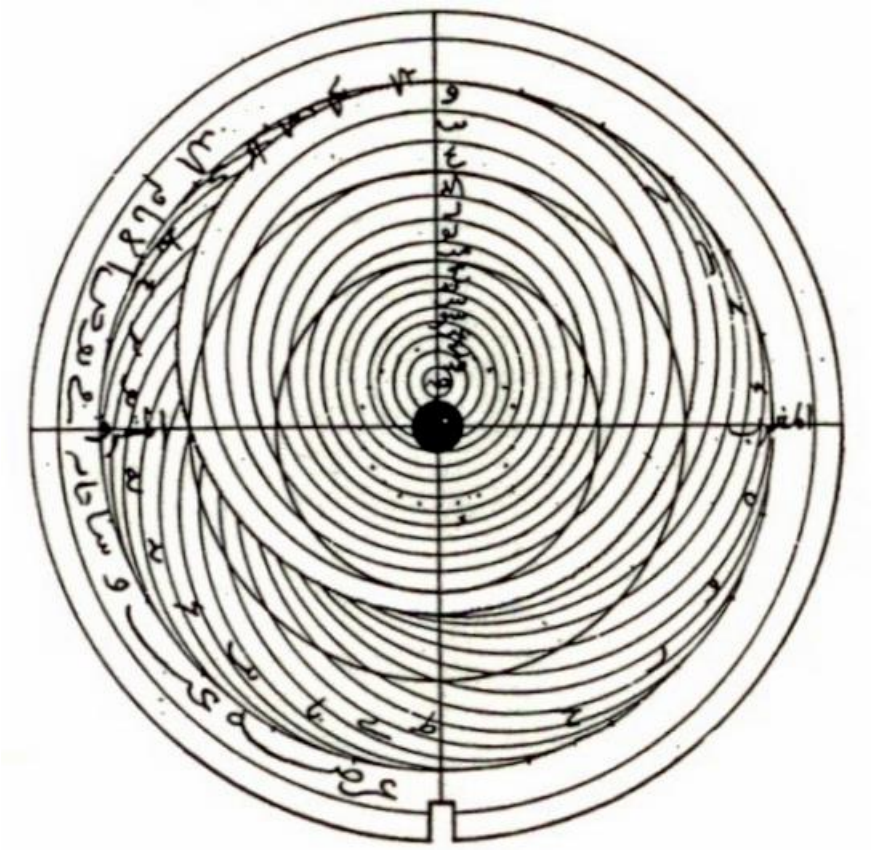


Figure A047.3 – Plate for latitude 72° (drawing from Sottas 1930)

Plate 5a bears stereographic projections for 72° (Sottas, fig. 8). This is perhaps the only astrolabe with a plate carrying stereographic projections for the arctic circle at latitude 72°. On this plate are drawn the vertical and horizontal diameters and the concentric circles of the tropics and equator. The horizon is shown as a full circle placed eccentrically, forming the boundary between the two sets of circles, viz. altitude circles drawn above/inside the horizon and the hour circes drawn below/outside the horizon. The line of the horizon cuts that of the equator at an angle of 18° and the horary circles cut the equator at the same angle.

The altitude circles are drawn for every 6° and numbered along the upper half of the vertical diameter. The hour circles are drawn from the western horizon and are numbered serially from 1 to 72.

On the eastern and western ends of the horizontal diameter are the labels *al-mashriq* (the east) and *al-maghrib* (the west) respectively. Outside the Capricorn circle, in the left half is a long label stating that the latitude is 72° and the longest day is 24 hours.

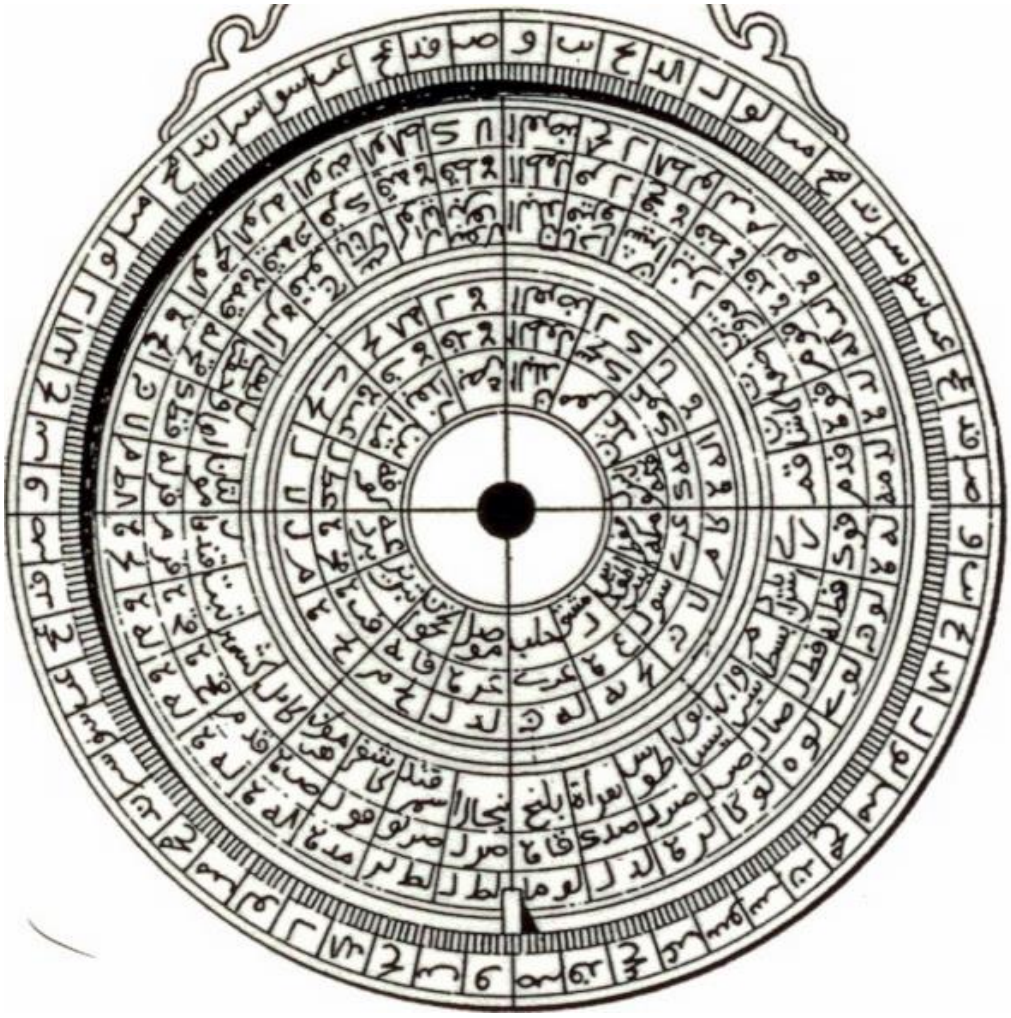


Figure A047.4 – Geographical Gazetteer (drawing from Sottas 1930)

GEOGRAPHICAL GAZETTEER

Gazetteer of 36 localities with their names, longitudes and latitudes engraved in two concentric circles. The letters are written upside down, the tops of the letters towards the centre of the astrolabe. The gazetteer commences in the inner circle, starting at the top centre and proceeds anticlockwise. Sottas (pp. 164-165) reproduces the gazetteer with the names of the localities in contemporary French spelling. The actual spelling in reproduced below. Sottas also drew a diagram of the gazetteer, but occasionally entered there wrong values. I have corrected these, as far as possible, with the help of a photo of the gazetteer.

Table A047-3 Geographical Gazetteer

	Place Name ***Al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
	Inner Circle		
1	Miṣr	63;20	30;20
2	ᶜAdan	76;20	11;0
3	Madīnat Rasūl	75;20	25;0
4	Makka Muᶜaẓẓam	77;10	21;40
5	Bayt al-Maqdis	66;30	31;50
6	Dimashq	70;0	33;15
7	Ḥalab	72;10	35;50
8	Mawṣil	77;0	34;30
9	Nakhajwān	81;15	38;40
10	Tabrīz	82;0	38;0
11	Bardaᶜa	83;0	40;30
12	Kūfa	79;30	31;30
13	Madā'īn	72;0	33;10
14	Baghdād	80.0	33;25
15	Baṣra	84;0	30;0
	Outer Circle		
16	Fīrūzābād	87;30	28;30
17	Shīrāz	88;0	29;36
18	Yazd	89;0	32;40
19	Qazwīn	85;0[323]	36;0

[323] Sottas 1930 mentions 85;00 correctly in the table but transcribes it as 84;00 in the diagram.

	Place Name ***Al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
20	Iṣfahān	86;40	32;25
21	Kāshān	86;0	34;0
22	Qumm	85;40[324]	34;45
23	Rayy	86;20	35;0
24	Astarābād	89;35	36;50
25	Bisṭām	89;30	36;10
26	Sabzawār	91;30	36;5
27	Nīsābūr	92;30	36;21
28	Ṭūs	92;30	37;0
29	Harāt	94;20	34;30
30	Balkh	101;0	36;41
31	Bukhārā	97;30[325]	39;50[326]
32	Samarqand	97;36[327]	39;37
33	Kāshghar	106;30	44;0
34	Hurmūz	92;0	25;0
35	Kābul	104;40	35;30
36	Kashmīr	108;0	35;0
37	Tubbat	110;0	35;0
38	Qandahār	107;40	33;0
39	Mūltān	107;35	29;40

324 Sottas 1930 mentions 85;40 correctly in the table but transcribes it as 84;40 in the diagram.

325 Sottas 1930 transcribes correctly 97;30 in the diagram but has 92;30 in the table.

326 Sottas 1930 transcribes wrongly 39;30 in the diagram but has 39;50 correctly in the table.

327 Sottas 1930 transcribes correctly 97;36 in the diagram but has 97;16 in the table.

	Place Name ***Al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
40	Lahāwar	109;20	31;50
41	Hadhrat Dihlī	113;35	28;0
42	Akra	115;0	26;43
43	Qannawj	115;50	26;35
44	Bānārasī	117;20	26;55
45	Kawāliyār[328]	115;0	26;29
46	Burhānpūr	109;0	20;31

328 Sottas 1930 explains that it is Kawahia (Cambaye); it is actually Gwalior.

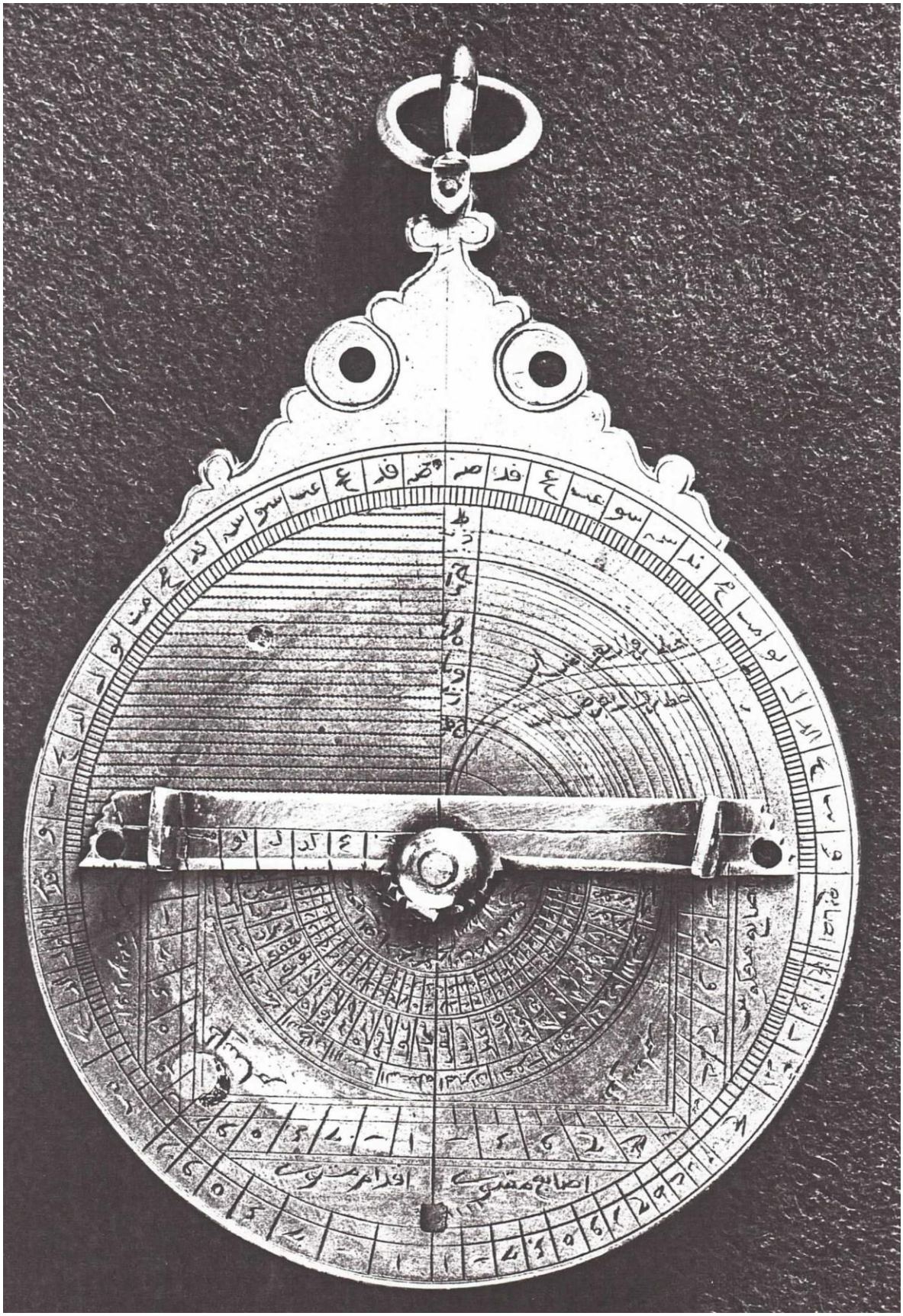


Figure A043.5. Back of the astrolabe (photo courtesy Professor David King)

BACK

The rim of the upper half carries altitude scales, divided in 1° and 6° numbered in groups of 6° as 6—90; 90— 6. In the upper left is the trigonometric quadrant with 30 horizontal parallels as dotted lines.

Declination circles divide the upper right quadrant into 6 zones, each zone representing a pair of zodiac signs. The signs are marked by their serial numbers along both the radii. Dotted circles subdivide each zone into 5 subzones corresponding to 6° of solar longitude. Against this background are traced two sigmoid graphs of the median altitude of the sun at latitudes 27[329] and 32. Because of the limited space, the usual expression *niṣf al-nahār* (half of the day) is replaced by the shorter synonym *zawāl* (midday) in the labels. They read here *khaṭṭ zawāl bi-ᶜarḍ 27* and *khaṭṭ zawāl bi-ᶜarḍ 32* respectively.

Shadow squares are engraved in the lower half, on the left for the base of 7 and on the right for the base of 6 and 12. The scales on the left are divided in 7 parts and numbered from 1 to 7. The scales on the right are divided into 6 parts and numbered from 1 to 7. Each part is then halved so that there are 12 units in the scales. In both the corners on the left and right are engraved the words *ẓill sullam* which are to be read along with the labels on the outside of the scales.

Vertical scale on the left: [*ẓill sullam*] *aqadām maᶜkūs* (scale of reverse shadows in feet)

Horizontal scale on the left: [*ẓill sullam*] *aqadām mustawī* (scale of direct shadows in feet)

Horizontal scale on the right:..[*ẓill sullam*] *aṣābiᶜ mustawī* (scale of direct shadows in digits)

Vertical scale on the right:..[*ẓill sullam*] *aṣābiᶜ maᶜkūs* (scale of reverse shadows in digits)

Within the shadow squares are four semi-circular rows. The outermost row contains the names of the 12 zodiac signs followed by the names of the corresponding 28 lunar mansions in the next row. The next two rows are filled with the table of the decans and their regents.

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329 Sottas 1930 misread the number as 26 and reproduced the label accordingly in his drawing; see fig. 1 on p. 156 and the translation of the label on p. 157.

The rim on the lower half carries the cotangent scales. The divisions in the scale on the left are numbered as 1, 2, 3, 4, 5, 6, 7, 12, 18, 24, 30, 36, … 60, *aqdām.* The divisions on the scale on the right are numbered as 1, 2, 3, … 12, 18, 24, 30, 36, … 60, *aṣābiʿ*.

ALIDADE

The alidade has ornate ends and an ornate centre-piece. It is graduated only in the right half, with divisions that match the parallels in the trigonometric quadrant, and numbered in 6s from 6 to 60 starting from the centre.

INSCRIPTION[330]

> '[Made by] the weakest of the servants [of God], Muḥammad Muqīm, son of Mullā ʿĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn.'

PROVENANCE

Between 1926 and 1930, the astrolabe was in the private collection of Dr Jules Sottas of Paris who sent a communication to the *Académie de Marine* in October 1926 which was published in 1930. In 1984 it was in private collection in Brussels and was exhibited there. Sometime between 1984 and 1996, the owner sold it back to a dealer in Paris.

BIBLIOGRAPHY

Anon 1984.

Sottas 1930.

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330 Sottas 1930 did not reproduce the text of inscription but gave an inaccurate translation in French. The inscription cannot be read in the available photo.

A048 ASTROLABE BY MUḤAMMAD MUQĪM, NOT DATED

Diameter 80 mm

Hyderabad, Saidiya Library[331]



Figure A048.1 – Front of the astrolabe (photo by Ahmad Athaullah)

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[331] I am highly grateful to Ahmad Athaullah Saheb who took great pains to send me detailed photos of the instruments in this family library.

With a diameter of 80 mm, this is perhaps the third smallest astrolabe made by Muqīm. It is slightly worn out, but well preserved. The engravings are filled with a white material which turned into patina.

Components

Body with *kursī* (d. 80, h. 112, t. 5) with shackle and ring, rete (d. 70) for 29 stars, 5 plates, alidade, pin. The original wedge is replaced by an S-shaped wire.

Front

The ring is well-crafted with a diamond cross-section and the shackle is trifoliate. Like the *kursī* in the previous astrolabe, the *kursī* here is rather plain with two eyelets prominently outlined. It terminates in a trifoliate finial. The limb is divided in 1° and in 6° and numbered in 6s as 6—360.



Figure A048.2 – Rete of the astrolabe (photo by Ahmad Athaullah)

Rete

The Capricorn ring and the much wider ecliptic ring are joined by the equinoctial bar which counterchanged at the centre. A segment of the solstitial bar runs down from the ecliptic circle and branches off to the left and right into vines that bear the star

pointers. The tracery of vines is asymmetric and is not continuous; it breaks off into several independent clusters. There are 29 named star pointers. The ecliptic ring is divided into the 12 signs of zodiac and labelled with their names. Each sign is subdivided into 5 units of 6° and numbered accordingly.

Table A048-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab Qayṭus J[anūbī]*	β Ceti
2	*Fam Qayṭus*	γ Ceti
3	*Ṣadr Qayṭus*	π Ceti
4	*Rās Ghūl*	β Persei
5	*Tālī Masāfat al-Nahr*	γ Eridani
6	*ᶜAyn Thawr*	α Tauri
7	*Rijl Jawjā' [Yusrā]*	β Orionis
8	*Yad Jawjā' [Yumnā?]*	α Orionis
9	*Rijl Jawjā' Yumnā*	κ Orionis
10	*Shiᶜrā Yamānī*	α Canis Majoris
11	*Shiᶜrā Shāmī*	α Canis Minoris
12	*Fard al-Shujāᶜ*	α Hydrae
13	*Qalb al-Asad* (?)	α Leonis
14	*Qāᶜidat Bāṭiya*	α Crateris
15	*ᶜAnāq*	ζ Ursae Minoris
16	*Janāḥ Ghurāb*	γ Corvi
17	*Simāk Aᶜzal*	α Virginis
18	*Simāk Rāmiḥ*	α Bootis
19	*ᶜUnuq Ḥayyah*	α Serpentis
20	*[Nayyir] Fakkah*	α Coronae Borealis

	Star Name	Identification
21	*Rās al-Ḥawwā*	α Ophiuchi
22	*[Nasr al Waqiᶜ]*	α Lyrrae
23	*Minqār Dajājah*	β Cygni
24	*Dhanab al-Dulfīn*	ε Delphini
25	*[Dhanab Dajājah]*	α Cygni
26	*Dhanab al-Jadī*	δ Capricorni
27	*Mankib Sākib al-Mā'*	α Aquarii
28	*Fam Faras*	ε Pegasi
29	*Sāq Sākib al-Mā'*	δ Aquarii

PLATES

There are five plates serving the following latitudes:

Table A048-2 Plates

	φ	Longest Day
1a	22°	13;22 hours
1b	25°	13;25 hours
2a	27°	13;43 hours
2b	32°	14;8 hours
3a	36°	14;32 hours
3b	40°	14;54 hours
4a	18°+72° double projection	
4b	0°+90° double projection	
5a	Plate of ecliptic coordinates	
5b	Plate of horizons	

φ	Longest Day

On plates 1-3, altitude circles are drawn for every 6° and labelled. Azimuths curves are traced for every 10° below horizons; on 3a above and below the horizon. Lines for seasonal hours are drawn on all the three plates. Lines for equal hours counted from the western horizon are drawn on 1a-b and 2a. Lines for equal hours since sunset and before sunrise are traced on 2b and 3a-b.

Plate 4 carries double projections of 18°+72° on the obverse and of 0°+90° on the reverse.

The plate of ecliptic coordinates has circles of latitude for each 6° and circles of longitudes for each 10°. Both sets are numbered. The names of the signs are written along the circle of the ecliptic. There is no label on the plate.

There is no label on the plate of horizons either. Four sets of 7 half horizons of the latitudes from 12° to 66° are arranged in the four quadrants. The horizons are numbered at both the extremities.

12	20	28	36	44	52	60
14	22	30	38	46	54	62
16	24	32	40	48	56	64
18	26	34	42	50	58	66

Declination scales are drawn along the two diameters and numbered as 6, 12, 18, 23;30.

GEOGRAPHICAL GAZETTEER

On the inner side of the mater is engraved a geographical gazetteer in two concentric circular bands providing the names, longitudes and latitudes of 54 localities.[332] The two circles are separated by an empty circle which is bounded by double lines on both sides. In the outer circle, the letters are written upside-down, but in

[332] This astrolabe, smaller by 10 mm than the preceding two astrolabes, has a gazetteer of 54 places while A047 has a gazetteer of 46 places and A048 of 42 places.

the inner circle they are straight. The astrolabe being very small, it is at times difficult to read the latitudes of places engraved in tiny letters in the innermost circle.



Figure A048.3 – Geographical gazetteer (photo by Ahmad Athaullah)

Table A048-3 Geographical Gazetteer

	Place Name ***Al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
	Outer Circle		
1	Miṣr	63;20	30;20
2	ᶜAdan	76;0	11;0
3	Madīnat Rasūl	75;20	25;0

	Place Name ***Al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
4	Makkā Muᶜaẓẓam	77;10	21;40
5	Ṭā'īf	77;30	21;20
6	Bayt al-Maqdis	66;30	31;50
7	Dimashq	70;0	33;15
8	Ḥalab	72;10	35;50
9	Nakhajwān	81;15	38;40
10	Tabrīz	82;0	38;0
11	Kūfa	79;30	31;30
12	Baghdād	80.0	33;25
13	Baṣra	84;0	30;0
14	Shīrāz	88;0	29;36
15	Yazd	89;0	32;40
16	Hamadān	83;0	35;10
17	Qazwīn	85;0	36;0
18	Iṣfahān	86;40	32;25
19	Kāshān	86;0	34;0
20	Qumm	85;40	34;45
21	Rayy	86;20	35;0
22	Astarābād	89;35	36;50
23	Bisṭām	89;30	36;10
24	Sabzawār	91;30	36;5
25	Nīsābūr	92;30	36;21
26	Ṭūs	92;30	37;0
27	Harāt	94;20	34;30

	Place Name ***Al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
28	Marw	97;0	37;40
29	Balkh	101;0	36;41
30	Badakhshān	104;24	37;10
31	Bukhārā	97;30	39;50
	Inner Circle		
32	Samarqand	99;36	39;37
33	Khujand	100;35	41;15
34	Kāshghar	106;30	44;0
35	Khutan	107;0	42;0
36	Hurmūz	92;0	25;0
37	Kābul	104;40	35;0
38	Kashmīr	108;0	35;0
39	Tubbat	110;0	40;0
40	Qandahār	107;40	33;0
41	Mūltān	107;35	29;40
42	Lahāwar	109;20	31;50
43	Haḍrat Dihlī	113;35	28;0
44	Akra	115;0	27;13
45	Qannawz	115;50	26;35
46	Kawāliyār	115;0	26;29
47	Bānārasī	117;20	26;55
48	Ujjayn	32;0 !	22;30
49	Burhānpūr	113;0	20;30
50	Aḥmadābād	108;40	23 (?);15

	Place Name ***Al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
51	Bījāpūr	108;30	17;20
52	Kolkanda	114;50	23;18
53	Sarāndīb	130;0	10;0
54	Kanbāyat	109;20	22;20

BACK

The rim of the two upper quadrants at the back carries the altitude scales divided in 1° and 6° and labelled as 6—90; 90—6. The rim of the lower half carries the cotangent scale, on the left for the base of 12 digits (labelled as *aṣābiᶜ*) and on the right for the base of 7 feet (labelled as *aqdām*).

The upper left is occupied by a trigonometric quadrant with 30 equidistant horizontal parallels. On the upper right, a solar quadrant with a circle of declination each for a pair of zodiac signs. The signs are labelled with their serial numbers along the two radii. Upon this grid are drawn two curves for the meridian altitude of the sun in all seasons for latitudes 27° and 32°, with the usual labels.



Figure A048.4 – Back of the astrolabe (photo by Ahmad Athaullah)

In the two lower quadrants, there are two shadow squares, on the left for the base of 12 digits and on the right for the base of 7 feet. The scales are divided, numbered and labelled in the usual manner.

The shadow squares are circumscribed by two concentric semi-circular scales; the outer one is inscribed with the names of the 12 zodiac signs and the inner one with those of the 28 lunar mansions.

ALIDADE

The straight bar alidade is plain without any graduations. The two ornate ends are tapered to a sharp point; the centre-piece is a plain circle. The sighting plates have two sighting holes each.

INSCRIPTION

Inside the shadow squares is the maker's signature in three lines:

aḍaᶜaf al-ᶜibād muḥammad muqīm ibn
mullā ᶜīsā ibn shaykh allāhdād
asṭurlābī humāyūnī lāhūrī.

'[Made by] the least of the servants [of God], Muḥammad Muqīm, son of Mullā ᶜĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe-maker of [the Emperor] Humāyūn.'

A049 ASTROLABE BY MUḤAMMAD MUQĪM, NOT DATED[333]

Diameter 90 mm

Qatar, Doha, Museum of Islamic Art (# MW.391.2007); Ex-Skinner, Bolton, USA

Répertoire 33



Figure A049.1 – Front of the astrolabe (photo courtesy Professor David Pingree)

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[333] This description is based on Linton 1980, no. 166, and the notes kindly provided by Professor David Pingree who described the astrolabe for the auction house Skinner; see also the Skinner 2002, p. 39.

A handy astrolabe with simple but elegantly designed *kursī* and rete. The lines of separation on the scales and many projected lines on the plates and on the back are dotted.

COMPONENTS

Body with *kursī* (d. 90), shackle and ring, rete, 5 plates, alidade, pin and horse.

FRONT

The ring is well-crafted; shackle with trifoliate shape and plain round bases. The *kursī* has lobed profiles and a trifoliate finial. It is pierced simply but elegantly, with 6 large perforations; two of these are shaped like bells or stylised tulips placed symmetrically on either side of the vertical line, three of the perforations are tear-shaped and the sixth one is triangular. Variations of this design can be seen in the retes of other astrolabes by Muqīm (A020, A021, A053).

The limb is divided in 1° and 6° and numbered in 6s from 6 to 90 in each quadrant separately.

RETE

The two broad rings of the Tropic of Capricorn and ecliptic are held together by a slender equinoctial bar which has counterchanges at the equinoxes. The inner edge of the Capricorn ring forms the circle of the Tropic of Capricorn. Therefore, a high triangular arch is attached to the ecliptic ring at the beginning of Capricorn, so that it functions as bridge up to the degree scale on the limb. The spaces between the rings is filled with a floriated tracery joining the star pointers. Inside the ecliptic ring, the tracery contains a heart-shaped motif in the middle. The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names; each sign is further subdivided into five units and numbered as 6, 12, 18, 24, 30, separately for each sign. Further subdivisions, if there are any, cannot be seen in the available photos. There is a handle near star pointer of *Fam al-Qayṭus.*

David Pingree has counted some 29 star pointers. The starkly abridged names engraved on them in tiny script are difficult to decipher. The following are what he could read; here the names are rearranged according to the increasing right ascensions.

Table A049-1 Stars on the Rete

	Star Name	Identification
01	*Dhanab al-Qayṭus*	β Cetii
02	*Ṣadr Qayṭus*	π Ceti
03	*Ghūr* ! (*Rās al-Ghūl*)	β Persei
04	*Dabarān*	α Tauri
05	*Yad Jawjā' Yumnā*	α Orionis
06	*Shirᶜrā Yamānī*	α Canis Majoris
07	*Fard al-Shujāᶜ*	α Hydrae
08	*Qāᶜidat* [*al-Bāṭiya*]	α Crateris
09	*ᶜAnāq*	ξ Ursae Majoris
10	*Janaḥ al-Ghurāb*	γ Corvi
11	*Simāk ᶜAzal*	α Virginis
12	[*Simāk*] *Rāmiḥ* (?)	α Bootis
13	[*Nayyir al-*] *Fakkah*	α Coronae Borealis
14	*ᶜUnuq Ḥayyah*	α Serpentis
15	[*Rās al-*] *Jāthī*	α Herculis
16	[*Nasr*] *Wāqiᶜ* (?)	α Lyrrae
17	[*Nasr*] *Ṭā'ir*	α Aquilae
18	[*Minqār*] *al-Dajājah* (?)	β Cygni
19	*Al-Ridf*	α Cygni
20	*Dhanab al-Jady*	δ Capricorni
21	*Sāq Sāqib al-Mā' J[anūbī]*	δ Aquarii
22	*Mankib Faras*	β Pegasi
23	[*Kaff al-*] *Khaḍīb*	β Cassiopeiae

Plates

There are five plates, but there is some uncertainty about the latitudes for which they are engraved: 22° and 25°; 32° and 35°; 36° and 40°; 0° + 72° + 90° and 18° + 30° (?); plate of ecliptic coordinates and plate of horizons. It is surprising that there is no single plate for the latitudes of 27° and 32° on which the Agra and Lahore, the two Mughal imperial cities are situated and for which two solar meridian altitude graphs are plotted on the back. Azimuths are sometimes engraved below the horizon. There are lines for seasonal hours and for equal hours drawn from the western horizon.

The plate of horizons carries four sets of half-horizons for the following latitudes:

4	14	24	34	44	54	64
6	16	26	36	46	56	66
8	18	28	38	48	58	
10	20	30	40	50	60	

Geographical Gazetteer

The geographical gazetteer is engraved in two concentric circles, providing the latitudes, names, longitudes of 42 places. The gazetteer commences in the inner circle. The places are arranged according to increasing longitudes.

Table A049-2 Geographical Gazetteer

	Place Name	L	φ
	Inner Circle		
01	Miṣr	63;70	30;20
02	Madīna	75;20	25;41
03	Makka	77;10	21;40
04	Bayt al-Maqdis	66;30	31;50
05	Dimashq	70;0	33;15
06	Tabrīz	87;0	38;0
07	Shīrāz	88;0	29;40
08	Qazwīn	85;0	36;0

	Place Name	L	φ
09	Iṣfahān	86;0	34;20
10	?	92;30	36;0
11	Harāt	?	37;30
12	Balkh	91;0	36;0
13	Bukhārā	94;35	39;50
14	Samarqand	99;16	39;37
15	Kāshghar	106;30	44;0
	Outer Circle		
16	Khutan	107;0	42;0
17	Hurmūz	92;0	26;0
18	Kābul	104;40	34;0
19	Kashmīr	108;0	35;0
20	Tubbat	105;0	40;0
21	Qandahār	102;40	33;0
22	Multān	107;35	29;40
23	Sālkūt	109;0	33;0
24	Lāhūr	109;20	31;50
25	Tānīsar	114;33	30;10
26	Bānībaht	113;20	28;52
27	Dihlī	113;35	28;39
28	Akbarābād	115;0	26;43
29	Kawālayār	111;0	26;29
30	Banāras	115;50	26;39
31	Qannawj	104;20	26;35

	Place Name	L	φ
32	Jawnbūr	119;6	26;36
33	Ajmīr	111;5	26;0
34	Ujjayn	100.50	23;30
35	Sarūj	72;40	34;50
36	Aḥmadābād	108;40	23;15
37	Burhānbūr	103;0	20;30
38	Dawlatābād	111;0	20;30
39	Bījābūr	105;30	17;20
40	Kūlkunda	114;19	18;20
41	Sarandīb	104;0	10;0
42	Kanbāyat	109;10	27;20

BACK

On the back dotted lines predominate: the vertical and horizontal diameters, alternate lines in the trigonometric quadrant, as also the boundaries between the cells in all the scales are marked by dotted lines. Likewise, the quarter circles in the upper right quadrant and the curves of the solar meridian altitudes are dotted.

The rim of the upper half contains the altitude scales divided in 1° and 6° and labelled in 6's as 6—90; 90—6.

In the upper left is the trigonometric quadrant with 20 horizontal and 20 vertical parallels.

The upper right quadrant is divided by 5 quarter circles into six segments, one for each pair of zodiac signs which are marked with their serial numbers along the two radii. Here are drawn two graphs of the solar meridian altitude for the latitudes of 27° and 32° with the labels *khaṭṭ zawāl bi-ᶜard 27* and *khaṭṭ zawāl bi-ᶜard 32* respectively.



Figure A049.2 – Back of the astrolabe (photo courtesy Professor David Pingree)

In the lower half are the shadow squares, on the left for the base of 12 and on the right for the base of 7. The scales are divided and numbered accordingly. The scales are accompanied by the following labels:

Vertical scale on the left: *ẓill sullam asabiᶜ maᶜkūs*

Horizontal scale on the left: *ẓill sullam asabiᶜ mustawī*

Horizontal scale on the right: *ẓill sullam aqadām mustawī*

Vertical scale on the right: *ẓill sullam aqadām maᶜkūs*

Within the shadow squares are two semi-circular rows containing the names of the 12 zodiac signs and those of the corresponding 28 lunar mansions respectively.

The rim on the lower half bears the scales of cotangents, marked on the left 6, 12, 18, 24, 30, 36, 47, 58, 60 *al-aṣābiᶜ* and on the right 6, 7, 12, 18, 22, 30, 41 (?), 55 (?) *al-aqdām.*

ALIDADE

Straight bar alidade with ornate tips and an ornate centre-piece, but without any graduations. Two holes in the sights. There is a pin and a wedge with a horse's head.

INSCRIPTION

In the space between the horizontal diameter and the semi-circular scales is engraved the astrolabe maker's signature, upside down:

> *ṣanᶜat muḥammad muqīm ibn ᶜīsā ibn allāhdād asṭurlābī humāyūnī lāhūrī*
>
> 'Made by Muḥammad Muqīm, son of ᶜĪsā, son of Allāhdād of Lahore, astrolabe maker to [the Emperor] Humāyūn.'

PROVENANCE

It appears to have come up for auction at Paris in 1978; subsequently in the private collection of Leonard Linton, Point Lookout, USA. Came up for auction at Nouveau Drouot, Paris, on 9 and 10 October 1980; again at Skinner, Bolton, USA in 2002.

BIBLIOGRAPHY

Alain Brieux, *Histoire des Sciences: Livres, Instruments, Machines,* catalogue, Paris, Novembre 1978, no. 10517.

Linton 1980, no. 166, pp. 96-97.

Skinner 2002, p. 39.

A050 SMALLEST ASTROLABE BY MUḤAMMAD MUQĪM, NOT DATED

Diameter 45 mm

PLU, ex-Sotheby's, New York

Répertoire 36



Figure A050.1 – Front and back of the astrolabe (photo from Christie's catalogue of 24.9.92)

With a diameter of 45 mm, it is the smallest astrolabe made by Muqīm; in fact, it is the smallest known astrolabe in the world. Even so all the features of the Mughal astrolabes are meticulously incorporated in this astrolabe. Christie's catalogue remarks: 'This is one of the smallest recorded astrolabes, and a remarkable testimony to the skill of Muhammad Muqim of Lahore, being typical of his work, the engraving having been achieved with great accuracy.'

COMPONENTS

Body with *kursī* (d. 45), shackle and ring, rete for 17 stars, 5 plates, alidade, pin and horse. The rete, alidade, pin and horse are not original.

FRONT

The ring is large and corrugated; the shackle is trifoliate. The *kursī* is worked *à jour,* incorporating the calligraphy *Allāh-u Akbar* inside the lobed frame, which terminates in a trifoliate finial. The limb, quite wide for its size, is divided in 2° and 6° and labelled in 6s from 6 to 90, separately for each quadrant, in clockwise direction. Dotted lines mark the boundaries of 6°.

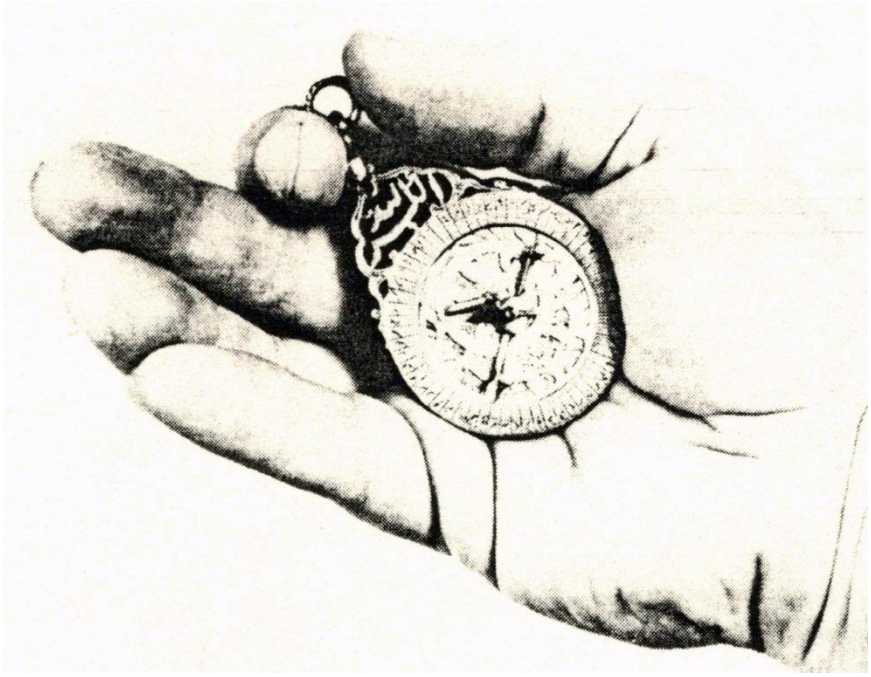


Figure A050.2 – The smallest astrolabe fits in the palm (photo from Saul Moskowitz catalogue 1990)

RETE

The rete is not original, but a late replacement. In the Sotheby's catalogue of 10 December 1981, where this astrolabe appears for the first time, the entry states 'lacking rete'; it does not appear in the illustration. In the catalogue of Saul Moskowitz of Spring 1990, where the astrolabe appears next, the rete is illustrated along with the alidade, pin and wedge, with the caption 'modern replacements'. Therefore, the rete must have been fabricated, not in India or Pakistan, but in the UK or US, between 1981 and 1990. Indeed, on the back of the rete is inscribed 'C.E. 1986'. Moskowitz catalogue states that it was 'made from a blank disc found with the instrument and engraved after an original rete from one of Muhammad Muqīm's larger astrolabes, suitably simplified for its reduced size (but still retaining its 18 stars).'

But the new rete does not resemble any rete in the known astrolabes made by Muqīm. With the arcs attached to the lower half of the Capricorn ring— the arcs from which the star pointers arise—, this new rete resembles the rete in the astrolabe of ʿĪsā

dated 1604 (A006). The present rete has 17 or 18 star pointers, but it is difficult to decipher the names in the photos.

PLATES

There are five plates serving the latitudes 27°, 32°; 36°, 0° + 90°; 40°, 18°+30°; plate of ecliptic coordinates and plate of horizons. A fifth plate with projections for latitudes 20°and 27° is less carefully engraved and is a late replacement.

From the small photos published in Christie's catalogue, it can be seen that in all latitude plates the altitude circles are for every 6° and labelled on both sides; azimuth arcs are drawn below the horizon for every 10° and labelled; there are lines for seasonal hours and sometimes also the lines for equal hours since sunset and before sunrise. At the centre are recorded the latitude (*ʿarḍ*) for which the plate is calibrated and the duration of the longest day in hours (*sāʿāt*). In other words, in this limited space are recorded all the features that are to be met with in larger astrolabes.

On the plate of ecliptic coordinates is inscribed the label *ṣafīḥat mīzān al-ʿankabūt,* while no such label is engraved on the plate of horizons on the reverse.

GEOGRAPHICAL GAZETTEER

A geographical gazetteer of 34 places with their longitudes and latitudes is engraved inside the mater in two circles.

BACK

The rim of the upper two quadrants bears the altitude scales, divided in 1°, 2°, 6° and labelled in 6° as 6—90; 90—6.

In the upper left is a trigonometric quadrant with 30 horizontal parallels, each third highlighted with dots. The upper right quadrant bears 5 declination arcs which divide the quadrant into 6 zones, each for a pair of zodiac signs which are marked by serial numbers along the two radii. Upon these are superimposed two graphs of solar meridian altitude for the latitudes of 27° and 32°. These are accompanied by the shorter labels *khaṭṭ zawāl bi-ʿarḍ 27* and *khaṭṭ zawāl bi-ʿarḍ 32* respectively.

Shadow squares are engraved in the lower half, on the left for the base 6/12 and on the right for the base 7. On the left the vertical and horizontal scales are divided in 6 parts, numbered from 1 to 6; then each division is halved to produce 12 divisions. On the right the two scales are divided into 7 parts and numbered from 1 to 7. The labels

are shortened here also. The vertical scale on the left is accompanied by the label *aṣābiʿ maʿkūs* (reverse [shadows in] feet) and the horizontal scale *aṣābiʿ mustawī* (direct [shadows in] digits). Similarly, the horizontal scale on the right is labelled as *aqdām mustawī* (direct [shadows in] feet) and the vertical scale as *aqdām maʿkūs* (reverse [shadows in] feet).

Circumscribing these squares are two semi-circular rows, the outer one inscribed with the names of the 12 zodiac signs and the inner one with the names of the 28 lunar mansions.

The rim of the lower half carries the cotangent scales. The scale on the left is marked with 6, 12, 18, 24, 30, 36, … 60, *aṣābiʿ;* that on the right with 6, 7, 8, 12, 18, 24, 30, 30, 36, …, 60, *aqdām.* Each of these divisions are subdivided into 5 parts in the adjoining semi-circular row.

Alidade

The alidade is rather plain, with a circular centre piece and the ends shaped like quarter circles. The alidade is not graduated. The pin has a rather large circular head. The wedge is shaped like a horse's head.

Inscription (acc. Répertoire)

Inside the shadow squares is the inscription in three lines

aḍʿaf al-ʿibād muḥammad
muqīm ibn mullā ʿīsā ibn
shaykh Allāhdād

'[Made by] the weakest of the servants [of God], Muḥammad Muqīm, son of Mullā ʿĪsā, son of Shaykh Allāhdād.'

Provenance

Although it is one of the most precious creations of the Lahore family, it changed hands rather frequently. It came up for auction, for the first time, at Sotheby's in December 1981 without the rete. Then in spring 1990, it made its appearance equipped with a rete, in the catalogue of Saul Moskowitz. Two years later it came up for auction at Christies in September 1992. It came up again for auction at Sotheby's, New York, in September 2001. Its present location is unknown.

BIBLIOGRAPHY

Sotheby's catalogue, 10 December 1981, lot 23, p. 11.

Saul Moskowitz catalogue 133, Spring 1990, lot 155, p. 37.[334]

Christie's catalogue of 24 September 1992, lot 116, pp. 44-45.

Sotheby's, New York, auction catalogue 21 September 2001, lot 147.

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334 The astrolabe appears to have been included also in an earlier catalogue of Saul Moskowitz with practically the same text, but I do not have the number of the catalogue.

A051⊙ ZOOMORPHIC ASTROLABE ATTRIBUTABLE TO MUḤAMMAD MUQĪM, NOT DATED[335]

Diameter 344 mm

Jaipur, Jai Singh's Observatory

CCA74



Figure A051.1 – Front of the astrolabe (photo by S. R. Sarma)

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[335] I had the privilege of accompanying Professor David King when he examined this astrolabe in 1991. This description is partly based on his notes. I copied the gazetteer on a subsequent visit.

This fabulous Mughal astrolabe with a zoomorphic rete and several other equally splendid Lahore astrolabes were collected by the astronomer-prince Sawai Jai Singh in the first quarter of the eighteenth century and were in his personal collection at Jaipur. This and the two other astrolabes made by Ḍiyā' al-Dīn Muḥmmad (A072 and A091) formed the basis for G. R. Kaye's pioneering discussion of the construction and use of the astrolabe in his book *The Astronomical Observatories of Jai Singh.*[336]

R. T. Gunther, the celebrated author of the *Astrolabes of the World*, was so impressed by this astrolabe that he wrote: 'The ankabut presents what is perhaps the finest example of tracery known to us, comprising foliations and star-animals most artfully disposed along the course of stems and tendrils that branch but never cross.'[337] He even embellished the cover of his book with an outline of the *kursī* and the rete printed in gold. Likewise Owen Gingerich is effusive in his appreciation of this astrolabe: 'A much later Indian astrolabe from around 1650, the so-called Jaipur A instrument, shows many playful elements, almost resembling a child's puzzle in the subtle and intricate way in which the animals have been incorporated into the tracery. Not only Vega and Alatair shown as birds, but Deneb (of Cygnus as well). Procyon and Sirius appear as dog's heads, possibly uniquely in the Islamic world. There is also a bull, a horse, and a river, and probably a whale and a bear among several other figures awaiting decipherment!'[338]

The astrolabe is not signed, but the 29 zoomorphic star pointers in the rete correspond exactly to those in the astrolabe made by Muḥammad Muqīm in 1637 which is now with the Salar Jung Museum of Hyderabad (A026). Therefore, this astrolabe can safely be attributed to Muqīm.

It is much larger than the signed astrolabe at Hyderabad and is filled with very fine engravings. In the upper right quadrant on the back, quarter circles are drawn for each 2° of the solar longitude. These circles fill the entire surface, leaving just 1 mm wide space in between. Likewise, on all the latitude plates, altitude circles are drawn for each

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336 Kaye 1918, pp. 16-36.

337 Gunther 1932, p. 204.

338 Gingerich 1987a, pp. 96, 102.

1°. On plates 1b and 5b lines are drawn for 1/6 part of a *ghaṭī* (= 4 minutes). Here also the space between lines is not wider than 1 mm.

COMPONENTS

Body with *kursī* (d. 344, h. 427, t. 19), shackle and ring, rete for 42 stars, 7 plates, alidade, elegant pin, washer and horse.

FRONT

Massive shackle and ring, both with diamond cross section. The shackle is trifoliate and its bases are circular. The *kursī* has a trifoliate finial and finely cut fretwork with a cartouche in the middle.

The degree scale on the rim is divided in 3°, 1° and 0;15° in three concentric bands. In the outer band, groups of 3° are numbered clockwise from 3° to 360°. On the edge there is a long inscription, possibly a Persian poem, the letters are in relief against a hatched background, like the names of the zodiac signs on the ecliptic ring.



Figure A051.2 – Rete of the astrolabe (photo by S. R. Sarma)

RETE

The two rings of the Tropic of Capricorn and the ecliptic are held together by the equinoctial bar which is counter-changed at the two points where it intersects the ecliptic. The upper edge of the middle segment of the bar represents the equinoctial colure. The ecliptic circle is divided into the 12 signs and labelled with their names which stand out in relief against a chased background. Each sign is divided into units of 3° and numbered as 3, 6, 9, …. 24, 27, 30. The sloped edge of the ecliptic circle is divided in 1°.

There are 42 named star pointers. Of these 29 are given zoomorphic or anthropomorphic forms as in the Hyderabad astrolabe with the same iconography. The star pointers are joined by a very delicate tracery of tendrils with stylized leaves and small flowers with four or five petals as in the openwork design of the *kursī*.

Table A051-1 Stars on the Rete

	Star Name	Identification	Symbolic Representation
1	*Dhanab al-Qayṭus J[anūbī]*	β Ceti	fin of the fish tail
2	*Baṭn al-Ḥūt*	β Andromedae	
3	*Fam al-Qayṭus*	γ Ceti	snarling dog's head
4	*Ṣadr al-Qayṭus*	π Ceti	
5	*Kaff al-Jadhmā'*	α Ceti	
6	*Rās al-Ghūl*	β Persei	demon's head with horns
7	*Tālī Masāfat al-Nahr*	γ Eridani	river with waves
8	*ᶜAyn al-Thawr*	α Tauri	bull's head with horns
9	*ᶜAyyūq*	α Aurigae	
10	*Rijl al-Jawjā' al-Yusrā*	β Orionis	shoe
11	*Yad al-Jawjā' al-Yusrā*	γ Orionis	hand
12	*Yad al-Jawjā' al-Yumnā*	α Orionis	hand
13	*Rijl al-Jawjā' al-Yumnā*	κ Orionis	shoe
14	*Shiᶜrā*	α Canis Majoris	dog's head
15	*Shiᶜrā*	α Canis Minoris	dog's head
16	*Mankhar al-Shujāᶜ*	σ Hydrae	snake's head
17	*Fard al-Shujāᶜ*	α Hydrae	
18	*Qalb al-Asad*	α Leonis	
19	*Rās al-Asad*	μ Leo	lion's head
20	*Ẓahr al-Dubb al-Akbar*	α Ursae Majoris	bear's back

	Star Name	Identification	Symbolic Representation
21	*Qāᶜidat al-Bāṭiya*	α Crateris	bucket
22	*Ẓahr al-Asad*	δ Leonis	
23	*Janāḥ al-Ghurāb*	γ Corvi	wing
24	*Simāk Aᶜzal*	α Virginis	Virgo's hand
25	*Al-ᶜAnāq*	ζ Ursae Majoris	
26	*Simāk-i Rāmiḥ*	α Bootis	
27	*Nayyir al-Fakkah*	α Coronae Borealis	crown, more like a cup
28	*ᶜUnuq al-Ḥayyah*	α Serpentis	snake's head
29	*Rās al-Jāthī*	α Herculis	human face
30	*Rās al-Ḥawwā*	α Ophiuchi	human face
31	*Nasr Wāqiᶜ*	α Lyrae	bird's head
32	*Minqār al-Dajājah*	β Cygni	chicken
33	*Nasr al-Ṭā'ir*	α Aquilae	bird's head and neck
34	*Dhanab al-Dajājah*	α Cygni	
35	*Dhanab al-Jady*	δ Capricorni	tail
36	*Fam al-Faras*	ε Pegasi	
37	*Sāq Sākib al-Mā' J[anūbiya]*	δ Aquarii	
38	*Mankib al-Faras*	β Pegasi	horse's head and shoulder
39	*Surrat al-Faras*	α Andromedae	Andromeda's face
40	*Janāḥ al-Faras*	γ Pegasi	tip of a wing
41	*Dhanab al-Qaytus Sh[amālī]*	ι Ceti	fin of the fish tail
42	*Kaff al-Khaḍīb*	β Cassiopeiae	

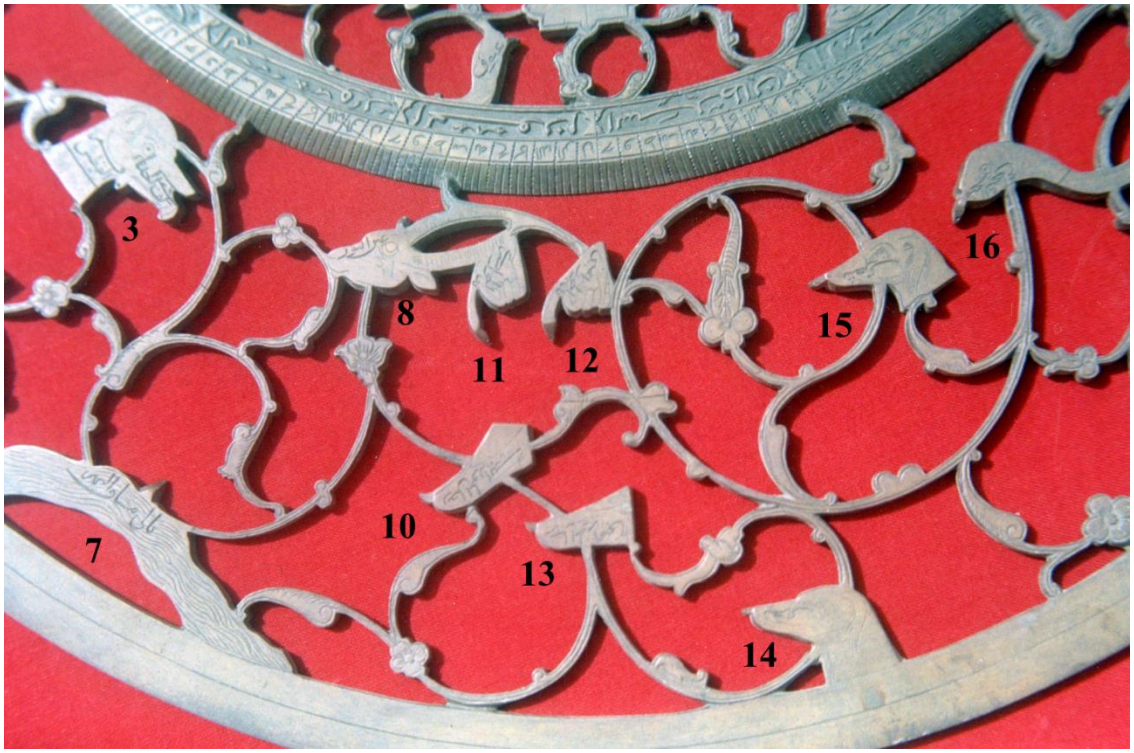


Figure A051.3 – Detail of Figure A051.2, showing (from left to right) the star pointers γ Ceti (3), γ Eridani (7), α Tauri (8), β Orionis (10), γ Orionis (11), α Orionis (12), κ Orionis (13), α Canis Majoris (14), α Canis Minoris (15) and σ Hydrae (16). At the top can be seen a section of the ecliptic ring with the embossed names of zodiac signs al-Thawr, al-Jawzā' and al-Saraṭān.

Plates

There are seven plates with the following specifications:

Table A051-2 Plates

	φ	Longest day *hours* *ghaṭīs*	Additional lines for *ghaṭīs*	Locality for which the plate is designed
1a	16;20,16°	12;59	*ghaṭī* lines	Golconda?
2a	18°	18;05[339]		Bijapur
3a	21°	13;21		Mecca
3b	23;30°	13;24		Ujjain/Tropic of Cancer
2b	25°	13;25		Medina

339 Clearly a mistake for 13;5 hours.

4a	27°	13;48[340]	*karhī* 34;25	*ghaṭī* lines	Agra
1b	28;39,20°	13;50		1/6 *ghaṭī* lines	Delhi
5a	30°	13;58		*ghaṭī* lines	
4b	32°	14;08	*karhā* 35;20	*ghaṭī* lines	Lahore
5b	35°	14;19	*karhā* 35;48	1/6 *ghaṭī* lines	
6a	36°	14;28			
6b	40°	14;52			
7a	Plate of ecliptic coordinates				
7b	Plate of horizons				

On the first six plates meant for different latitudes, the altitude circles are drawn for every 1° and each fifth line is highlighted by dotted lines. Azimuth arcs are drawn for every 5°, sometimes below the horizon and some other times both above and below the horizon.

There is much variation in hour lines; besides the lines of seasonal hours and equal hours since sunset and before sunrise, there are lines for (equal) *ghaṭīs* on some plates, viz. 1a (16;20,16°), 4a (27°), 4b (32°) and 5a (30°). On 1b (28;39,20°) and 5b (35°) there are lines for still finer time units, viz., 1/6 *ghaṭīs* (= 4 minutes). It must have been a stupendous task to draw these dotted lines for 1/6 *ghaṭī,* leaving very little space between every two lines (see Figure A051.8). While the lower half is thus filled with densely packed lines in just two plates, the upper half of all plates is filled in the same manner with altitude circles drawn for every 1° (see Figure A051.4).

On each of these, the latitude (*al-ʿarḍ*) for which it is designed is mentioned as also the maximum duration of the daylight at this latitude in hours (*al-sāʿāt*). On the three plates (4a for 27°, 4b for 32° and 5b for 35°), the maximum duration is also mentioned in *ghaṭīs* (spelt *karhī* or *karhā,* the latter apparently plural). One would have

340 13;48 hours translate to 34;30 *ghaṭīs.* In Muqīm's astrolabes the usual value at latitude 27° is 13;43 or 13;46 hrs. The latter equals to 34;25 *ghaṭīs* which is engraved on the plate.

expected that this done consistently on all plates which carry *ghaṭī* lines, but this is not done on plates 1a, 1b, and 5a.

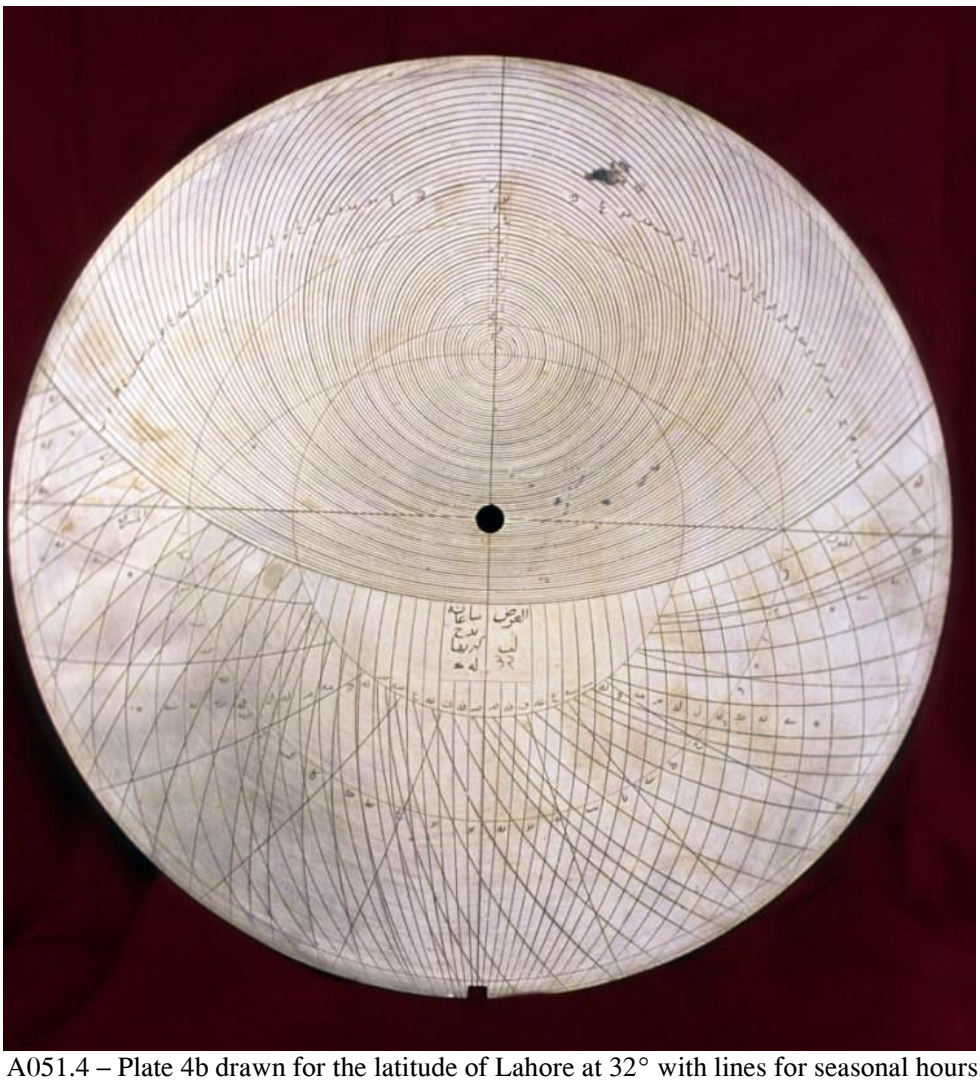


Figure A051.4 – Plate 4b drawn for the latitude of Lahore at 32° with lines for seasonal hours, equal hours and *ghaṭīs,* the last two counted from the western horizon (photo by S. R. Sarma)

Plate 7a is engraved as the plate of ecliptic coordinates with altitude circles for each 1° and longitude circles for each 6°. The names of zodiac signs are engraved along the ecliptic circle together with the subdivisions. On the reverse side of this plate is the plate of horizons with four sets of half-horizons for latitudes:

4	8	12	…	64
5	9	13	…	65
6	10	14	…	66
7	11	15	…	67

In addition, there are three full circles of horizons for higher latitudes which are not mentioned but presumably for 72°. The declination scales are divided in 1° and labelled in 3° up to 23;30°.

Geographical Gazetteer

On the inner side of the mater is engraved a very large geographical gazetteer with the longitudes, names and latitudes (in this order) of 235 places in five concentric circles. Although the gazetteer is engraved with the enormous number of 1700 entries, it does not look cluttered because of the judicial use of the empty spaces between the five circles. Moreover, variety is introduced in each circle.



Figure A051.5 – Geographical gazetteer (photo by S. R. Sarma)

Each unit comprising the longitude, place name and latitude engraved one below the other is separated from the next by a pair of lines, the style of which varies from circle to circle. In the first circle the lines of separation are zigzag lines and every tenth pair of lines (i.e. after 10 towns) is highlighted with dots; in the second circle, the lines of separation are also jig-jag lines (but facing the opposite direction) and here every eighth pair is highlighted with dots; in the third circle the lines of separation are straight lines and here every sixth pair is highlighted; in the fourth circle the lines of separation are curved to the right and every fourth pair is highlighted; finally in the fifth circle the lines of separation are curved to the left and here every second pair is dotted. Since each succeeding circle is smaller than the previous one, the dotted lines of separation in successive circles are in alignment and can be seen as radiating from the centre.

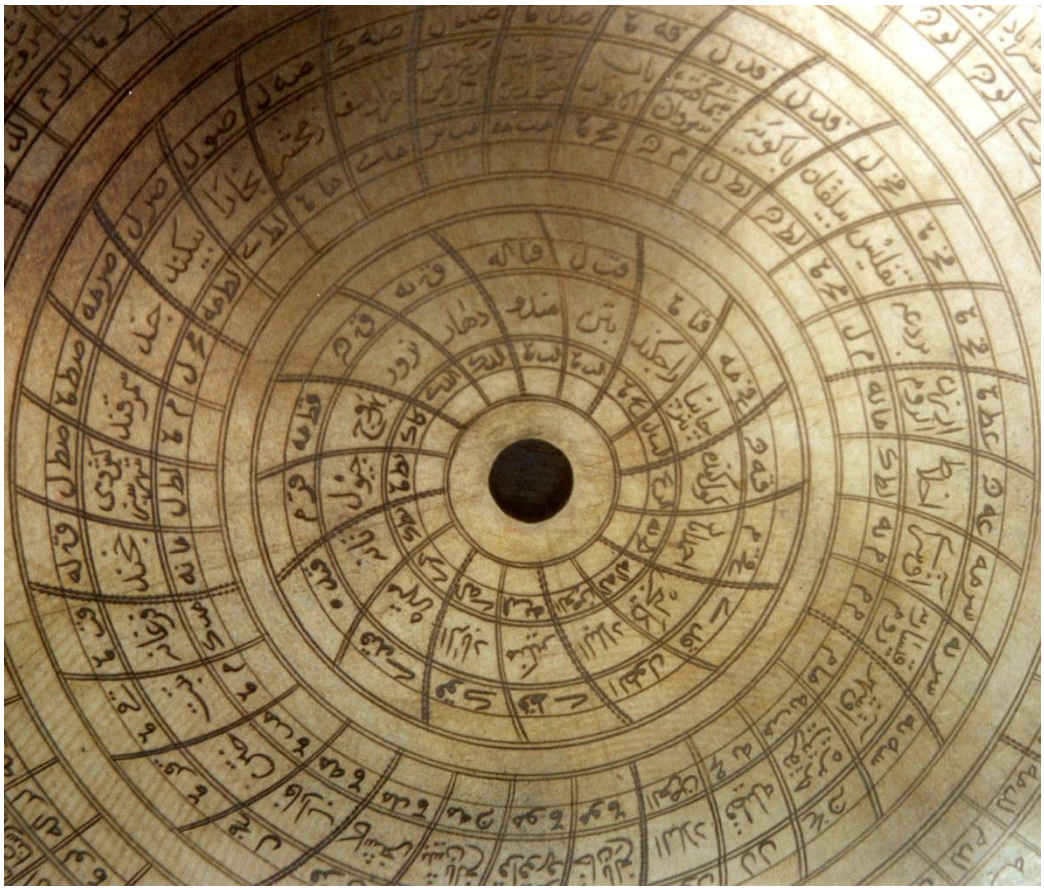


Figure A051.6 – Detail of Figure A051.5

In each circle, the first cell (to the left of the vertical radius) is occupied by the argument. From then on the gazetteer proceeds leftwards.

The places are arranged roughly according to increasing latitudes, starting with the coast of the mythical Oceanus on latitude 0° and going up to Khān Bāligh (modern Beijing) on 46° in the fourth circle. Several cities of the Indian subcontinent are already

mentioned in the first and second circles. Some other Indian cities are enumerated in the fifth circle, as a kind of addendum.

Table A051-3 Geographical Gazetteer

	Place Name	L	φ
	First Circle		
1	Sāḥil Baḥr Awqiyānūs	11;0	0;0
2	Jarmī dār al-Mulk Ḥabasha	65;0	9;30
3	ᶜAdan	76;0	11;00
4	Barbar az Bilād Zanj	78;0	6;30
5	Jazīrat Sarāndīb	130;0	10;0
6	Jamkūt	176;0	5;0
7	Kankdaz	180;0	0;0
8	Dhabīd	74;20	14;10
9	Jabal	75;0	13;30
10	Ṣanaᶜā’ Dār al-Mulk Yaman	77;0	14;30
11	Ẓafār	77;35	13;20
12	ᶜAmmān Sahār Qaṣba	84;15	19;20
13	Zaytūn	154;0	17;15
14	Bījābūr	105;30	17;20
15	Sūs al-Aqṣa Maghrib	15;30	24;0
16	Qatīf	74;0	25;0
17	Jᶜana	74;0	21;0

	Place Name	L	φ
18	Madīnat Rasūl ᶜAlayhi al-Salām	75;0	25;0
19	Khaybar	75;20	24;20
20	Jadda	76;00	21;0
21	Makka Muᶜaẓẓam	77;10	21;40
22	Tā'īf	77;30	21;20
23	Ḥajar Baḥrayn	83;15	25;15
24	Jazīrah Sarāb	88;30	25;0
25	Hurmūz	92;0	24;0
26	Jīruft	93;0	26;30
27	Tīz Qaṣba Makrān	103;0	24;15
28	Mansūra	105;0	26;40
29	Ṣanam Sawmnāt	107;10	22;15
30	Kanbāyat	109;20	22;20
31	Qannawj	104;50	26;15
32	Banāras	116;20	26;15
33	Dawlatābād	101;0	20;30
34	Kawālīyīr	104;0	26;29
35	Lakhnawtī	105;53	26;30
36	Kopāmayū	116;33	26;45
37	Jawnbūr	119;6	26;36
38	Karah wa Mānikbūr	118;10	26;49

	Place Name	L	φ
39	Ajmīr	112;5	26;0
40	Awadh	118;6	27:22
41	Akbarābād Dar al-Khalāfat	115;4	26;43
42	Burhānpūr	113;0	20;30
43	Asfī	12;15	30;15
44	Ṭāhart ᶜAlyā	35;32	31;45
45	Qayrawān	41;15	31;15
46	Mahdiyya	42;15	32;30
47	Ṭārābulus Maghrib	45;15	32;30
48	Iskandariyya	61;55	30;58
49	Miṣr	63;0	30;20
50	Dumayāt	63;12	31;35
51	Qulzum az Kanār Darya	64;15	28;30
52	Bayt al-Maqdis	66;30	31;50
53	Qaysāriyya Shām	66;30	32;50
54	ᶜAmmān	67;20	31;0
55	Ṭabariyya	68;15	32;0
56	Baᶜalbāk	70;45	33;15
57	Dimashq	70;0	33;20
58	Ḥilla	79;15	32;15
59	Kūfa	79;30	31;30
60	Baghdād	80;15	33;20

	Place Name	L	φ
61	Madā’īn	80;20	33;0
62	Nuᶜmāniyya	80;20	33;15
63	Wāsit	81;30	32;20
64	Ḥulwān	80;55	34;0
65	Baṣra	84;0	30;0
66	Ahwāz	84;0	31;0
67	Tustar	84;30	31;30
68	Ḥaṣn Mahdī	84;15	30;15
69	Rāmhurmūz	85;45	31;0
70	Iṣfahān	86;3	32;15
71	Kādhirūn	47;0	29;15
72	Nawbandkān	47;15	30;10
73	Abarquh	77;20	31;30
74	Fīrūzābād	77;30	28;10
75	Shīrāz	48;0	29;30
76	Iṣṭakhr	88;30	30;0
77	Yazd	89;0	32;0
78	Dārābjird	90;15	28;15
79	Sirjān	90;20	29;30
	Second Circle		
80	Kirmān	91;30	30;0
81	Ṭabas Gilakī	92;0	33;0
82	Zarand	92;15	30;15
83	Bardshīr	92;30	30;15

	Place Name	L	φ
84	Khabīṣ	93;0	31;15
85	Bam	94;0	28;30
86	Ṭabas Sinā	94;19	33;15
87	Zaranj az Sijistān	97;40	32;30
88	Kīj az Makrān	99;0	28;30
89	Bust	100;0	33;0
90	Maymand	101;55	33;20
91	Ghazna az Zābulistān	104;20	33;25
92	Ribaṭ Amīr	105;0	24;0
93	Multān	106;25	29;40
94	Qandahār	107;40	33;0
95	Nahlawāra	108;20	28;40
96	Parshūr	105;55	31;0
97	Lāhūr	109;20	31;50
98	Dihlī	113;35	28;39
99	Farmal	104;35	32;55
100	Sālkūt	109;0	33;0
101	Hānsī	112;25	29;45
102	Sunām	112;25	30;30
103	Tānīsar	112;33	30;10
104	Pānīpat	113;20	28;52
105	Baran	114;0	28;48
106	Kol-Jalālī	114;19	28;4

	Place Name	L	φ
107	Badāūan	114;59	27;32
108	Sulṭānkūt	115;0	28;30
109	Samīr	105;40	32;15
110	Bajāv Qayānūs Ṭanharirdīn?	70;15	35;0
111	Jazīrah Aqrīṭis wa Madīhnā	55;40	36;30
112	Jayrūn	67;30	35;15
113	Ṭarsūs	68;40	36;50
114	Ṭarābulus Shām	69;40	35;15
115	Ḥimṣ	70;45	34;0
116	Ḥalab	72;10	35;50
117	Mārdīn	74;15	37;50
118	Jazīra ibn ᶜUmar	75;30	34;30
119	Bukhār ?	76;0	36;0
120	ᶜĀna	76;30	34;0
121	Mawṣil	77;0	36;50
122	Arjīs	77;0	38;30
123	Niṣībīn	75;20	37;40
124	Afdar	77;20	36;52
125	Nawshahr	78;20	38;10
126	Nakadīt	73;25	34;0
127	Sāmrā	79;15	34;15
128	Salmās	79;15	37;40

	Place Name	L	φ
129	Ūrmiya	79;45	37;0
130	Daybul	80;30	38;0
131	Tajwān	81;15	37;45
132	Qaṣr Shīrīn	81;40	33;45
133	Marāqha	80;0	36;20
134	Tabrīz	82;0	38;0
135	Ardabīl	82;20	37;20
136	Miyāna	82;30	36;0
137	Hamadān	83;0	35;10
138	Zanjān	83;0	36;30
139	Suhraward	83;0	36;0
140	Nahāwand	83;0	34;20
141	Abhar	84;30	36;45
142	Karaj	84;45	34;0
	Third Circle		
143	Sāwa	85;0	36;15
144	Qazwīn	85;0	36;15
145	Sulṭāniyya	85;0	36;30
146	Abah	85;10	34;40
147	Qūm	85;40	34;45
148	Jurbādaqān	85;35	34;15
149	Kāshān	86;0	34;0
150	Rayy	86;20	35;0
151	Khuwār	87;10	35;40

	Place Name	L	φ
152	Amul	87;20	36;0
153	Dāmghān	88;0	37;20
154	Samnān	87;20	36;40
155	Sāriya	88;0	37;0
156	Busṭām	89;30	36;10
157	Astarābād	89;30	36;50
158	Jurjān	90;0	36;50
159	Farāwa	90;0	39;0
160	Sabzawār	91;30	36;0
161	Isfarāīn	91;40	37;55
162	Turshīz	92;0	35;0
163	Nīshābūr	92;30	36;21
164	Mashhad	92;30	36;0
165	Tūn	92;30	34;30
166	Nūqān	92;45	38;40
167	Qā'īn	93;20	36;30
168	Zūzan	93;30	35;19
169	Jūrjān	92;0	37;0
170	Marv Shāhijān	94;0	37;40
171	Harāt	94;20	34;30
172	Sarakhs	94;30	36;0
173	Bādghīs	94;30	35;20
174	Marv Rūd	94;40	34;30
175	Būshank	95;40	37;50

	Place Name	L	φ	
176	Ṭāliqān Khurāsān	98;15	37;30	
177	Fāriyāb	99;0	36;45	
178	Balkh	101;0	36;41	
179	Samanjān	102;15	37;15	
180	Ṭāliqān Ṭukhāristān	102;50	37;25	
181	Andarāb	103;45	36;0	
182	Badakhshān	104;25	36;10	
183	Kābul	104;40	34;30	
184	Kābul ᶜAhrāz	104;40	35;0	
185	Kashmīr	105;0	35;0	
186	Bulūr	103;0	36;0	
187	Ashnūna	17;15	42;40	Lisbon
188	Wasit Jazūrah Fārs	18;14	39;5	
189	Madīnat Salām	28;15	43;15	Medinaceli, Spain
	Fourth Circle			
190	Taṭīla	30;30	43;15	
191	Jazīrah Niqarnīt	58;50	42;15	
192	Āqshahr	65;15	41;40	
193	Qaysāriyya Rūm	67;15	40;40	
194	Āqsarāy	67;45	40;15	
195	Akhlāt	75;50	39;20	

	Place Name	L	φ
196	Arzan al-Rūm	79;0	41;15
197	Bardaᶜa	83;0	40;30
198	Tiflīs	83;0	43;0
199	Baylaqān	83;30	39;50
200	Bākūya	84;30	39;30
201	Sharwān Shamā Faṣadī?	84;30	40;50
202	Bāb al-Abwāb	85;0	43;0
203	Khwārizm Jurjāniya	94;0	42;44
204	Almāk Yaman Karīzdhād	94;30	42;17
205	Hazār Asf	95;20	41;10
206	Zamakhshar	95;30	41;0
207	Bukhārā	96;30	39;10
208	Baykand	97;30	39;45
209	Jind	97;45	43;30
210	Samarqand	99;0	40;0
211	Shahar Shabz Kish Rūmī	99;30	39;30
212	Khujand	100;15	41;55
213	Farghānā	102;0	42;20
214	Tubbat	110;0	40;0
215	Khutan	104;0	42;0
216	Fārāb	88;30	45;0
217	Kāshghar	107;30	44;0

	Place Name	L	φ	
218	Bashīn Bāligh	102;0	45;50	
219	Qarāqūrūm	105;0	46;0	
220	Khān Bāligh	124;0	46;0	
	Fifth Circle			
221	Kālanjar	104;10	25;25	
222	Aḥmadābād	108;40	28;15	
223	Kolkanda	105;50	24;18!	
224	Chānpānīr	108;45	22;30	
225	Rājkand	102;0	18;0	
226	Batn	102;30	24;0	
227	Mandū	102;25	22;0	
228	Dhār	100;15	24;20	
229	Narwar	100;50	24;10	
230	Bahrūj	109;45	21;20	
231	Juyūl	107;40	19;0	
232	Tāna	114;5	19;20	Thane
233	Mathrah	114;10	27;10	Mathura
234	Ilāhbād	106;20	25;10	
235	Mankīr	109;10	22;15	

BACK

The rim of the two upper quadrants bears the altitude scales, divided in 0;30°, 1° and 3° and labelled as 3—90; 90—3.

In the upper left is a sexagesimal trigonometric quadrant with 60 horizontal and 60 vertical parallels with each third line highlighted. There is a semicircle on the

horizontal radius and quarter circles with radii at 24 (obliquity) and 30 units; the latter is unusual.

The upper right quadrant is engraved as the solar quadrant with declination circles for each 2°of the longitude of the sun, with every third circle highlighted with dots. The corresponding signs are labelled along the two radii and groups of 6° are numbered separately for each sign. Two sigmoid curves are drawn to show the meridian altitudes of the sun throughout the year for the latitudes of 27° and 32°. Along these curves are inscribed the labels *khaṭṭ niṣf al-nahār bi-ᶜarḍ 27* (line of the midday altitude at the latitude of 27°) and *khaṭṭ niṣf al-nahār bi-ᶜarḍ 32* (line of the midday altitude at the latitude of 32°).

In the lower half are the two shadow squares. On the left is the shadow square for the base of 12 and 60. Here the vertical and horizontal scales are divided into 12 parts each and numbered accordingly. Each part is further subdivided into 5 units and numbered in 5s from 5 to 60. The horizontal scale is accompanied by the label *ẓill sullam aṣābiᶜ mustawī* and the vertical scale by the label *ẓill sullam aṣābiᶜ maᶜkūs.* These labels are inscribed inside the shadow squares.

Outside the shadow squares, there are additional labels for the sexagesimal scale; under the horizontal is engraved *ẓill sittaynī mustawī* and to the left of the vertical scale *ẓill sittaynī maᶜkūs.*

On the right is the shadow square for the base of 7. Here the vertical and horizontal scales are divided into 7 parts each and numbered accordingly. The horizontal scale is accompanied by the label *ẓill sullam aqdām mustawī* and the vertical scale by *ẓill sullam aqadām maᶜkūs.*



Figure A051.7 – Back of the astrolabe (photo by S. R. Sarma)

The lower half of the rim is engraved with the cotangent scales in two semi-circular rows. The unequal divisions in the scale on the left are numbered in 3s from 3 to 60, followed by the label *ẓill aṣābiʿ*. Those in the scale on the right are likewise

numbered in 3s from 3 to 60, followed by the label *ẓill aqdām.* The scale that follows is divided in single units.

Inside the cotangent scales are three semi-circular rows containing a table of limits of the signs (*ḥudūd*). In the first row are engraved the names of the signs in full. In the second row, the names of the planets (five for each planet) are inscribed with the last letters of their names and in the third row the strengths of each of the five planets in *Abjad* notation.

Within the shadow squares, there are four concentric semi-circular rows. The outermost row carries the names of the 28 lunar mansions, while the next is filled with the names of the 12 corresponding zodiac signs. In the next two rows are mentioned the regents and the decans respectively.

Besides these two semi-circular tables, there are three rectangular tables. Below the shadow squares is a table with the title *mabādi'-yi aqālīm-i sabᶜa* (beginnings of the seven climates) in four rows and eight columns.[341] It displays the latitudes (*al-ᶜarūḍ*) and the hours of the maximum daylight (*al-sāᶜāt*) at the beginning (*mabdā'*) and the middle (*wasaṭ*) of the seven climates (*aqālīm*).

Table A051-4 Climates

aqālīm	***mabādī wa awāsiṭ***	***al-ᶜarūḍ***	***al-sāᶜāt***
Al-Awwal	*mabdā'*	12;43	12;45
	wasaṭ	16;44	13;0
Al-Thānī	*mabdā'*	20;31	13;15
	wasaṭ	24;10	13;30
Al-Thālith	*mabdā'*	27;34	13;45
	wasaṭ	30;46	14;0
Al-Rābiᶜ	*mabdā'*	33;43	14;45
	wasaṭ	36;28	14;30
Al-Khāmis	*mabdā'*	39;1	14;45

341 Cf. Kaye 1918, p. 132.

aqālīm	***mabādī wa awāsiṭ***	***al-ᶜarūḍ***	***al-sāᶜāt***
	wasaṭ	41;21	15;0
Al-Sādis	*mabdā'*	43;30	15;15
	wasaṭ	45;39	15;30
Al-Sābiᶜ	*mabdā'*	47;38	15;45
	wasaṭ	48;59	16;0

To the left of the shadow squares is a table with the heading *faḍl al-dawr* (excess of revolution) in 9 x 4 cells, providing the multiples of the difference between the length of the tropical year and 365 days.

To the right of the shadow squares is another rectangular table entitled *arbāb muthallathāt lāylī wa nahārī* (the regents of the triplicities, nocturnal and diurnal). The triplicities and the regents are enumerated in four sub-tables according to their nature: *nārī* (fiery), *tarābī* (earthy), *hawā'ī* (airy) and *hāmī* (watery).

ALIDADE, PIN, HORSE

The alidade is rectilinear with pierced clef ends and a trifoliate centerpiece. It bears an ecliptic scale on the right with the names of the signs inscribed in full in two rows and a sexagesimal scale and a universal hour scale on the left. There is a small quatrefoil on the top of the decorated button on the pin and an eight-petalled flower shaped washer. The wedge is horse-shaped.



Figure A051.8 – Plate 3b with Devanagari additions

Provenance and Additional Markings in Devanagari

In the early eighteenth century, Sawai Jai Singh acquired this astrolabe along with some other outstanding astrolabes of the Lahore family. Apparently it was he who caused the word *yantrarāja* (Sanskrit name for the astrolabe meaning 'king of instruments') to be engraved in Devanāgarī on both sides of the cartouche in the crown. The numerical values of the latitudes in Devanagari script were engraved on some plates (21°, 23;30°, 27°, 32°) for the benefit of those of his astronomers who did not read Arabic/Persian script. On the plate for Delhi, the name of the city is also engraved along with the latitude (*dīlī 28; 39*) in Devanagari as can be seen in Figure A051.8 above.

Bibliography

Kaye 1918, p. 16, Figures 5 and 7. Lists it as Jaipur A.

Gunther 1932, I, no. 74, pp. 204-205, figs. 102 (rete) 103 (back).

A052 ASTROLABE ATTRIBUTABLE TO MUḤAMMAD MUQĪM[342]

Not dated, Lahore

Diameter 263 mm

Qatar, Doha, Museum of Islamic Art (# MW.396.2007); ex-Alain Brieux, Paris; ex-Nachet, Paris

Répertoire 29

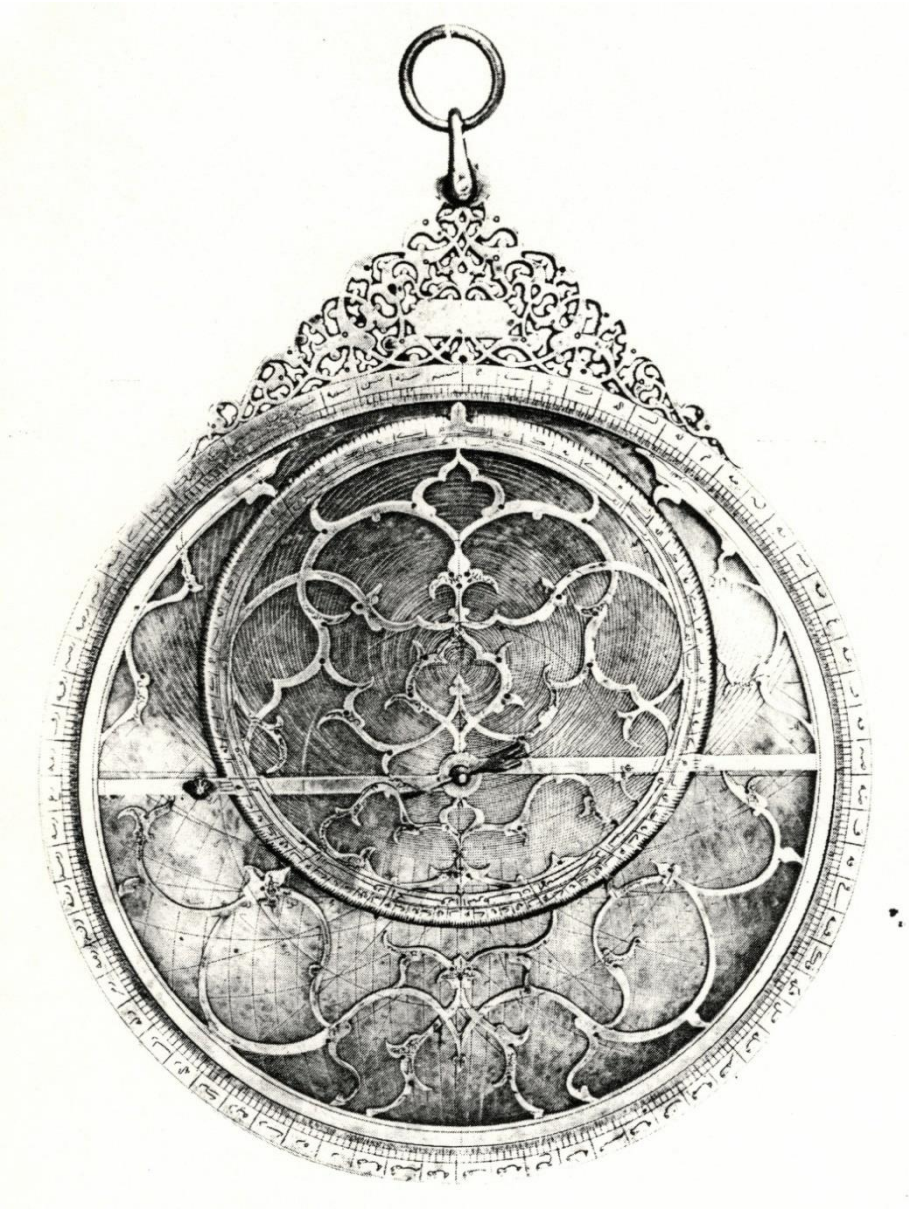


Figure A052.1 – Front of the astrolabe (photo from a Brieux catalogue)

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342 Entry based on Alain Brieux, *Instruments scientifique du troisième siècle avant l'ère chrétinne à 1946,* Paris, Novembre 1983, p. 31, no. 13; also an unidentified catalogue of Alain Brieux where this astrolabe is illustrated and described under the serial number 10518.

This large and elegant astrolabe is not signed, nor dated, but there cannot be any doubt that it was made by Muḥammad Muqīm. The Répertoire notes that it has a great similarity to the astrolabe signed by Muqīm (A031).

The simple ring and shackle appear to be replacements. The multi-lobed *kursī* displays very fine fretwork with long-stemmed tulips with flared petals and a longish cartouche. The degree scale on the limb is divided in 1° and 5° and numbered in 5s from 5 to 360.

In the rete, the two rings of Capricorn and ecliptic are held together by the equinoctial bar which has a counter change at the centre. The ecliptic ring is divided into the 12 signs of zodiac and labelled with their names; each sign is divided into units of 5° and numbered accordingly. These units are further subdivided into 1° along the rim. There are said to be 37 star pointers which are joined by an elegant floral tracery. Inside the ecliptic ring, the tracery forms stylized trifoliate frames one upon the other along the solstitial colure.

The 5 plates serve the following latitudes: 21° and the plate of ecliptic coordinates; 40° and 45°; 30° and 37°; 27° and 32°; plate of horizons and a plate of unknown function. The plate visible under the rete has altitude circles for every 1° and azimuth curves for every 6° and lines and seasonal hours and equal hours counted from the western and eastern horizons.

On the back, the upper half of the rim carries the altitude scales divided in 1° and 5° and numbered as 5—90; 90— 5. In the upper left is the trigonometric quadrant with 60 horizontal parallels. In the upper right is the solar quadrant which is divided by the declination arcs into 6 zones, one for each pair of signs. Six curves for seasonal hours are drawn here which are numbered from 1 to 6.

In the lower half are drawn very small shadow squares, on the left for the base of 12 and on the right for 7. The scales are divided and numbered accordingly. Strangely, the vertical scale on the left is not accompanied by a label, while the remaining three are accompanied by the following, unusual, labels:

Horizontal scale on the left: *ẓill sullam bi-al-aṣābi*^{c}

Horizontal scale on the right: *ẓill sullam bi-al-aqdām*

Vertical scale on the right: *ẓill ma*^{c}*kūs bi-al-aqadām*

The lower half of the rim carries the cotangent scales. The scale on the right is marked 5, 10, 15, … 40, 45, 50, *ẓill aṣābiᶜ*. The scale on the right is marked 5, 10, 15, … 40, 45, *ẓill maᶜkūs bi-al-aqdām.*

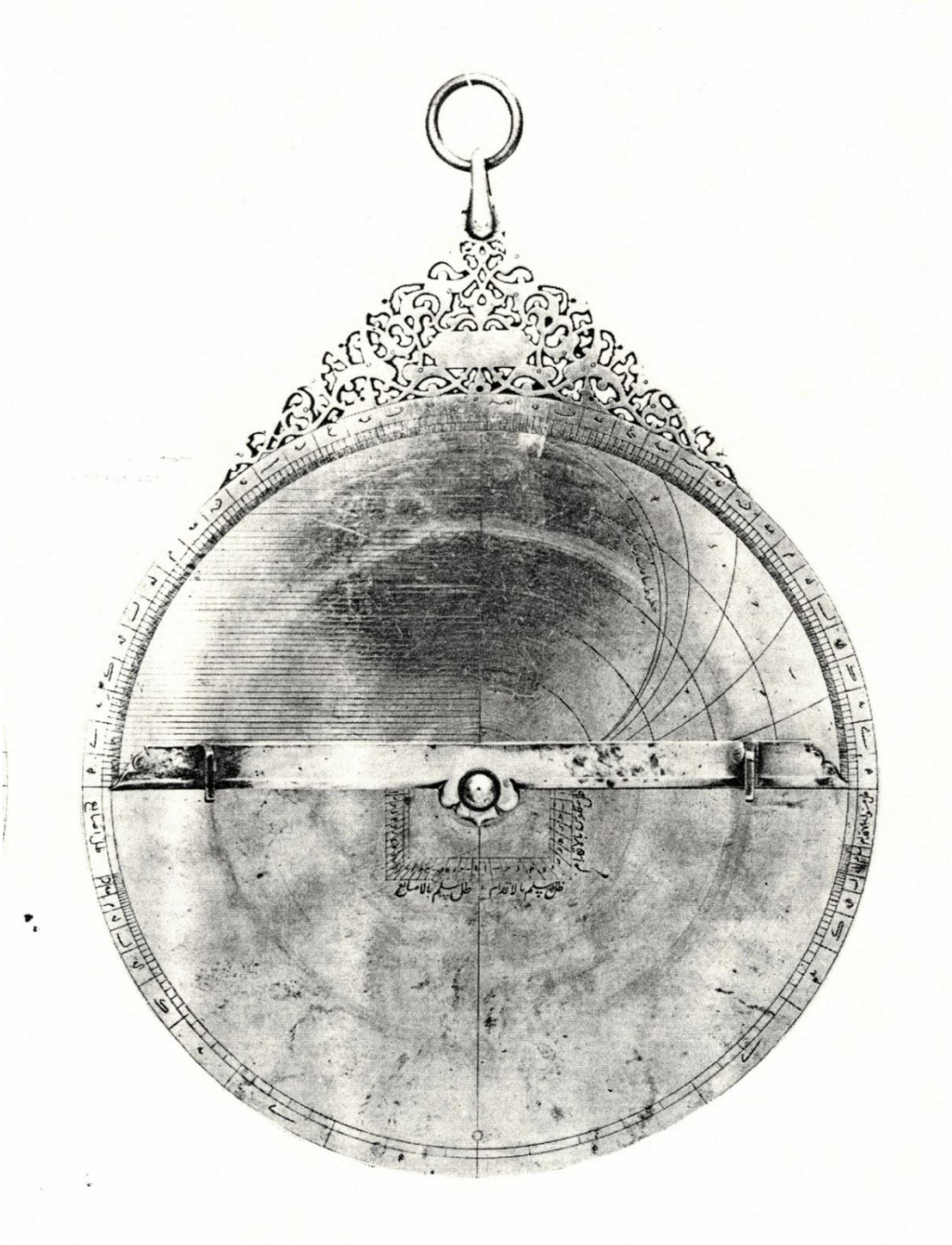


Figure A052.2 – Back of the astrolabe (photo from Brieux catalogue)

Surprisingly the rest of the lower half is blank. The alidade has ornate ends and an ornate centre piece, but carries no graduations.

A053 ASTROLABE ATTRIBUTABLE TO MUḤAMMAD MUQĪM, NOT DATED[343]

Diameter 204 mm

PLU: ex-Alain Brieux, Paris



Figure A053.1 – Front of the astrolabe (photo from Brieux catalogue 1969)

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[343] Entry based on Alain Brieux, *Histoire des Sciences: Livres, Autographs, instruments, astrolabes …*, Paris 1969, no. 5819.

This large and well-crafted astrolabe is not signed, nor dated, but can certainly be attributed to Muḥammad Muqīm.

The *kursī* with multi-lobed profiles is elaborately reticulated, with a cartouche resembling a casket with a triangular base and a lid with a long oval handle. The finial imitates the form of the cartouche. The surface is engraved with decorative lines and small circles. The degree scale on the limb is divided in 1° and 5° and numbered in 5s from 5 to 360.

In the rete, the two rings of Capricorn and ecliptic are held together by a slender equinoctial bar which has a counter change at the centre. The ecliptic ring is divided into the 12 signs and labelled with their names; each sign is divided into units of 2° and numbered accordingly. There are said to be 40 star pointers. Probably there were originally two handles, one on the western end of the equinoctial bar, the other at 18° of Capricorn; both are now missing.

The catalogue states that there are 5 plates. In the photo, the plate of ecliptic coordinates can be seen under the rete. On it are drawn latitude circles for each 1° and longitude circles for each 6°. The name of the plate *mīzān al-ʿankabūt* can be seen at the bottom.

No information is available about the alidade. The pin, shown in the photo, appears to be original. The horse, also shown in the photo, is a replacement.

A054 ASTROLABE ATTRIBUTABLE TO MUḤAMMAD MUQĪM

Diameter 160

PLU; ex-London, Christie's

CCA 84



Figure A054.1 – Front of the astrolabe
(photo from the archives of the Museum of the History of Science, Oxford)

With two large bell or tulip-shaped incisions, the *kursī* in this astrolabe offers a new variation to the design that can be seen in three other astrolabes by Muqīm (A020, A021 and A048). Here the surface is embellished with winding tendrils joining tulips with two flared petals executed in very low relief. Therefore, this astrolabe must have been made by Muqīm. Remarkably, no astrological tables are engraved on the back, but two curves for the beginning and end of the mid-afternoon *ʿaṣr* at Lahore on latitude 32°.

COMPONENTS

Body with *kursī* (d. 160), shackle and ring, rete for 30 stars, 5 plates, alidade, pin and horse. Ring and shackle do not appear to be original.

FRONT

The ring and shackle are plain and do not appear to be original. The *kursī* is well crafted with six large incisions. The profiles are multi-lobed and the finial trifoliate. Both the sides of the *kursī* are embellished by decorations in low relief. The degree scale on the limb is divided in 1° and 5° and numbered from 5 to 360.

RETE

In the rete, the two rings of Capricorn and ecliptic are held together by the equinoctial bar which has a counter change at the centre. The ecliptic ring is divided into 12 zodiac signs and labelled with their names. Each sign is divided into 5 units of 6° each and numbered accordingly. The rim and edge of the ecliptic ring are calibrated in 1°. There are 30 named star pointers in the shape of tulip petals. These are joined by a nearly symmetrical tracery of tendrils with small leaves and flowers. There is a knob near the west point.

Table A054-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus*	β Ceti
2	*Baṭn al-Ḥūt*	β Andromedae
3	*Al-Musalsala*	γ Andromedae
4	*Rās al-Ghūl*	β Persei

	Star Name	Identification
5	*Fam al-Qayṭus*	γ Ceti
6	*ᶜAyn al-Thawr*	α Tauri
7	*ᶜAyyūq*	α Aurigae
8	*Rijl al-Jawzā' al-Yusrā*	β Orionis
9	*Yad al-Jawzā' al-Yusrā*	γ Orionis
10	*Shiᶜrā Yamānī*	α Canis Majoris
11	*Shiᶜrā Shāmī*	α Canis Minoris
12	*Mankhar al-Shujāᶜ*	σ Hydrae
13	*Fard al-Shujāᶜ*	α Hydrae
14	*Qalb al-Asad*	α Leonis
15	*Ẓahr al-Asad*	δ Leonis
16	*Ṣarfa*	β Leonis
17	*Janāḥ al-Ghurāb*	γ Corvi
18	*Simāk Aᶜzal*	α Virginis
19	*Simāk Rāmiḥ*	α Bootis
20	*Nayyir Fakkah*	α Coronae Borealis
21	*ᶜUnuq al-Ḥayyah*	α Serpentis
22	*Qalb al-ᶜAqrab*	α Scorpii
23	*Rās al-Ḥawwā*	α Ophiuchi
24	*Rās al-Jāthī*	α Herculis[344]
25	*Nasr Wāqiᶜ*	α Lyrae

344 Wrongly placed.

	Star Name	Identification
26	*Minqār al-Dajājah*	β Cygni
27	[*Dhanab al-Jadī*][345]	δ Capricorni
28	[*Sāq Sākib al-Mā'*][346]	δ Aquarii
29	*Mankib al-Faras*	β Pegasi
30	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are 5 plates serving the following latitudes. The engraved values for duration of the longest days are not available.

Table A054-2 Plates

	φ	(locality)
1a	21;40°	(Mecca)
1b	25°	(Medina)
2a	27°	(Agra)
2b	31;50°	(Lahore)
3a	38°	
3b	45°	
4a	30°	
4b	Plate of horizons	
5a	36°	
5b	Plate of ecliptic coordinates	

345 Wrongly labelled as *Dhanab al-Ḥūt.*

346 Wrongly labelled as *Dhanab al-Jadī.*

φ	(locality)

On all the plates (except 4b and 5b), altitude circles are drawn for each 3 degrees, azimuth circles for each 10°, curves for seasonal hours and for equal hours since sunset and until sunrise.

GEOGRAPHICAL GAZETTEER

There is an incomplete geographical gazetteer in two circles. The outer circle is filled with the names and coordinates of 47 places; the 24 cells in the inner circle are blank. No photo of the gazetteer is available.

BACK

On the back, the upper half of the rim carries two altitude scales, divided in 1° and 5° and numbered 5—90; 90—5. In the upper left is a trigonometric quadrant with 60 horizontal parallels, i.e. one for each unit of the sixtieth division of the radius. In the upper right is a solar quadrant with arcs of solar declination for each 10° of the solar longitude. Every third circle, marking the boundary between two signs, is dotted. The signs are marked with their serial numbers along the two radii. There are three curves. The upper one carries the label *khaṭṭ al-zawāl* (line of midday). The other two are for the beginning and end of the mid-afternoon (*ᶜaṣr*) prayer with the labels *khaṭṭ awwal al-ᶜaṣr* (line of the begin of the prayer *al-ᶜaṣr*) and *khaṭṭ ākhir al-ᶜaṣr* (line of the end of the prayer *al-ᶜaṣr*) respectively.[347] But it is not specified for which latitude these three curves are drawn.

347 King 2005, pp. 46-50, esp. p. 48, '… the beginning of the *ᶜaṣr* (B: shadow increase [from midday] equal to the length of the gnomon) and at the end of the *ᶜaṣr* (C: shadow increase equal to twice the length of the gnomon) …'

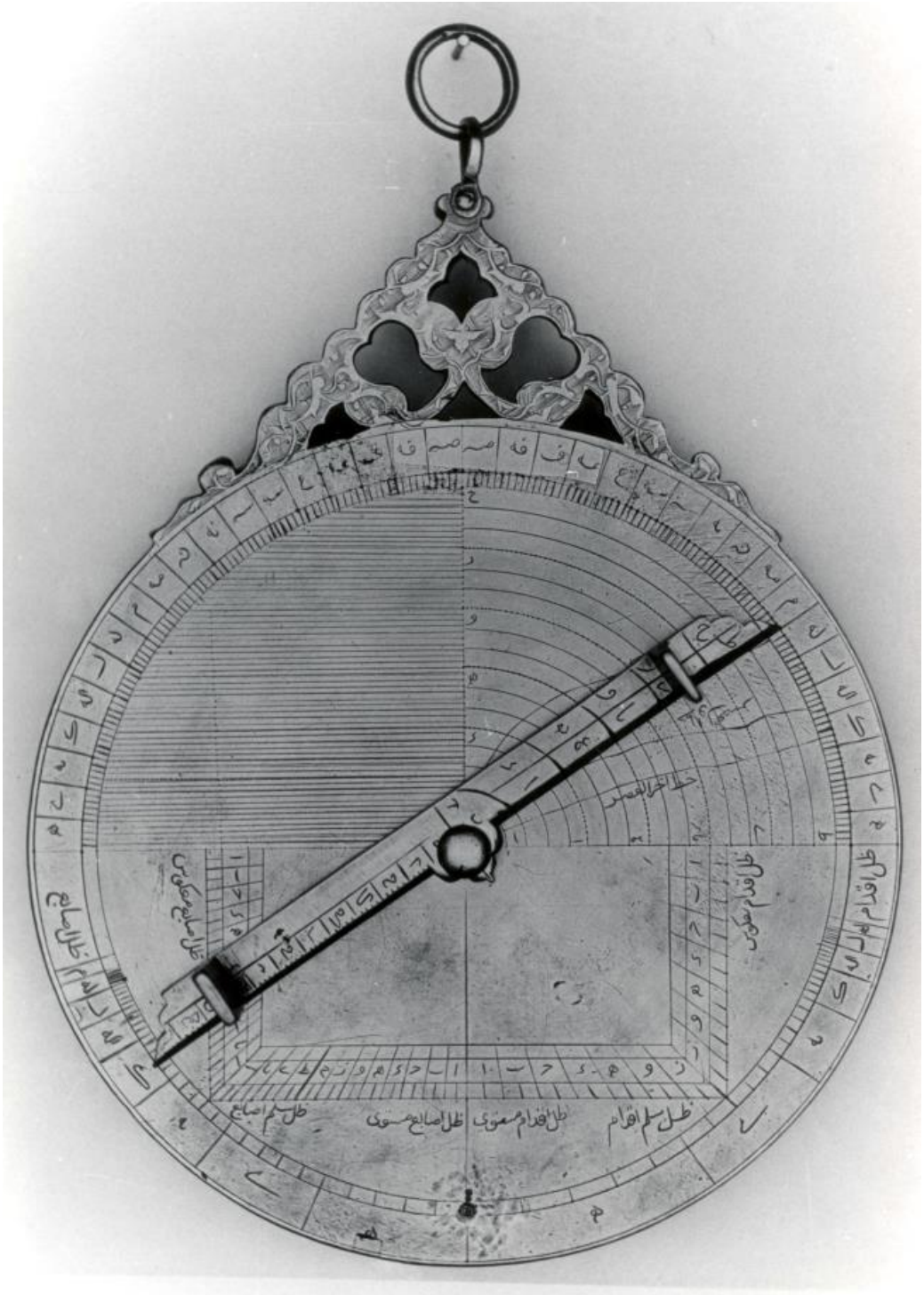


Figure A054.2 – Back of the astrolabe
(courtesy Museum of the History of Science, Oxford)

In the lower half, there are shadow squares, on the left for a base of 12 digits and on the right for a base of 6 feet. The vertical and horizontal scales on the left are divided into 12 units and in 24 units. The vertical scale is accompanied by the label *ẓill aṣābiʿ maʿkūs*. The horizontal scale has two labels: *ẓill aṣābiʿ mustawī* and *ẓill sullam aṣābiʿ*

The scales on the right are divided into 7 divisions. Here the vertical scale has the label *ẓill aqdām maᶜkūs* and the horizontal scale *ẓill aqadām mustawī* and *ẓill sullam aqdām.*

The rim on the lower half is engraved with two cotangent scales, on the left in digits and on the right in feet. The unequal divisions in the scale on the left are numbered as 5, 10, 15, 20, 25, 30, 35, 40, followed by the label *ẓill aṣābiᶜ*. The divisions of the scale on the right are also numbered in the same way, but are followed by the label *ẓill aqdām.*

On the edge of the astrolabe, near the top, is engraved *Ṣāhib Maghfūr al-Ḥusaynī al-Jilānī* which must be the name of an owner.

ALIDADE

The alidade has ornate ends and an ornate centre piece. The right hand side is calibrated with a sexagesimal scale to match with the trigonometric quadrant and numbered in 5s from the centre up to the end from 5 to 60. The left hand side has a solar longitude scale marked with the serial numbers of the signs for use with the solar quadrant. The longish wedge is nicely shaped and decorated as the head of a horse.

PROVENANCE

This astrolabe was formerly in the Samuel Verplank Hoffmann Collection, New York, no. 5, and in New York Historical Society (Acc. no. 1943.195; Inv. no. 322464); it was loaned for some time to the Museum of History and Technology (now the National Museum of American History, Washington, D.C.). It came up for auction at Christie's thrice in 1975, 1990 and 1993. Its present location is not known.

BIBLIOGRAPHY

Gunther 1932, no. 88, p. 217.

Gibbs & Saliba 1984, no. 88, pp. 134-137.

Christie's catalogues of 9 April 1975 (lot 104, plate 14);[348] 29 March 1990 (lot 166) and 6 May 1993 (lot 114).

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348 This catalogue proclaims: 'Indian astrolabes are relatively uncommon, the present being a good example of the earlier Persian influenced style.'

A055⊙ ASTROLABE ATTRIBUTABLE TO MUḤAMMAD MUQĪM, NOT DATED

Diameter 107 mm

Oxford, Museum of the History of Science (#54063)

CCA 1014



Figure A055.1 – Geographical gazetteer (photo by S. R. Sarma)

Of this well-crafted astrolabe with excellent calligraphy, only the mater and four plates survive. The astrolabe is neither signed nor dated. The *kursī* with two large bell-

shaped incisions resembles closely the *kursīs* in some of the astrolabes signed by Muḥammad Muqīm (A018, A021, A048,). Moreover, there is a close resemblance between the gazetteer of 69 places in this astrolabe and the same with 69 places in Muqīm's astrolabe of 1051/1641-42 (A026). Therefore, there cannot be any doubt that the present astrolabe is made by Muqīm. An unusual feature is the location of the plug inside the limb of the astrolabe which is situated at the North-West point and not at the north point as is the general practice. Consequently, the projections on the reverse sides of the plates had to be engraved upside-down so that the plug fits into the notch. On the plate of horizons, the horizon at the latitude of 72° is shown as an eccentric circle with the label *ʿarḍ 72*; this too is unusual.

COMPONENTS

Body with *kursī* (d. 107, h.136, t. 6), shackle, ring and 4 plates. The rete, alidade, pin and horse are missing.

FRONT

The ring is well made with a diamond cross-section; the trifoliate shackle also has a diamond cross section. The *kursī* is pierced with six large perforations, producing a pleasing design. The finial is trifoliate. The surface is smooth without any engravings.

The limb is graduated in 1°, 3°, 6°; labelled 6—90; 6—90; 6—90; 6—90.

PLATES

Inside the limb there is space for 5 plates, but only 4 plates are extant.

Table A055-1 Plates

	φ	Longest Day
1a	27°	13;43 hours
1b	32°	14;8 hours
2a	34°	14;22 hours
2b	18° + 30°	
3a	36°	14;32 hours
3b	40°	14;54 hours

φ	Longest Day
4a	Plate of ecliptic coordinates
4b	Plate of horizons

On plates 1-3, altitude circles are drawn for each 6°and azimuth arcs for each 10° below the horizon. There are plain lines for seasonal hours and dotted lines for equal hours; the latter are for hours since sunset on some plates; on others for hours since sunset and hours before sunrise. The east and the west points are labelled; the meridian line is dotted; the prime meridian is dotted below the horizon.



Figure A055.2 – Plate of horizons (photo by S. R. Sarma)

The plate of ecliptic coordinates has latitude circles engraved for each 6° and longitude circles for each 10°; every third circle which forms the boundary between two consecutive signs is dotted. The name of the plate is engraved at the bottom as *ṣafīhat mīẓān al-ᶜankabūt.*

The plate of horizons carries four sets of half horizons for latitudes 6° to 66°, with intervals of 8° in each set. There are declination scales divided in 2 units and labelled in 6s as 6, 12, 18, 23;30. The name of the plate is not engraved. Interestingly, a dotted circle is drawn eccentrically for the horizon at the latitude of 72° with the label *ʿarḍ 72*. Muqim drew projections for the latitude of 72°, together with those for 0° and 90°, in some of his astrolabes (A030, A040, A047); in one undated astrolabe (A047), he drew projections exclusively for latitude 72° where the horizon is shown as an eccentric circle (Figure A047.3). But the horizon for 72° is rarely shown on the plate of horizons (see also A058).

GEOGRAPHICAL GAZETTEER

The geographical gazetteer provides the longitudes, names and latitudes (in this order) for 69 localities in three circles. It is comparable to the gazetteer in A028.

Table A055-2 Geographical Gazetteer

	Place Name	L	φ
	Outer Circle		
1	Qayrawān	41;0	31;40
2	Miṣr	63;20	30;20
3	ʿAdan	76;0	11;0
4	Madīnat Ṭayyaba	75;20	25;0
5	Makka Musharraf	77;10	21;40
6	Ṭā'īf	77;30	21;20
7	Bayt al-Maqdis	66;30	31;50
8	Dimashq	70;0	33;15
9	Ḥalab	74;10	35;50
10	Marāgha	84;0	37;20
11	Tabrīz	82;0	38;0
12	Kūfa	79;10	31;30

	Place Name	L	φ
13	Baghdād	80;0	33;25
14	Baṣrah	84;0	30;11
15	Fīrūzābād	87;30	28;10
16	Shīrāz	88;0	29;36
17	Yazd	89;0	32;0
18	Qazwīn	85;0	36;0
19	Iṣfahān	86;40	32;25
20	Kāshān	86;0	34;0
21	Sabzawār	91;30	36;0
22	Mashhad	92;30	37;0
23	Harāt	94;20	34;30
24	Balkh	81;0	36;11
25	Badakhshān	84;24	37;10
26	Bukhārā	97;30	39;50
27	Samarqand	99;16	39;37
28	Khujand	100;35	41;55
29	Kāshghar	106;30	44;0
30	Khutan	107;0	42;0
31	Hurmūz	92;0	25;0
	Middle Circle		
32	Kirmān	91;30	30;5
33	Ghazna	104;20	33;35
34	Kābul	104;40	34;30
35	Dabīl	102;30	25;10

	Place Name	L	φ
36	Qandahār	107;40	33;0
37	Tubbat	110;0	40;0
38	Kashmīr	108;0	35;0
39	Multān	107;35	29;40
40	Lāhūr	109;20	31;50
41	Dihlī	113;35	28;39
42	Akra	115;0	26;43
43	Qannawj	115;50	26;35
44	Banāras	117;20	26;55
45	Kawāliyār	115;0	26;29
46	Barūj	112;5	21;20
47	Lahkanawtī	114;4	26;30
48	Kopāmaw	116;33	26;45
49	Karah Manakpūr	118;10	29;49
50	Ajmīr	112;0	26;0
51	Awadh	118;6	27;22
52	Baran	114;0	28;48
53	Kol Jalālī	114;19	28;4
54	Badāūn	114;59	27;32
	Inner Circle		
55	Kalpī	116;45	26;56
56	Jawnbūr	119;6	26;36
57	Jadda	76;0	21;0
58	Ujjayn	110;50	23;30

	Place Name	L	φ
59	Narwar	114;0	25;20
60	Mandū	112;25	22;15
61	Burhānpūr	113;0	20;30
62	Dawlatābād	111;0	20;30
63	Juyūl	106;40	19;0
64	Aḥmadābād	108;40	23;15
65	Kolkanda	114;20	28;4
66	Bijāpūr	105;30	16;20
67	Sarāndib	104;0	10;0
68	Jamkūt	177;0	5;0
69	Baykanil?	97;30	19;45

BACK

The rim of the two upper quadrants carries altitude scales which are divided in 1°, 3°, 6° as in the front and numbered in 6s as 6—90; 90—6. The rim of the lower half is engraved with the scales of cotangents and their subdivisions.

In the upper left quadrant, there are 30 horizontal parallels, every third highlighted with dots. The upper right quadrant is divided by dotted quarter circles into 6 zones, each representing a pair of signs; each sign is subdivided into decans by plain quarter circles. The signs are labelled with their serial numbers from 0 to 11and the decans as 10, 20, 30 along the two radii. On this quadrant are drawn two solar meridian altitude graphs for the latitudes 27° and 32° with the usual labels.

In the lower half, there are shadow squares, on the left for the base of 12 and on the right for 7, with the usual divisions and labels. Within the shadow squares are two semi-circular rows containing the names of the 28 lunar mansions and the 12 corresponding zodiac signs, the latter indicated by their serial numbers from 0 to 11.



Figure A055.3 – Back of the astrolabe (photo by S. R. Sarma)

PROVENANCE

Formerly in the private collection of Henri Michel; donated by Billmeir to the Museum of the History of Science.

A056 ASTROLABE ATTRIBUTABLE TO MUḤAMMAD MUQĪM, NOT DATED

Diameter 105 mm

Qatar, Doha, Museum of Islamic Art (# MW.396.2007); ex-London, Christie's (auction catalogue of 7 Match 1991, lot 86)

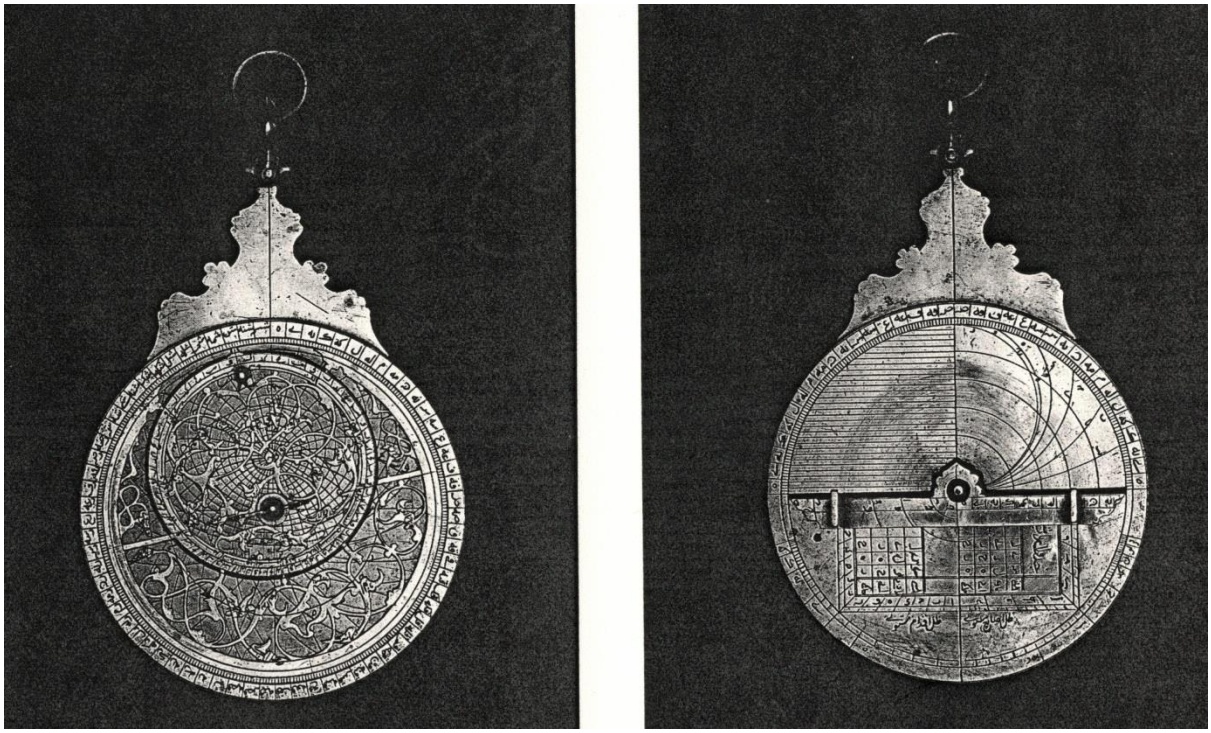


Figure A056.1 – Front and back views of the astrolabe (© Christie's, London)

With the extravagant form of its *kursī,* this astrolabe looks exactly like the astrolabe at the Institut du Monde Arabe, Paris (A042). Both have the same diameter of 105 mm, but there is a subtle difference in the design of the tracery in the rete. In the astrolabe at Paris, the tracery inside the ecliptic ring winds like a spiral and comes to stop midway between the centre of the rete and the southern tip. But here, the tracery makes loops around the inner edge of the ecliptic ring. More differences, but also similarities, can be seen on the back.

COMPONENTS

Body with *kursī* (d. 105), shackle and ring, rete, 4 plates, alidade, pin and wedge.

FRONT

The ling is very large; the shackle is of trifoliate shape. The high *kursī* is solid and plain, but the profiles are flamboyant with tri-lobed protuberances. The degree scale on the limb is divided in 1° and 5° and numbered from 5 to 360.

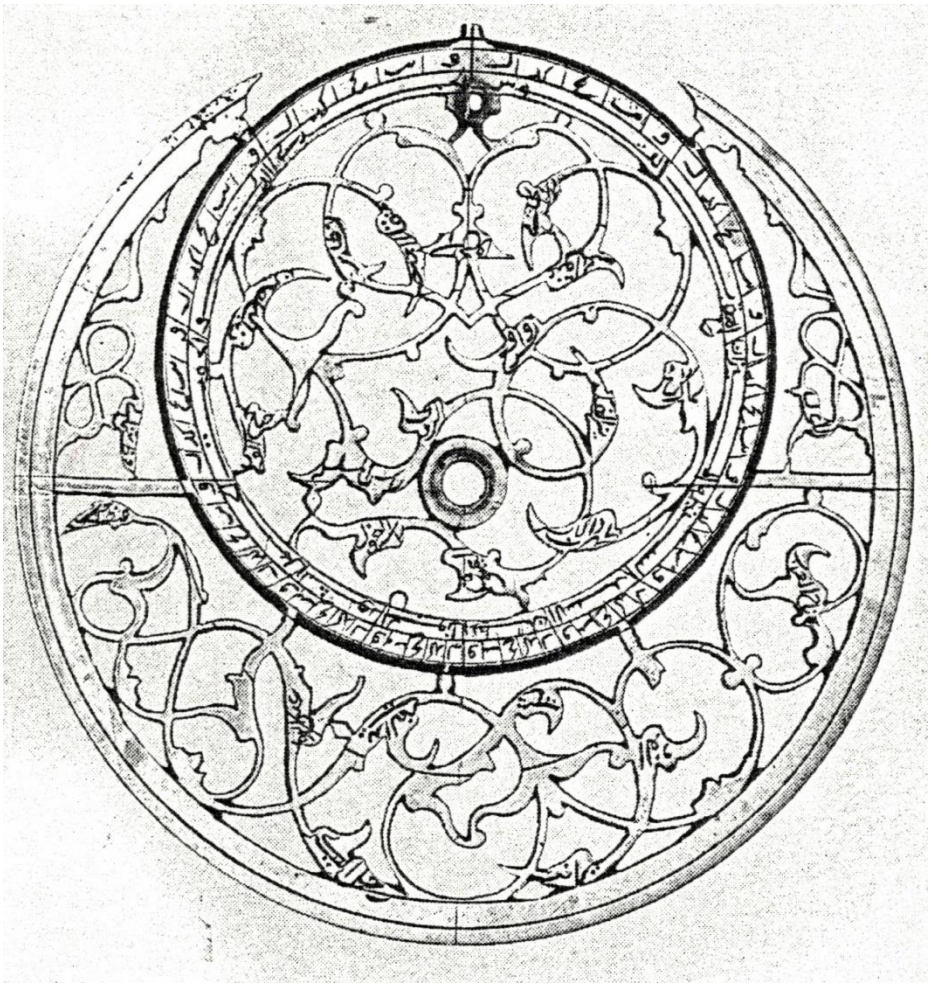


Figure A056.2 – Rete of the astrolabe (© Christie's, London)

Rete

The peripheral Capricorn ring and the ecliptic ring are joined by the equinoctial bar and the floral tracery that joins the star pointers. Unusually, the equinoctial bar is not represented in full; only two segments in the east and west situated between the rings are shown. The upper edge of the eastern segment and the lower edge of the western segment lie on the equinoctial colure. The ecliptic ring is divided in 12 signs of the zodiac and labelled with their names; each sign is divided in units of 6° and numbered accordingly. Traces of the broken lines of the equinoctial and solstitial colures are visible. There are about 25 named star pointers. There is a handle at the top, just below the ecliptic ring.

Plates

There are four plates; three plates are designed for latitudes 22° and 29°, 32° and 34°, 37° and 42°. The fourth plate is engraved with the plate of ecliptic coordinates on one side and with the plate of horizons on the other. The numerical values of latitudes

and hours are engraved in the same line after the argument. The photos of these plates are published in Christie's catalogue, but the values of the maximum duration of the daylight are difficult to read in those photos. In the plate of horizons, there are eight sets of half horizons which are not properly numbered. The declination scales are drawn only twice, not along the diameters, but obliquely at the SW. These scales are not numbered.

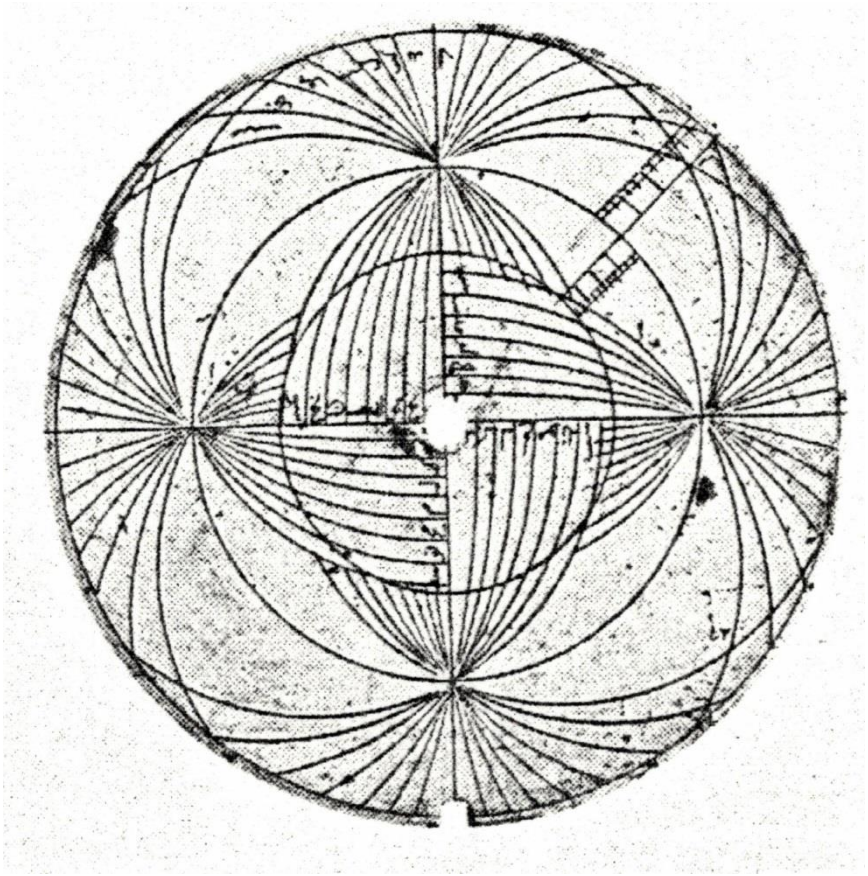


Figure A056.3 – Plate of horizons (© Christie's, London)

Geographical Gazetteer

No information is available about the geographical gazetteer.

Back

On the back, the rim of the upper half carries two altitude scales divided in 1° and 5° and numbered as 5—90; 90—5. In the upper left is a trigonometric quadrant with 30 horizontal parallel lines. The upper right quadrant is divided by solar declination arcs into 6 zones, one each for a pair of zodiac signs. Neither the names of the signs, nor their serial numbers are engraved along the two radii. Here is engraved also a universal horary quadrant with 6 hour lines. From the horizontal radius up to the vertical radius, the hours are numbered from 1 to 6, and in the reverse direction from 7 to 12.

Shadow squares are drawn in the lower half, on the left for a gnomon of 7 feet and on the right for a gnomon of 12 digits. The vertical and horizontal scales on the left are divided into 7 units and numbered accordingly. On the right, the scales are first divided into 4 units and then in a parallel column in 12 units. They are numbered in 3s as 3, 6, 9, 12. The vertical scales do not carry any labels; the horizontal scale on the left has the label *ẓill aqdām mustawī* and that on the right *ẓill aṣābiʿ mustawī.*

The rim on the lower half is engraved with cotangent scales. The unequal divisions of the cotangent scale on the left are numbered as is 5, 10, 15, 20, 25, but there is no label thereafter. There is a division of 7, but it is not numbered. These divisions are subdivided into 5 units in the parallel column. The unequal divisions of the cotangent scale on the right are numbered as 6, 12, 18, 24, 30, 36, 42, without a label thereafter. These divisions are subdivided into 5 units in the parallel column.

Within the shadow squares, there are two small tables of the triplicities with the heading *jadwal arbāb muthallathāth* (table of the regents of the triplicities).

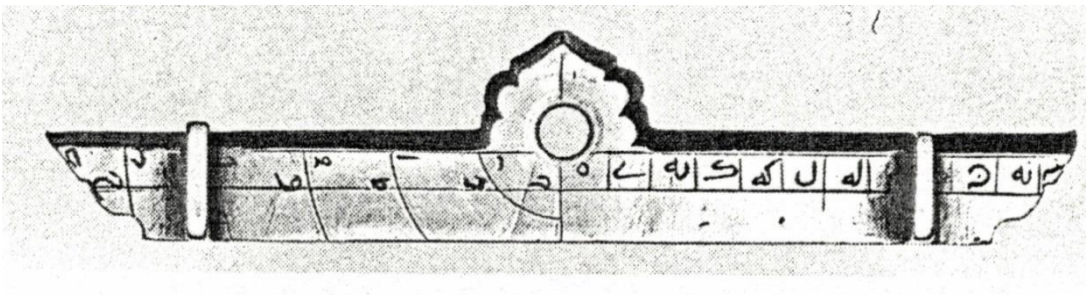


Figure A056.4 – Graduated alidade (© Christie's, London)

Alidade

The alidade has ornate ends and an ornate centre piece. The right hand side is calibrated with a sexagesimal scale to match with the trigonometric quadrant and numbered in 5s from the centre up to the end from 5 to 60. The left hand side has a solar longitude scale marked with the serial numbers of the signs for use with the solar quadrant. The wedge is of silver.

Bibliography

Christie's catalogue of 7.3.1991, lot 86, with a full set of photos.

A057 ASTROLABE ATTRIBUTABLE TO MUḤAMMAD MUQĪM, NOT DATED

Diameter 100 mm

Hyderabad, Saidiya Library



Figure A057.1 – Front of the astrolabe (photo by Ahmad Athaullah)

A highly interesting miniature astrolabe with many unusual features, such as the lines for the beginning and end of the *ʿaṣr* prayers at 27° and 32° on the back (cf. A040 and A054), crepuscular prayer lines on the plates, interesting composite projections in plate 6a, and western type of horizons.

COMPONENTS

Body (d. 100, h. 120, t. 10) with ring, shackle, rete, 6 plates, alidade, pin, washer, wedge (?), wooden case.

FRONT

The *kursī* is solid and plain with two large eyelets on the sides in the style of the Kufic astrolabes as in A047 and A048. The finial is trifoliate but not pronounced. The shackle is large and of trifoliate shape. The limb is graduated in 1° and 6° and numbered in 6s from 6 to 360.



Figure A057.2 – Rete of the Astrolabe (photo by Ahmad Athaullah)

RETE

The peripheral Capricorn ring is very slender and the ecliptic ring very wide; these two are held together by the equinoctial bar which changes counter four times. The circles of the Tropic of Cancer and of the ecliptic are well marked in their respective rings. Traces of the equatorial circle and of the Tropic of Cancer are visible on the ecliptic ring. The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names. Each sign is subdivided in groups of 6° and numbered accordingly. The 22 star pointers to the south of the ecliptic and 19 to the north are joined by unconnected segments of tracery. There is a handle on the rim at the NW point.

PLATES

There are six plates. They do not have a notch at the north point as is the general practice, but a hole, as large as the hole and the centre, on the meridian a little above the north point. At the same place on the inner side of the mater is a pin which receives the plates.

Table A057-1 Plates

	φ	Longest Day	
1a	25°	13;25 hours	crepuscular prayer lines
1b	22°	13;22 hours	north + south projection ?
2a	0°+90°		
2b	18°+ 72°		
3a	40°	14;54 hours	crepuscular prayer lines
3b	36°	14;22 hours	crepuscular prayer lines
4a	27°	13;46 hours	crepuscular prayer lines
4b	32°	14;8 hours	crepuscular prayer lines
5a	30°+72°		
5b	Plate of ecliptic coordinates		
6a	Plate of horizons (western type, 8 sets of horizons)		
6b	27°+32°		

φ	Longest Day

On 5 plates there are crepuscular or twilight prayer lines 18° below the horizon. They carry labels *ṭulūᶜ al-fajr* (rise of the morning twilight) on the east and *maghīb al-shafq* (setting of the evening twilight) on the west.

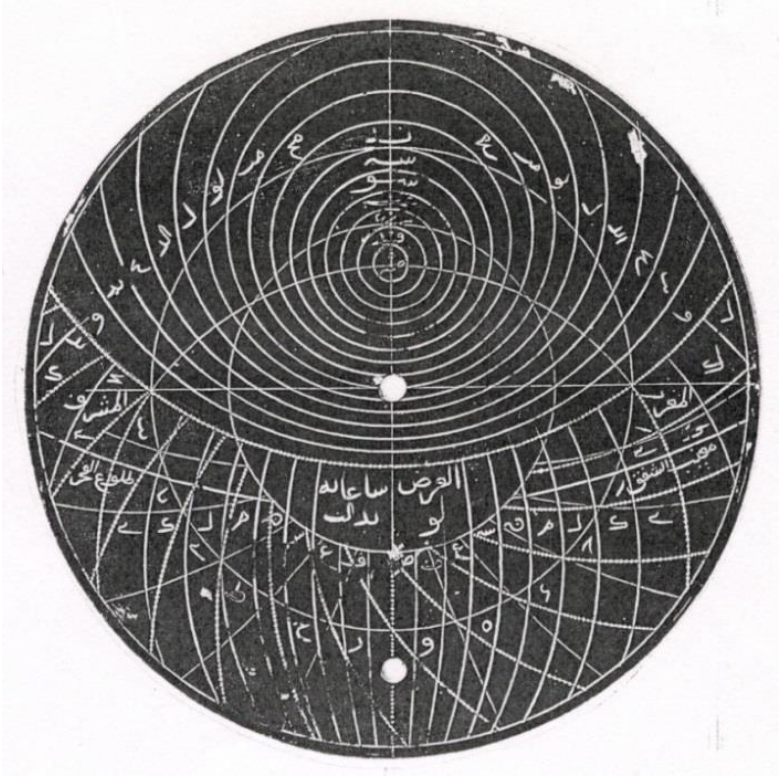


Figure A057.3 – Plate for latitude 36° (photo by Ahmad Athaullah)
Notice the crepuscular lines below the horizon and the labels in the east and west.

Plate 1b is calibrated for latitude 22°. On this plate altitude circles are drawn also below the horizon in a southern projection (cf. Figure A013.6)

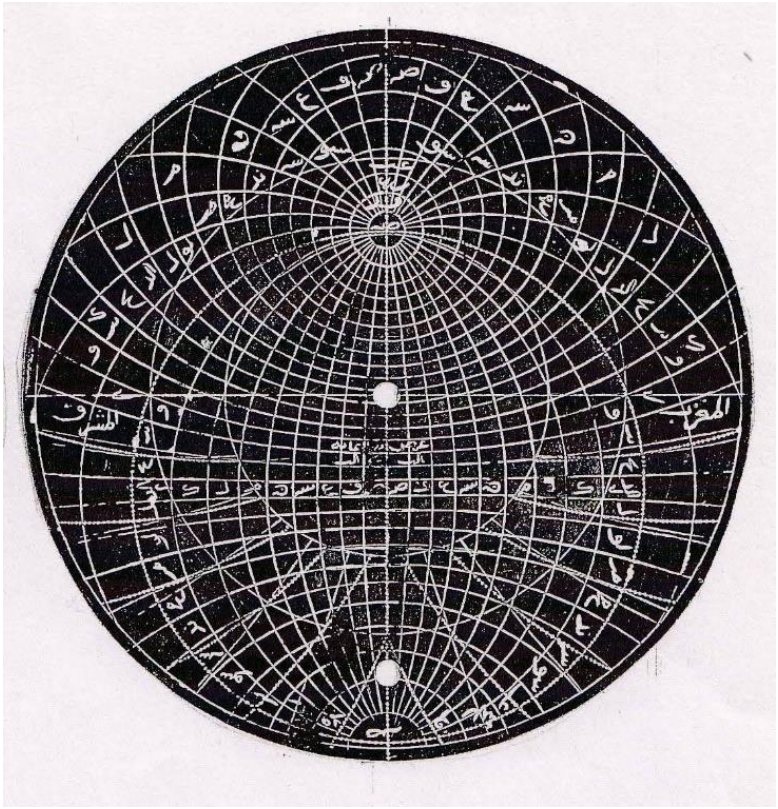


Figure A057.4 – Plate 1b for latitude 22° (photo by Ahmad Athaullah)

On 6b, are composite projections of 27° and 32°. There are two families of arcs representing 6° of astrologiacal houses at these latitudes. [349]

[349] Similar arcs are to be seen on the plate to be used with the Zawraqi horizons in Qāi'm's astrolabe of 1635 (A013).

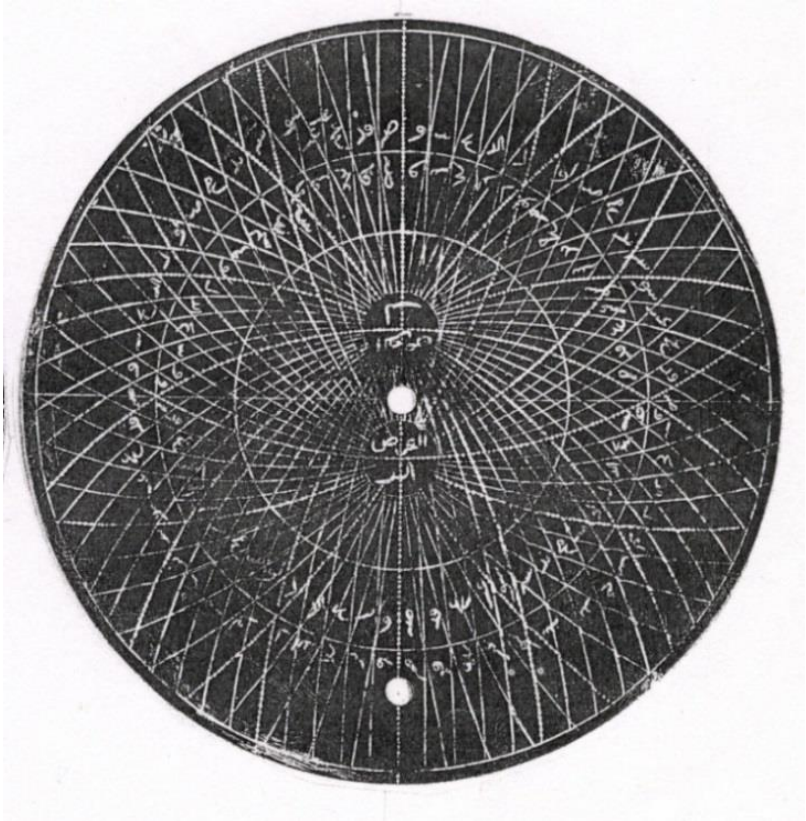


Figure A057.5 – Composite plate for latitudes 27° and 32° (photo by the Owner)

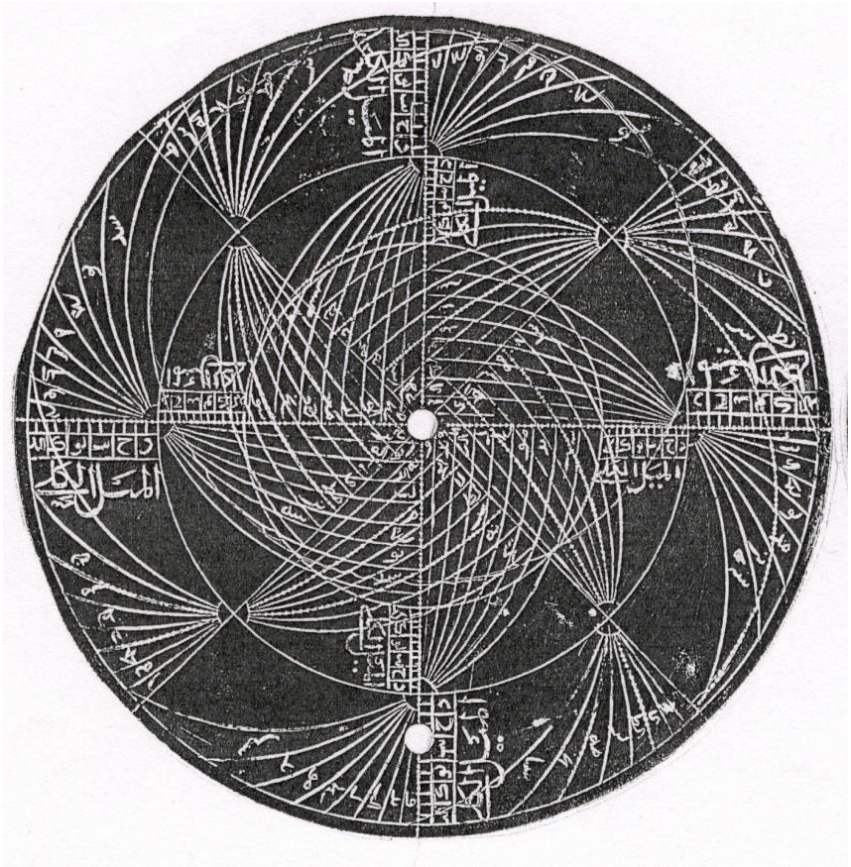


Figure A057.6 – Plate of horizons (photo by the Owner)

On the plate of horizons are engraved 8 sets of half horizons for each degree of latitude from 6° to 67°. The half horizons are arranged in the style of the astrolabes of the Maghrib.

6	14	…	54	62
7	15	…	55	63
8	16	…	56	64
9	17	…	57	65
10	18	…	58	66
11	19	…	59	67
12	20	…	60	
13	21	…	61	

Declination scales are engraved along the horizontal and vertical diameters, once each between the Tropic of Capricorn and equator and between the equator and the Tropic of Cancer. The scales are divided in 2° and numbered in 4s from 4 to 22. They are accompanied by the label *al-mayl al-kullī* (the maximum declination). But the name of the plate is not engraved.



Figure A057.7 – Geographical gazetteer (photo by Ahmad Athaullah)

GEOGRAPHICAL GAZETTEER

On the inner side of the mater is engraved, very neatly and in two concentric bands, a geographical gazetteer which contains the names, longitudes and latitudes of 54 localities.

Table A057-2 Geographical Gazetteer

	Place Name	L	φ
	Outer Circle		
1	Miṣr	63;20	30;20
2	Madīnat Rasūl	75;20	25;0

	Place Name	L	φ
3	Makka Mubārak	77;10	21;40
4	Bayt al-Maqdis	66;30	31;50
5	Dimashq	70;0	33;15
6	Ḥalab	72;10	35;50
7	Maragha	87;10	34;20
8	Tabrīz	82;0	38;0
9	Kūfa	79;10	31;30
10	Baghdād	80;0	33;25
11	Baṣra	84;0	30;11
12	Fīrūzābād	87;30	28;10
13	Shīrāz	88;0	29;36
14	Yazd	89;0	32;0
15	Qazwīn	85;0	36;0
16	Iṣfahān	86;40	32;25
17	Kāshān	86;0	34;0
18	Bistām	89;30	36;10
19	Sabzawār	91;30	37;0
20	Mashhad	92;6	37;0
21	Harāt	94;20	34;30
22	Balkh	101;0	36;41
23	Badakhshān	104;24	37;10
24	Bukhārā	97;30	39;50
25	Samarqand	99;36	39;37
26	Khujand	100;35	41;55

	Place Name	L	φ
27	Kāshghar	106;30	44;0
28	Khutan	107;0	42;0
29	Hurmūz	92;0	25;0
30	Kirmān	91;30	30;5
31	Ghazna	104;20	33;35
32	Kabul	104;40	34;30
33	Dabīl	102;30	25;10
34	Qandahār	107;40	33;0
35	Tubbat	110;0	40;0
	Inner Circle		
36	Kashmīr	108;0	35;0
37	Lāhūr	109;20	31;50
38	Haḍrat Dihlī	114;33	28;33
39	Ākra	114;0	27;13
40	Qannawj	115;50	26;35
41	Bānāras	117;20	26;55
42	Kawāliyar	115;0	26;29
43	Baruj	101;5	21;20
44	Kālpī	117;45	25;56
45	?	108;45	32;30
46	Jawnbūr	119;6	26;36
47	Kara	117;6	26;36
48	Jadda	76;0	21;0
49	Ajmīr	110;50	23;30

	Place Name	L	φ
50	Bījābūr	105;30	-- --
51	Burhānbūr	103;4	20;30
52	Kūlkanda	114;19	-- --
53	Sarāndīb	130;0	10;0
54	Kanbayāt	109;4	22;20



Figure A057.8 – Back of the astrolabe (photo by Ahmad Athaullah)

BACK

The rim of the upper half carries altitude scales divided in 1° and 6° and numbered in 6s as 6—90; 90—6. In the upper left is engraved a trigonometric quadrant with 60 equidistant horizontal parallels, with every sixth highlighted with dots. Radials are drawn for each 6° of arc to facilitate the determination of cosines. Every sixth line of these parallels is highlighted with dots.

On the upper right is a solar quadrant, with a circle of declination each for a pair of zodiac signs. Upon these circles horizontal parallels are stereographically projected, one for each 3° of arc. Every alternative line of these parallels is highlighted as a dotted line. Superimposed upon this grid are two curves for the solar meridian altitude for all seasons. The upper one is dotted; it is for the latitude 27° (Agra) and carries the label: *khaṭṭ nisf al-nahār bi-ᶜarḍ 27.* The lower curve is plain and meant for the latitude 32°. It carries the label *khaṭṭ nisf al-nahār bi-ᶜarḍ* 32. Below this pair there is a second pair of dotted and plain curves, with the labels [*khaṭṭ*] *awwal ᶜaṣr 27* and [*khaṭṭ*] *awwal ᶜaṣr 32* (line of the begin of the mid-afternoon prayer *ᶜaṣr* at latitudes 27° and 32°). This is followed by a third pair of dotted and plain curves with the labels [*khaṭṭ*] *ākhi*[*r*] *ᶜaṣr 27* and [*khaṭṭ*] *ākhir ᶜaṣr 32* (line of the end of the afternoon prayer). These two additional sets of curves show the times of the beginning and end of mid-afternoon prayer called *ᶜaṣr*.



Figure A057.9 – Upper right quadrant on the back with the prayer lines (photo by the Owner)

Two shadow squares are engraved in the lower half, on the left for the base of 7 and on the right for the base of 6 and 12; the vertical and horizontal scales on both sides are divided, numbered and labelled accordingly.

Inside the shadow squares is a table with the heading *faḍl al-dawr* (excess of revolution).

The rim of the lower half is engraved with the cotangent scales and their subdivisions in two semi-circular rows. The next 6 semi-circular rows contain the names of the 28 lunar mansions, the names of 12 zodiac signs, the limits of the signs and the decans and their regents.

ALIDADE

The alidade has ornate ends and ornate centre-piece. The right hand side is endowed with a sexagesimal scale matching with the divisions on the upper left

quadrant; the left hand side is engraved with a zodiac scale to match the divisions on the upper right quadrant. There is a nicely carved wooden box for the astrolabe.



Figure A057.10 – Wooden box for the astrolabe (photo by Ahmad Athaullah)

A058⊙ ASTROLABE BY MUḤAMMAD MUQĪM, NOT DATED

Diameter 92 mm

Leiden, Museum Boerhaave (A 277)

CCA 1097



Figure A058.1 – Front of the astrolabe (photo by Professor Jan Houben)

The signature on the back of this well-crafted astrolabe states that it is the 'work of the servant Muḥammad Muqīm' (*ʿamal al-ʿabd muḥammad muqīm*). In a long study of this astrolabe, published in 1948, C. A. Crommelin, the then director of the Museum Boerhaave,[350] assumed that this Muḥammad Muqīm is the Muḥammad Muqīm of the well-known Lahore family.[351] But a closer examination of the astrolabe shows that it differs considerably from the astrolabes signed by Muḥammad Muqīm of Lahore. For one thing, the signature merely mentions the name Muḥammad Muqīm without any reference to the forefathers as is usually done on the Lahore astrolabes. There is no plate calibrated for the latitudes of 27° and 32° on its two sides, nor are there solar meridian altitude curves for these latitudes on the back, which are invariably present in all the astrolabes signed by Muḥammad Muqīm of Lahore. Furthermore, there are several features in this astrolabe which differ from the extant astrolabes made by Muḥammad Muqīm of Lahore. Strangest of all is that on the star pointers of the rete, aside from the names of 38 fixed stars, the names of five terrestrial cities are engraved, these being Baghdād, Makka, Mashhad, Madīna and Kūfa

There is another astrolabe maker of the same name, viz. Muḥammad Muqīm al-Yazdī, who is almost contemporaneous to Muqīm of Lahore. Five of his astrolabes are said to be extant. One of these, dated AH 1057 (AD 1047-48) is with the Museum of the History of Science, Oxford (45747); another, undated, is at the National Maritime Museum, Greenwich (AST0566). Stylistically, these astrolabes differ markedly from the present astrolabe at Leiden.

Between the two Muḥammad Muqīms then, the one from Lahore is more likely to be the maker of the present astrolabe. Therefore, this is astrolabe is included in his oeuvre.

COMPONENTS

Body with *kursī* (d. 92, h. 118, t. 5.5), shackle, ring and cord, rete for 38 stars, 4 plates (d. 80), rule, alidade, pin and wedege. Ring, shackle, rule and wedge are probably replacements.

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350 Crommelin 1948.

351 Crommelin 1948, p. 25: 'Lahore, le domicile du constructeur, a une latitude de 31°30′….'.

FRONT

The *kursī* has lobed profiles and a trifoliate finial; it is elegantly fretted with large symmetric perforations; two hour-glass shaped motifs are on the central vertical line.

The limb is divided in 1° and 5° and numbered in 5s as 5—360. The *Abjad* numerals are written upside down (i.e. the upper parts of the letters are towards the centre of the astrolabe), which is somewhat unusual.

RETE

The peripheral Capricorn ring and the ecliptic ring are held together by the equinoctial bar which is counter-changed at the equinoxes. A segment of solstitial bar runs from the centre to the upper rim, but bifurcates itself before reaching it. The ecliptic ring is divided into the twelve signs of the zodiac and labelled with their names. Each sign is divided in groups of 6° and the divisions are numbered accordingly as 6, 12, 18, 24 and 30. A round handle is attached on the peripheral ring slightly to the left of the north point. There are 36 mainly leaf-shaped star pointers. The tracery joining the star pointers is not continuous, but consists of separate clusters, each joining a few star pointers. On the leaves and on the tendrils which join them, there are deeply-cut decorative lines. This feature is not seen in the astrolabes signed by Muqīm of Lahore. The star list reproduced below is substantially after Crommelin, but here it is rearranged in the order of increasing right ascension; some stars which Crommelin did not notice are added here.



Figure A058.2 – Rete of the Astrolabe (photo by Professor Jan Houben)

Table A058-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab [al-Qayṭus] Shamālī*	ι Ceti
2	*Dhanab [al-Qayṭus Janūbī]*	β Ceti
3	*Dhanab al-Musalsala*[352]	β Andromedae

[352] Engraved as Ḥanab al-Musalsalah.

	Star Name	Identification
4	*Ṣadr al-Qayṭus*	π Ceti
5	*Fam [al-Qayṭus]*	γ Ceti
6	*Mirfaq al-Ghūl*	α Persei
7	*Tālī Masāfat [al-Nahr]*	γ Eridani
8	*ᶜAyn al-Thawr*	α Tauri
9	*Rijl al-Yusrā*	β Orionis
10	*Yad al-Yusrā*	γ Orionis
11	*Yad al-Yumnā*	α Orionis
12	*Rijl [al-Yumnā]*	κ Orionis
13	*Shiᶜrā Yamānī*	α Canis Majoris
14	*Shiᶜrā Shāmī*	α Canis Minoris
15	*Ṭarfat al-Safīna*	ρ Puppis
16	*Fard al-Shujāᶜ*	α Hydrae
17	*Qalb al-Asad*	α Leonis
18	*Ẓahr al-Dubb*[353]	α Ursae Majoris
19	*Qā ᶜidat [al-Bāṭiya]*	α Crateris
20	*Janāḥ al-Ghurāb*	γ Corvi
21	*Qā'id [al-Dubb]*	η Ursae Majoris
22	*Simāk Aᶜzal*	α Virginis
23	*[Simāk] Rāmiḥ*	α Bootis
24	*Nayyir al-Fakkah*	α Coronae Borealis
25	*ᶜUnuq al-Ḥayyah*	α Serpentis

[353] Engraved as *Dūb.*

	Star Name	Identification
26	*Rukbat [al-Ḥawwā]*	ε Ophiuchi
27	*Qalb al-ᶜAqrab*	α Scorpii
28	*Mirfaq al-Ḥawwā*	κ Ophiuchi
29	*Rās [al-Ḥawwā]*	α Ophiuchi
30	*[Nasr] Wāqiᶜ*	α Lyrae
31	*Dhanab al-ᶜUqāb*	ζ Aquilae
32	*Minqār al-Dajājah*	β Cygni
33	*Nasr Ṭā'ir*	α Aquilae
34	*Dhanab [al-Dajājah]*	α Cygni
35	*Fam [al-Faras]*	ε Pegasi
36	*Dhanab al-Jadī*	δ Capricorni
37	*Mankib al-Faras*	β Pegasi
38	*Kaff [al-Khaḍīb]*	β Cassiopeiae

It is strange that the stars include *Mirfaq al-Ghūl* (α Persei) instead of the more common *Rās al-Ghūl* (β Persei). *Qā'id al-Dubb* (η Ursae Majoris) and *Dhanab al-ᶜUqāb* (ζ Aquilae) are also rarely used in the Lahore astrolabes.

Most unusual is that the names of five terrestrial localities are engraved on star pointers: Baghdād (*a*), Makka (*b),* Mashhad (*c*), Madīna (*d*) and Kūfa (*e*). The purpose of these terrestrial names in the stellar regions is inexplicable.

Plates

There are four plates, each with a rectangular notch at the north point, to fit into the peg at the corresponding place in the mater. Strangely there is no plate calibrated on one side for latitude 27° (Agra) and on the other for latitude 32° (Lahore); such a plate occurs invariably in all astrolabes made by Muḥammad Muqīm of Lahore. Plate 2a is made for the latitude of Delhi at 29°, but this capital city of India is not mentioned in the geographical gazetteer which, however, includes Agra and Lahore.

Table A058-2 Plates

	φ	Longest Day
1a	24°	13;30 hours
2a	29°	13;52 hours
3a	30°	13;58 hours
2b	34°	14;19 hours
3b	36°	14;28 hours
1b	37°	14;34 hours
4a	0°+ 90°	
4b	Plate of horizons	

Plates 1-3 have altitude circles traced for every 6°. Under the western and eastern horizons *al-maghrib* and *al-mashriq* are inscribed respectively. The azimuth arcs and hour circles vary from plate to plate. On some plates (24°and 29°) there are no azimuth arcs at all.

On three plates (29°, 30° and 34°), seasonal hours are marked with ordinal numbers which are engraved just below the circle of equator: *al-awwalī* (the first), *al-thāniyah, al-thālitha, al-rābiᶜa, al-khāmisa, al-sādisa, al-sābi'a, al-thāmina, al-tāsiᶜa, al-ᶜāshira, al-hādī ᶜashr, al-thāniya ᶜashr.* On plate 2a for 29° and on 2b for 34°, both the seasonal hours and the equal hours counted from the western horizons have the ordinal numbers as common labels.

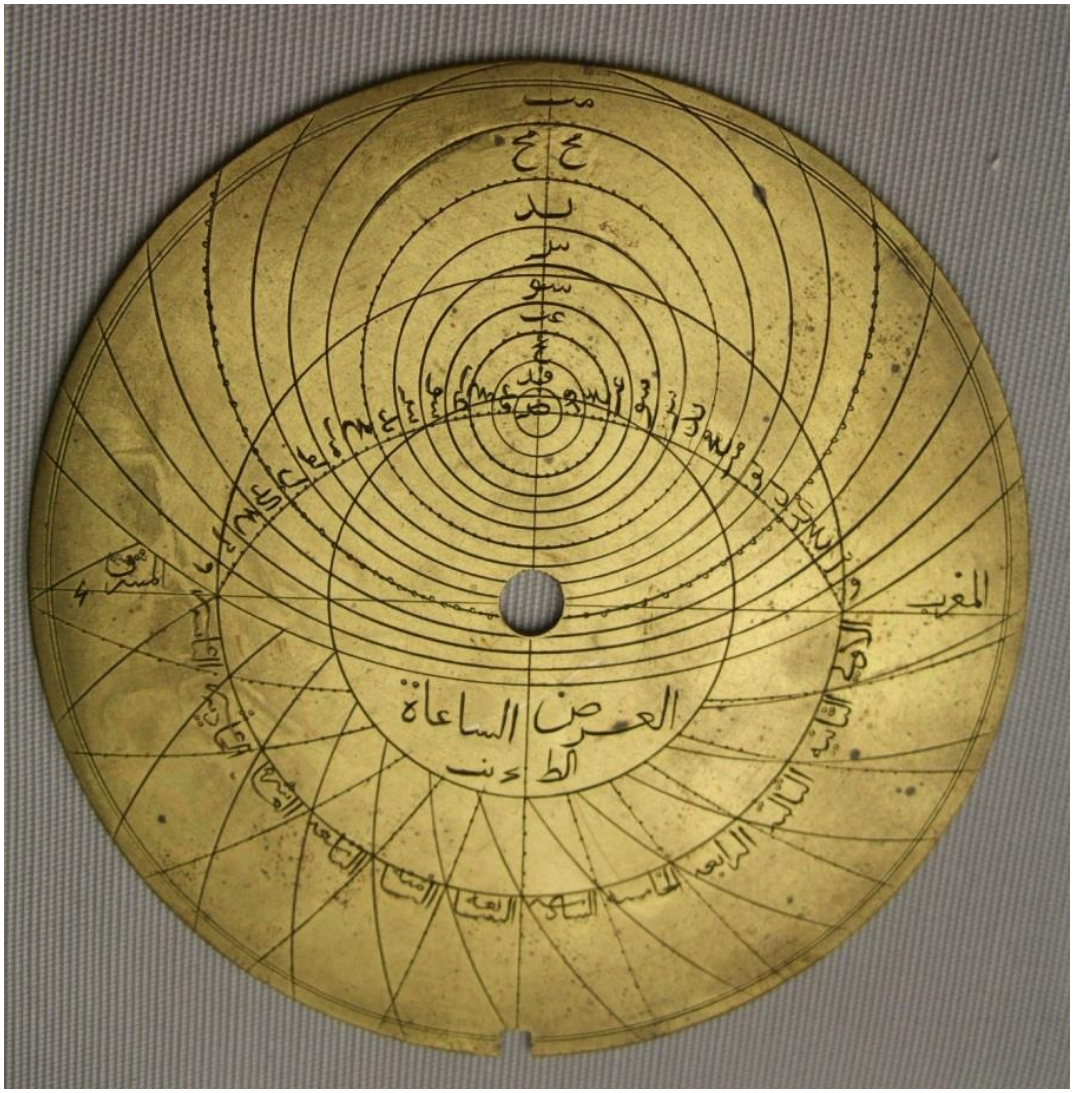


Figure A058.3 – Plate for latitude 29° (photo by Professor Jan Houben)

On plate 2b for latitude 34° altitude circles are drawn for every 6°; these are numbered on both sides of the meridian. Every fourth line (i.e. 24°) is highlighted by small circles and not with dots as is the usual case. Azimuth arcs are drawn above the horizon for every 10°; these are also numbered on both sides of the meridian. Every third line (i.e., 30°) is highlighted by dots. Interestingly, on the altitude circles for 24° and 48°, their points of intersection with azimuth arcs are marked with large X-like symbols.

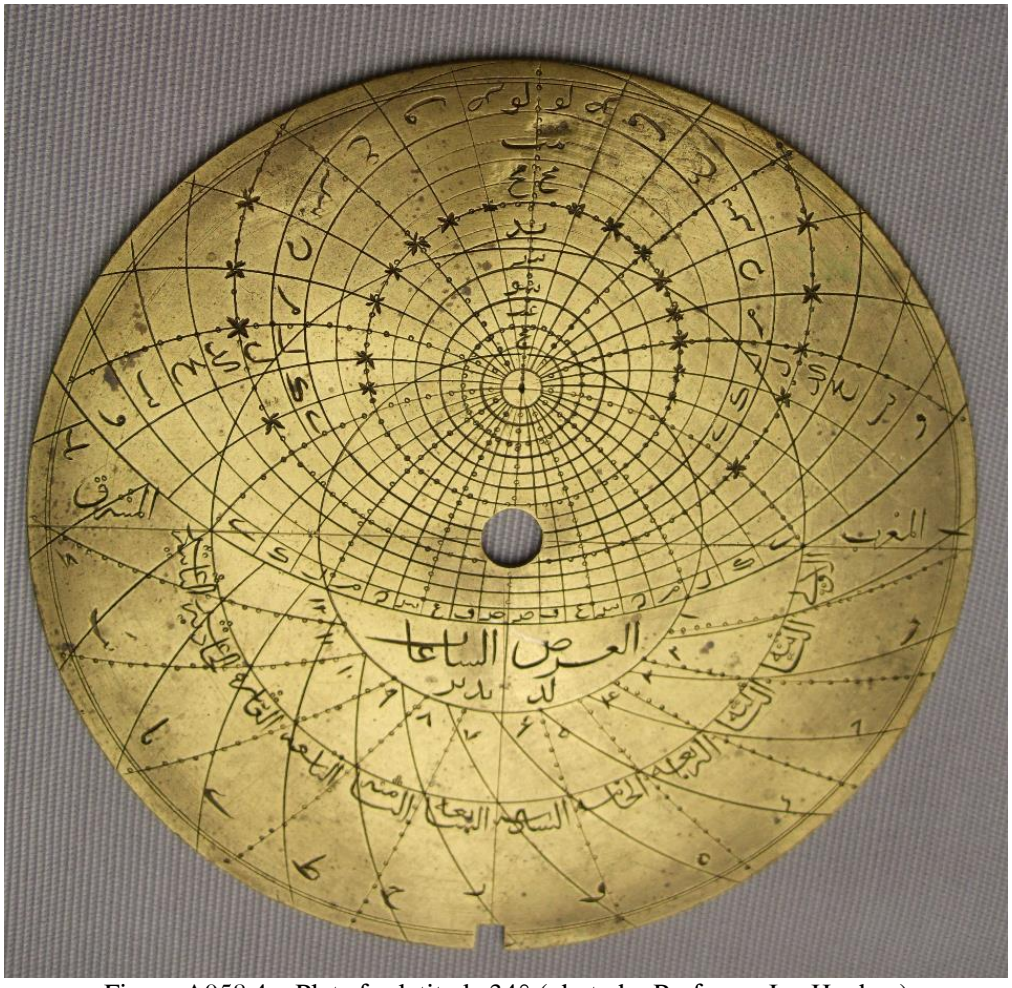


Figure A058.4 – Plate for latitude 34° (photo by Professor Jan Houben)

In the lower half are drawn dotted lines for seasonal hours and plain lines for equal hours from the western horizon. The seasonal hours are numbered from 1 to 12 in common Arabic/Persian numerals just below the circle of the Tropic of Cancer. The equal hours are numbered on the rim from 1 to 14 in *Abjad* symbols. Finally, both kinds of hours are jointly numbered in ordinal numbers in Persian below the arc of the equator. On this plate, the small circles used in the place of dots on the lines as well as in words appear to have been punched with a die and not engraved by hand.

While 4a carries a combined projection of 0° and 90° as in many Lahore astrolabes, the reverse side 4b is engraved as the plate of horizons, with the following four sets of half-horizons for latitudes from 12 to 66, which are numbered at both the extremities:

12	20	28	36	44	52	60
14	22	30	38	46	54	62
16	24	32	40	48	56	64
18	26	34	42	50	58	66

In addition, there is a full circle for the arctic latitude 72° (see also A054). But there are no declination scales.



Figure A058.5 – Geographical gazetteer (photo by Professor Jan Houben)

Geographical Gazetteer

The gazetteer provides the names, longitudes, latitudes, *inḥirāf* and *jahat* of 52 localities in two circles. In the outer circle, the five items are arranged in the sequence of *jahat*, place name, longitude, latitude and *inḥirāf*; in the inner row the sequence is place name, longitude, latitude, *inḥirāf* and *jahat.* The last two parameters are not given for all places. Of the 52 localities, only three (Lahore, Multan and Agra) are in India proper.

Table A058-3 Geographical Gazetteer

	Place Name	L	φ	*inḥirāf*	*jahat*
	Outer circle				
1	Makka	77;10	21;40	0;0	
2	Madina	75;20	25;0	37;10	SE
3	Miṣr	63;20	30;20	—	—
4	Sanaʿā’	74;0	14;30	—	—
5	[A]l-Ḥasā	83;30	24;0	69	—
6	Bayt al-Maqdis	66;0	31;50	—	—
7	Dimashq	70;0	33;15	—	—
8	Ḥalab	72;10	35;50	80;35	SE
9	Mawṣil	77;0	34;30	—	—
10	Nakhjewān	81;15	38;40	—	—
11	Marāghah	82	37;20	16;11	SW (*gh-j*)
12	Tabrīz	82;0	38;0	15;46	SW
13	Ardabil	82;30	38;0	17;4	SW

	Place Name	L	φ	*inḥirāf*	*jahat*
14	Sarmar Rāī[354]	79	34;0	4;16	SW
15	Amul	88;20	36;5	35;1	SW
16	Kūfa	79;30	31;30	—	—
17	Baghdād	80;0	33;25	??	SW
18	Baṣra	84;0	30;0	16;5	
19	Shustar	84;30	31;30	—	—
20	Kāzirun	87;0	29;15	11;14	SW
21	Shīrāz	88;0	29;0	?;8	SW
22	Yazd	89	32	43;29	SW
23	Hamadān	83;0	35;10	32;16	SW
24	Qazwīn	85;0	36;0	37;34	SW
25	Jurbādaqān	85;30	34;14	2?	SW
26	Iṣfahān	86;40	32;25	40;21	SW
27	Kāshān	86;0	34;0	34;31	SW
28	Qumm	85;40	34;45	31;15	SW
29	Tāliqān	85;45	36;10	—	SW
30	Astarābād	89;35	36;50	38;48	SW
31	Samnān	88;0	36;0	36;17	SW
32	Harāt	94;20	34;20	54;8	SW
33	Tūn	92;30	34;30	45;6	SW
34	Tūs	92;30	37;0	45;6	SW
35	Nishābūr	92;30	36;21	—	SW

[354] Correct form is Sarman Rāī, i.e., Samurra

	Place Name	L	φ	*inḥirāf*	*jahat*
	Inner Circle				
36	Sabzewār	92;30	36;0	?	SW
37	Bistām	89;30	36;10	39;8	SW
38	Zūzan	93;30	34;20	—	—
39	Lahāwar	109;20	31;50	—	—
40	Multān	107;35	29;40	—	—
41	Qandahar	104;40	33;0	75;5	SW
42	Samarqand	99;36	39;37	—	—
43	Bukhārā	97;20	39;50	—	—
44	Badakhshān	104;24	37;10	—	—
45	Akra	114	27;13	—	—
46	Kābul	104;40	34;26	—	—
47	Marw	97;0	37;40	52;30	SW
48	Bulghār ?	115	52	—	—
49	Chīn	140	22		
50	[Dhākā] Bankālā	135	23		
51	Istanbūl	?	43		
52	Balkh	105	36		



Figure A058.6 – Back of the astrolabe (photo by Professor Jan Houben)

Back

The rim of the two upper quadrants carries altitude scales which are divided in 1° and 5° and numbered as 5, 10, 5, 20 … 5, 90; 90, 5, … 20, 5, 10, 5.

In the upper left quadrant are traced 30 equidistant horizontal parallels with every fifth highlighted with dots. Upon these are plotted five curves of unequal hours; these are numbered serially from 1 to 6. In the upper right quadrant, 7 declination arcs are drawn at unequal intervals and the related zodiac signs are marked by their serial numbers along the two radii.

In the lower half, close to the centre are two shadow squares; on the left for 7 feet and on the right for 12 digits. The scales are divided and numbered accordingly. The labels are abridged: the vertical scale on the left is labelled as *ẓill aqdām* and that on the right as *ẓill aṣābiʿ*. Two horizontal scales are labelled simply as *mustawī.*

The rim of the lower half carries the cotangent scales. The unequal divisions in the scale on the left are numbered from the meridian onwards as 5, 10, 15, 25, 30, 35; these are followed by the label *ẓill aqdām.* The unequal divisions in the scale on the right are numbered from the meridian onwards as 5, 10, 15, 25, 30, 35, 40, 45, followed by the label *ẓill aṣābiʿ*. Each of these divisions is subdivided into four units in the adjacent semi-circular row.

Inside the cotangent scales are five semi-circular rows. Each one is labelled on the left as well as on the right. The first row, counting from the outside, contains the names of the planetary lords of the limits, indicated by the last letters of their Arabic names, with the label *al-kawākib* (the planets). The second row provides the strengths of the limits with the *Abjad* symbols, with the label *al-ḥudūd* (the limits). In the third row are engraved the names of the zodiac signs in large bold letters; here the label reads *al-burūj* (the signs). In the fourth row are engraved the names of the planetary lords of the decans / faces, three for each sign, with the label *al-wujūh* (the faces). In the fifth and the last row are the names of the 28 lunar mansions with the labels *al-manāzil* (the lunar mansions).

Finally, inside the shadow squares is engraved the table of triplicities, divided according to the four elements, and their nocturnal regents.

ALIDADE ETC

The alidade has ornate ends, but the centre-piece is plain and there are no graduations on the alidade. The pin has a large spherical head. The long wedge has a slit running along the entire length; it must have been taken from some other instrument and

used here as the wedge. The rule in the front does not have any graduations: it may not be original.



Figure A058.7 – Signature on the back (detail from Figure A058.6

INSCRIPTION

The maker's name is engraved inside a triangular arch-like border, above the innermost semicircle and below the shadow squares and reads

ᶜamal al-ᶜabd muḥammad muqīm

'The work of the servant Muḥammad Muqīm'

BIBLIOGRAPHY

Crommelin 1948.

ḌIYĀ' AL-DĪN MUḤAMMAD

The instrument production in the Lahore family reached its culmination, both in quantity and quality, in the oeuvre of Ḍiyā' al-Dīn Muḥammad (*fl.* 1637-1680) of the fourth generation. He is the most prolific and versatile member of the family. He inherited his father Qā'im Muḥammad's skill in casting celestial globes and his uncle Muqīm's virtuosity in crafting astrolabes. He also attempted a number of unusual varieties of astrolabes and globes. There are extant 34 astrolabes which bear his signature; another 12 astrolabes can be attributed to him on stylistic grounds.[355] Moreover, he also produced some 18 celestial globes.

On a majority of his instruments, he signs his name as ضیاؤالدین , but in a few cases he writes without *wāw* (و) ضیاءالدین , as shown in the table below. The name 'Ḍiyā' al-Dīn' means 'the light of the faith' in Arabic and this name is fairly common among Muslims. But it is never written with a *wāw* in between. Scholars of Arabic and Persian whom I consulted are unanimous in saying that the letter *wāw* (و) here is not in accordance with the Indo-Persian or Persian usage and that it should not have been added in this name. From his vast and varied oeuvre, it is evident that Ḍiyā' al-Dīn was not a mere artisan, but a scholar well-versed in mathematical astronomy and well-acquainted with Arabic works on astronomical instruments by the Andalusian astronomers. Why then did he spell his name in this manner in most of his creations remains a mystery.[356]

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[355] CCA attributes the following four astrolabes to Ḍiyā' al-Dīn, but these are not mentioned in the Répertoire; therefore, they are not included in our catalogue:

CCA 3524	nd	d. ?	Paris Landau Collection
CCA 3525	nd	d. ?	Paris Landau Collection
CCA 3517	nd	d. ?	Paris Alain Brieux
CCA 2829	1068/1657	d. ?	'Cairo, Hariri Collection (Instruments now thought to be in Cairo, Museum of Islamic Art)'; but I was informed that the Cairo museum does not have such an astrolabe.

[356] It is also a mystery why the knowledgeable Répertoire refers to him as 'Muḥammad b. Qā'im Muḥammad' in the heading to the section dealing with his instruments and dismisses 'Ḍiyā' ud-Dīn' as the surname!

Astrolabe A061 of 1057/1647-48
Chicago

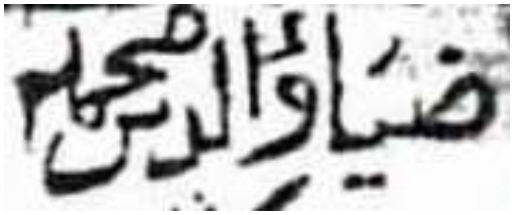




Astrolabe A062 of 1059/1649-50
Lucknow

Celestial Globe of 1064/1653-54
Aligarh





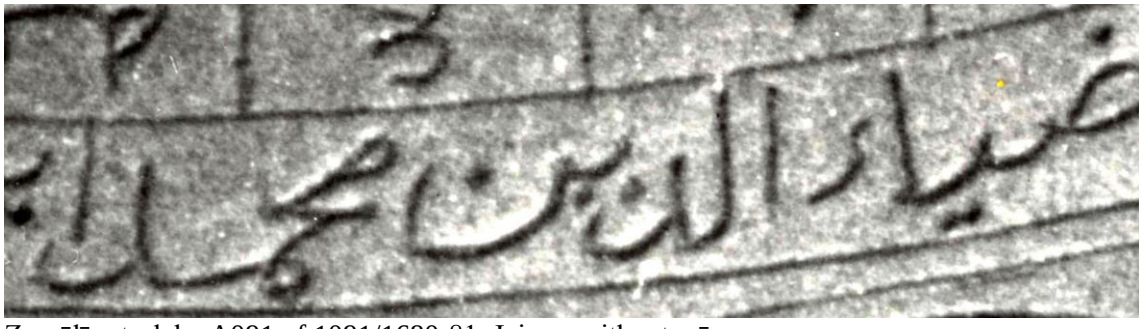
Astrolabe A076 of 1070/1659-60
Washington

Celestial Globe of 1074/1663-64
Hyderabad





Astrolabe A072 of 1067/1656-57
Jaipur, without wāw



Zarqālī astrolabe A091 of 1091/1680-81, Jaipur, without wāw

Ḍiyā’ al-Dīn’s astrolabes range from 52 to 555 mm in diameter. Like Muqīm, he also made several miniature astrolabes with diameters measuring less than 100 mm. Muqīm’s astrolabe with a diameter of 45 mm is the world’s smallest (A050), but many of its original components are missing, whereas Ḍiyā’ al-Dīn’s astrolabe of 1064/1653-54 (A071) with its diameter of 65.5 mm is fully intact. The delicately crafted miniature astrolabe has a jewel-like quality.

The *kursīs* in Ḍiyā’ al-Dīn’s astrolabes are mostly reticulated and their surface is engraved with decorative patterns. He incorporates large flowers in the *kursīs* as well as in the traceries of the retes. Some of the floral compositions with large flowers and leaves in the retes (e.g. A070, A072, A074, A075, A091 and A094) recall similar floral arrangements in *pietra dura* style in Mughal monuments.

Ḍiyā’ al-Dīn’s geographical gazetteers generally commence with Mecca or Medina and reach up to India. But in 8 astrolabes, the gazetteers are arranged according to climates of antiquity (*iqlīm*) (e.g. A073, A074, A088 and others). In three astrolabes, the gazetteers are arranged according to regions (also called *iqlīm*) from the Maghreb in the west up to Hind in the east (A062, A072 and A093). Apparently Ḍiyā’ al-Dīn is the only one to arrange the gazetteers in this fashion.

Like Muqīm, Ḍiyā’ also draws two graphs for the midday altitude of the sun throughout the year for the latitudes of Agra (27°) and Lahore (32°) on the back of several astrolabes. After Shāh Jahān shifted the Mughal capital from Agra to Delhi in 1639, Ḍiyā’ began to add a third graph for the latitude of Delhi (29°). In A097, there is a fourth graph for 36° (middle of the fourth climate, i.e., the middle of the inhabited world). A095 and A101 have 2 more graphs for latitudes 21° (Mecca) and 24° (Tropic of Cancer). A067 of 1062/1651-52 displays 8 graphs for latitudes 15°, 19°, 21°, 27°, 29°, 32°, 35° and 40°. The highest number of curves to be found in the Lahore astrolabes are in A096 for 9 latitudes, viz., 19°, 27°, 32°, 36°, 40°, 44°, 49°, 56° and 60°.

As in Muqīm’s astrolabes, in Ḍiyā’ al-Dīn’s astrolabes also, the number of astrological tables engraved on the back vary according to the size of the astrolabe. Smaller astrolabes carry just two semi-circular rows engraved with the names of the 12 signs and the names of 28 lunar mansions. On larger astrolabes, there are also tables of the limits, faces, triplicities and excess of revolution.

Three astrolabes contain a table which is not found in other Lahore astrolabes. This table is called *zadwal sāᶜāt ṭulūᶜ burūj bi-ᶜarḍ baᶜḍī az bilād mulk al-Hind* (table of the times of rising of signs in the latitudes of some of the localities belonging to the country of India). While A072 provides the rising times of the signs at each degree of latitude from 20° to 39°,[357] A092 has a table from 20° to 40° and A093 from 21° to 40°.

In astrolabe A101, the upper right quadrant is designed as a solar quadrant as well as a universal horary quadrant. As a solar quadrant, it carries declination arcs for every 10° of solar longitude and 6 sigmoid curves to show the midday altitude of the sun throughout the year at 6 different latitudes. As a universal horary quadrant, it bears dotted arcs of unequal hours, numbered from 1 to 6 in the anticlockwise direction and from 7 to 12 in the reverse direction.

The lower half on back of the astrolabe A098 is designed in an extraordinary manner. The shadow squares, usually engraved in the lower half, are superimposed on the trigonometric and solar quadrants in the upper half. The lower half is engraved as the left half of a plate for latitude 27° with the altitude circles for each 6° and with lines for equal hours before sunrise. Moreover, the ecliptic circle is drawn along with the names of the 6 signs from *al-Saraṭān* to *al-Qaws.* These projections are framed by a degree scale, divided in 2° and 10° and labelled in 10s, from 90 to 10 (from the south point to the east point) and again from 10 to 90 (from the east point to the north point). With this configuration, the standard operations can be performed by means of the alidade as is done on an astrolabe quadrant.

Zawraqī Horizons

We have seen that Qā’im Muḥammad incorporates *zawraqī* or ‘ship’ horizons for the first time in two of his astrolabes. Ḍiyā’ al-Dīn adds them in 7 astrolabes in two different styles. In astrolabes A082 and A093, two small horizons for latitudes 29° and 32° are inserted in the rete in such a manner that they form a fish-like figure inside the ecliptic ring. A special plate is designed to be used with these horizons, on which astrological houses, divided into 5 units of 6°, are drawn for the two latitudes and a

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357 This table is reproduced in Kaye 1918, p. 23.

miniature plate is created inside the circle of Cancer where the two small horizons on the rete fit. The positions of several stars are marked on this miniature plate with dots enclosed in small circles. A073 also follows the same style, but with just a single horizon for latitude 32°.

In the second style, the horizons are large and stretch over the whole width of the rete up the Capricorn ring on both sides. The plates to be used with the horizons do not carry miniature plates inside the circle of Cancer, but the entire plates are filled with star positions and astrological houses. Thus in A100, there are two *zawraqī* horizons for latitudes 29° and 32° and the two plates calibrated for 29° and for 32° are engraved with astrological houses as well as star positions. There are slight variations in this style. In A099, two *zawraqī* horizons for 29° and 32° are added to the rete; on the plate face calibrated for 29°, the positions of all those stars are marked which are in the rete; on another plate face, astrological houses are marked for both these latitudes 29° and 32°. In astrolabe A101, there is just one *zawraqī* horizon on the rete for latitude 24° and the plate face for 24° is marked with star positions and astrological houses. In another variation, in A102, there is an extra rete carrying just two *zawraqī* horizons for latitudes 37° and 38°, but without any corresponding plates for these latitudes.

North-South Astrolabes

Three astrolabes are designed as north-south astrolabes (*asṭurlāb shamālī wa janūbī*). In A090, the obverse side of the single plate is engraved as a latitude plate for 33° and on it is superimposed a northern projection of the ecliptic circle together with the positions of 46 stars, while the reverse side is designed for latitude 35° on which a southern projection of the ecliptic circle is drawn and the positions of the same 46 stars, but with southern orientation, are marked. The choice of these latitudes is rather intriguing. There is a minimal rete consisting of just the ecliptic ring and an alidade with a sighting tube.

Astrolabe A103 also consists of a single plate on which the two sides carry respectively the northern and southern projections of the ecliptic and of some star positions. However, the obverse side is engraved with a double projection for two latitudes 32° and 36° and the reverse with a quadruple projection for latitudes 22°, 25°, 27° and 29°.

Astrolabe A104 is much more complex with two separate retes, one with a northern projection and another with a southern projection, and with plates carrying either northern projections, or southern projections, or both.

Zarqālī Universal astrolabe

The crowing glory of Ḍiyā’ al-Dīn’s work is the monumental *Zarqālī* astrolabe he made in 1681 with a diameter of 555 mm. It consists of a single plate which can be used at all latitudes. It was originally designed by Ibn al-Zarqalluh at Toledo in the eleventh century. There are not many Zarqālī astrolabes extant today and none of these is comparable to the magnificent creation of Ḍiyā’ al-Dīn Muḥammad.

A059⊙ ASTROLABE BY ḌIYĀ AL-DĪN MUḤAMMAD, 1047 AH (AD 1637-38) [358]

Diameter 117 mm

Chicago, Adler Planetarium & Astronomy Museum (# A-86)

CCA 2558; Répertoire 4



Figure A059.1 – Front of the astrolabe (accession no. A-86). Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

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[358] Entry based on Pingree 2009, No. 15, pp. 64-68; the star list has been rearranged according to increasing right ascensions.

This is the earliest known astrolabe made by Ḍiyā’ al-Dīn Muḥammad. Following his uncle Muḥammad Muqīm, Ḍiyā’ al-Dīn calibrates the two sides of a plate for the latitudes of 27° and 32° respectively and draws, on the upper right quadrant on the back, two sigmoid curves of the solar meridian altitudes for the same two latitudes, these being the latitudes of Agra and Lahore, the two Mughal imperial cities.

Components

Body with *kursī* (d. 117, h. 142, t. 8), shackle and ring, rete for 27 stars, 4 plates, alidade, pin and horse. Body and rete of brass; alidade, pin and horse of a darker alloy; plates of copper.

Front

From the photo it is not clear whether the shackle has a trefoil form and whether there is a trifoliate finial on the *kursī.* The *kursī* has lobed profiles and a simple but symmetric fretwork. The limb is divided in 1° and 6°. Dotted lines mark the boundaries of 3° and 6° and plain lines those of 1°. Labelled in 6s from 6 to 360.

Rete

The two circles of the Tropic of Capricorn and ecliptic are held together by an equinoctial bar which has two counter changes on either side of the centre about the middle of the centre and the ecliptic ring. This is somewhat unusual; unusual are also the 27 star pointers having the shape of vultures perched on a tree. These star pointers generally emanate from the two rings and from the equinoctial bar. Four pointers however arise from an upside down arch in the lower half. There is a handle on the Capricorn ring at the north point. The 27 stars marked on the rete are as follows:

Table A059-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab Qayṭus*	β Ceti[359]
2	*Ṣadr*	π Ceti
3	*Ghūl*	β Persei
4	*Masāfat al-Nahr*	γ Eridani
5	*ᶜAyn al-Thawr*	α Tauri
6	*ᶜAyyūq*	α Aurigae
7	*Rijl al-Yusrā*	β Orionis
8	*Yad Yumnā*	α Orionis
9	*Shiᶜrā Yamānī*	a Canis Minoris
10	*[Shiᶜrā] Shāmī*	α Canis Majoris
11	*Fard al-Shujāᶜ*	α Hydrae
12	*Ẓahr al-Dubb*	α Ursae Majoris
13	*Qāᶜidat*	α Crateris
14	*Janāḥ al-Ghurāb*	γ Corvi
15	*Simāk Aᶜzal*	α Virginis
16	*Simāk Rāmiḥ*	α Bootis
17	*Nayyir Fakkah*	α Coronae Borealis
18	*ᶜUnuq al-Ḥayyah*	α Serpentis
19	*Qalb al-ᶜAqrab*	α Scorpii
20	*Rās al-Ḥawwā*	α Ophiuchi
21	*Nasr Wāqiᶜ*	α Lyrae

[359] Pingree identifies it as ι Cet, but the star is placed clearly in Aries; therefore, it is the southern counterpart, viz. *Dhanab Qayṭus Janūbī*.

	Star Name	Identification
22	*Nasr Ṭā’ir*	α Aquilae
23	*Dhanab Dajājah*	α Cygni
24	*Fam al-Faras*	ε Pegasi
25	*Sāq Ayman*	δ Aquarii
26	*Mankib al-Faras*	β Pegasi
27	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are four plates with notches at the north point.

Table A059-2

	φ	Longest day
1a	27°	13;43 hours
1b	32°	14;8 hours
2a	30°	13;58 hours
2b	34°	14;12 hours
3a	36°	14;32 hours
3b	40°	14;54 hours
4a	Plate of ecliptic coordinates	
4b	Plate of horizons	

The first three plates carry altitude circles for every 6°, plain lines for seasonal hours and dotted lines for equal hours counted from the western horizon. The prime vertical is drawn as a plain line above the horizon and is dotted below the horizon. The azimuths are drawn for every 10°, but their location varies: on 1a, 2a, 2b, 3a they are drawn below the horizon; on 1b both above and below the horizon; on 3b only above the horizon.

On the plate of ecliptic coordinates (4a), the arcs for the celestial longitudes are drawn at intervals of 10° and numbered as 10, 20, 30, separately for each zodiac sign. The circles of the celestial latitudes are drawn for every 6°. These are numbered from 6 to 90 to the north of the ecliptic up to the zenith and from 6 to 48 to the south up to the Tropic of Capricorn. The names of the zodiac signs are inscribed partly outside the ecliptic circle and partly inside. Beneath the horizontal diameter is written *al-mashriq* in the east and *al-maghrib* in the west. Above the north point, there is label identifying the plate as *ṣafīḥat mīzān al-ᶜankabūt.*

The reverse side of this plate (4b) is engraved as the plate of horizons with half-horizons drawn for the following latitudes:

4	14	24	34	44	54	64
6	16	26	36	46	56	66
8	18	28	38	48	58	
10	20	30	40	50	60	

Declination scales are drawn along the vertical and horizontal diameters and labelled 6, 12, 18, 24. The name of the plate is not engraved.



Figure A059.2 – Geographical gazetteer (accession no. A-86)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Geographical Gazetteer

On the inner side of the mater is engraved a gazetteer in two circles, providing the names, longitudes and latitudes, in this order, for 50 localities:

Table A059-3 Geographical Gazetteer

	Place Name *al-bilād*	**L** *al-ṭūl*	**φ** *al-arḍ*
	Outer Circle		
1	Madīnat Rasūl	75;20	25;0
2	Makka Mubārak	77;10	21;40
3	Ḥalab	72;10	35;50
4	Sumyāt	72;35	40;0
5	Arbīl	77;20	35;0
6	Kūfa	79;30	31;30
7	Baṣra	84;0	30;0
8	Shīrāz	88;0	29;36
9	Yazd	89;0	32;30
10	Iṣfahān	86;40	32;25
11	Qum	85;40	35;45
12	Rayy	86;20	35;0
13	Ṭūs	92;30	36;0
14	Samarqand	99;56	39;37
15	Hurmūz	92;0	25;0
16	Kābulistān	104;20	33;35
17	Tatta	102;7	25;10
18	Multān	107;35	29;40
19	Qandahār	107;40	33;0
20	Kashmīr	108;0	35;0

	Place Name ***al-bilād***	**L** ***al-ṭūl***	**φ** ***al-arḍ***
21	Tubbat	110;0	40;0
22	Lāhūr	109;20	31;50
23	Siyālkūt	109;10	33;0
24	Dimashq	70;0	33;15
25	Miṣr	63;20	30;20
26	Tabrīz	82;0	38;0
27	Madā’in	72;0	33;10
28	Baghdād	80;30	33;25
29	Balkh	101;0	36;41
30	Badakhshān	104;24	37;30
31	Bukhārā	97;30	39;50
	Inner Circle		
32	Sunām	114;0	30;30
33	Bānībatah	113;20	28;52
34	Tānīsar	112;26	30;10
35	Dihlī	113;35	28;20 !
36	Akra	114;0	27;13 !
37	Qannawj	116;50	26;36
38	Jawnbūr	119;6	26;36
39	Bānārasī	117;20	26;55
40	Ajmīr	111;5	25;0 !
41	Kawāliyār	115;0	26;29
42	Aḥmadābād	108;40	23;15
43	Kanbāyat	109;10	22;20

	Place Name ***al-bilād***	**L** ***al-ṭūl***	**φ** ***al-arḍ***
44	Ujjayn	102;0	22;30
45	Mandū	107;10	22;13
46	Burhānbūr	109;0	20;31
47	Jidda[360]	76;0	21;0
48	Bījābūr	105;30	17;20
49	Dawlatābād	111;0	20;30
50	Aḥmadnakar	107;0	19;0

[360] It is intriguing that Jeddah of Saudi Arabia is inserted here among the Indian towns in many astrolabes of Ḍiyā' al-Dīn and also of Muqīm.



Figure A059.3 – Back of the astrolabe (from Pingree 2009)

BACK

The rim of the upper half carries the altitude scales which are graduated for 1° and 6°, and labelled as 6—90; 90—6. The rim of the lower half has the scales of cotangents.

In the upper left quadrant are drawn 30 horizontal parallels, with every third highlighted with dots, representing the cosines for every 2 of the 60 parts of the Radius.

In the upper right quadrant are declination arcs, the spaces between every two lines representing a pair of zodiac signs. The related signs are marked by their serial numbers from 0 to 11 along the two radii. Upon these arcs are drawn two curves for the midday altitude of the sun at the latitudes of 27° and 32°, accompanied by the labels *khaṭṭ niṣf al-nahār bi-ᶜarḍ 27°* and *khaṭṭ niṣf al-nahār bi-ᶜarḍ* 32.

In the lower half, immediately below the horizontal diameter are the shadow squares, on the left for a base of 12 and on the right for a base of 7. The vertical and horizontal scales are divided, accordingly into 12 or 7 parts and numbered. Inside the squares, in the corner between the vertical and horizontal scales on the left is the label *ẓill sullam aṣābiᶜ,* and on the right *ẓill sullam aqdām.* Outside the squares are the following labels along the four scales:

Vertical scale on the left: *ẓill aṣābiᶜ maᶜkūs*

Horizontal scale on the left: *ẓill aṣābiᶜ mustawī*

Horizontal scale on the right: *ẓill aqdām mustawī*

Vertical scale on the right: *ẓill aqdām maᶜkūs*

Inside the shadow squares are two semi-circular rows in which the names of the 12 signs of the zodiac and those of the 28 lunar mansions are inscribed. In the space between these semi-circular scales and the horizontal diameter is the maker's inscription, written upside down (see below).

ALIDADE

The straight-bar alidade has ornate ends and an ornate centre-piece. The right hand side is divided in units matching the divisions in the upper left quadrant and numbered in 6s from 6 to 60. It also carries a scale for sundials. The left hand side is marked with arcs to match the declination arcs in the upper right quadrant along with the serial numbers of the pair of zodiac signs. The pin is original, but the wedge, made out of a bent piece of metal, is a replacement.

INSCRIPTION

ᶜamal ḍiyā’ al-dīn muḥammad ibn qā’im muḥammad ibn mullā ᶜīsā
ibn mullā allāhdād asṭurlābī humāyūnī lāhūrī
fī sanah 1047 hijrī

‘The work of Ḍiyā’ al-Dīn Muḥammad, son of Qā’im Muḥammad, son of Mullā ᶜĪsā, son of Mullā Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the year 1047 Hijrī.’

PROVENANCE

Ali Kuli Khan; Adler purchase before 1945.

BIBLIOGRAPHY

Pingree 2009, no. 15, pp. 64-68.

A060 ASTROLABE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1056 AH (AD 1646-47)

Diameter 193 mm

PLU, ex-Paris, Collection Nicolas Landau

CCA 2600; Répertoire 2

COMPONENTS

Body, rete for 47 stars, 6 plates

BACK

Upper left quadrant carries a graph of sines; upper right quadrant has declination arcs with two sigmoid curves showing the midday altitude of the sun at the latitudes 27° and 32°.

INSCRIPTION

As recorded in the Répertoire:

ayn sanᶜat ḍiyā' al-dīn muḥammad
ibn qā'im muḥammad ibn ᶜīsā ibn allāhdād
asṭurlābī humāyūnī lāhūrī
fī sanah 1054 hijrī gh-n-w

'This is the work of Ḍiyā' al-Dīn Muḥammad, son of Qā'im Muḥammad, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the year 1054 Hijrī, [in *Abjad* notation] 1000+50+4.'

PROVENANCE

Ex-collection Nicolas Landau, Paris

Ex-Collection H. P. Locker, Würzburg

BIBLIOGRAPHY

Catalogue Sotheby's, 27 March 72, lot 79.

A061⊙ ASTROLABE BY ḌIYĀ AL-DĪN MUḤAMMAD 1057 AH (AD 1647-48)[361]

Diameter 121 mm

Chicago, Adler Planetarium & Astronomy Museum (#A-70)

CCA 1095; Répertoire 3



Figure A061.1 – Front of the astrolabe (accession no. A-70)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

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[361] Entry based on Pingree 2009, No. 16, pp. 69-72; the star list has been rearranged according to increasing right ascension.

The *kursī*, though of simple fretwork, is a great improvement on the previous astrolabe of 1637, with elegant profiles and exaggerated trifoliate finial. The rete shows, for the first time, a floral tracery joining the star pointers. In the inscription, all the three ancestors are given the title *mullā* (learned).

COMPONENTS

Body with *kursī* (d. 121, h. 170, t. 9), shackle and ring, rete for 33 stars, 4 plates, alidade and pin; the wedge is missing.

FRONT

The ring is large, the shackle probably of trefoil shape and the *kursī* elegant with profiles made up of ogees at the base and at the top with a lobe in between and with a trifoliate finial. The fretwork is simple but pleasing with the motif of a triangle in the middle below which the empty space is also of triangular shape.

The scale on the limb divided in 1° and 5°, and numbered from 5 to 360.

RETE

The two rings of Capricorn and ecliptic are held together by the equinoctial bar which has counter changes at its two intersections with the ecliptic ring. There is a large handle a little to the right of the north point. Its large spherical head matches with that of the pin.

The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names. Each sign is divided into 5 units of 6° each; the division lines are dotted. The units are numbered 6, 12, 18, 24, 30 separately in each sign.

The star pointers are joined by a symmetric floral tracery with the dominant motif of a three-petalled tulip in the middle of the ecliptic ring; the same motif is repeated right below under the ecliptic ring. On the either side of the meridian line, slender tulips with their two flared petals are placed almost symmetrically.

Table A061-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus al-Janūbī*	β Ceti

	Star Name	Identification
2	*Baṭn al-Ḥūt*	β Andromedae
3	*Rijl al-Musalsala*	γ Andromedae
4	*Fam al-Qayṭus*	γ Ceti
5	*Ṣadr al-Qayṭus*	π Ceti
6	*Tālī Masāfat al-Nahr*	γ Eridani
7	*ᶜAyn al-Thawr*	α Tauri
8	*ᶜĀyyūq*	α Aurigae
9	*Rijl al-Jawzā’ al-Yusrā*	β Orionis
10	*Yad al-Jawzā’ al-Yusrā*	γ Orionis
11	*Rijl al-Jawzā’ al-Yumnā*	κ Orionis
12	*Shiᶜrā Shāmī*	α Canis Minoris
13	*[Fa]rd al-Shujāᶜ*	α Hydrae
14	*Ẓahr al-Dubb al-Aᶜẓam*	α Ursae Majoris
15	*Qāᶜidat al-Bāṭiya*	α Crateris
16	*Al-ᶜAnāq*	ζ Ursae Majoris
17	*Janāḥ al-Ghurāb*	γ Corvi
18	*Al-Aᶜẓal*	α Virginis
19	*Rāmiḥ*	α Bootis
20	*Kiffa Janūbī*	α Librae
21	*ᶜUnuq al-Ḥayyah*	α Serpentis
22	*Rās al-Jāthī*	α Herculis
23	*ᶜAyn al-Tinnīn*	α Draconis
24	*Yad al-Ḥawwā*	δ Ophiuchi
25	*Wāqiᶜ*	α Lyrae

	Star Name	Identification
26	*Nasr Ṭā'ir*	α Aquilae
27	*Dhanab al-Dulfīn*	ε Delphini
28	*Fam al-Faras* (?)	ε Pegasi
29	*Dhanab al-Jadī*	δ Capricorni
30	*Sāq Sākib al-Mā' Janūbī*	δ Aquarii
31	*Dhanab al-Qayṭus al-Shamālī*	ι Ceti
32	*Al-Faras*	β Pegasi
33	*Kaff al-Khaḍīb*	β Cassioperiae

PLATES

There are four plates, but the first two bear identical calibrations!

Table A061-2 Plates

	φ	Longest day
1a	27°	13;43 hours
1b	32°	14;8 hours
2a	27°	13;43 hours
2b	32°	14;8 hours
3a	36°	14;32 hours
3b	40°	14;58 hours
4a	Plate of ecliptic coordinates	
4b	Plate of horizons	

On plates 1-3, altitude circles are drawn for every 3°, each fifth line dotted; azimuth arcs are drawn for every 15° below the horizon and plain lines for seasonal hours and dotted lines for equal hours counted from the western horizon.

On the plate of ecliptic coordinates, arcs of the celestial longitudes are drawn for every 10° and labelled as 10, 20, 30, separately for each zodiac sign. The circles of celestial latitudes are drawn for every 6° and numbered from the ecliptic northwards up to the zenith and southwards up to the Tropic of Capricorn. The names of the signs are written along the ecliptic circle, some inside the circle and others outside the circle. Just above the north point is the label *ṣafīhat mīzān al-ᶜankabūt.*

On the plate of horizons, half horizons are drawn for the following latitudes:

4	12	20	…	60
6	14	22	…	62
8	16	24	…	64
10	18	26	…	66

Declination scales are engraved along the vertical and horizontal diameters and labelled as 6, 12, 18, 23;30, where 23;30 indicates the maximum obliquity. There is no label on this side of the plate.

GEOGRAPHICAL GAZETTEER

The gazetteer is engraved in two circles, each separated by a blank circle, with the place names, longitudes and latitudes for 58 localities beginning with the holy city of Mecca.

Table A061-3 Geographical Gazetteer

	Place Name ***asmāʾ al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
	Outer Circle		
1	Makka Muᶜaẓẓam	77;10	21;40
2	Madīnat Musharrafa	75;20	25;0

	Place Name *asmā' al-buldān*	**L** *al-ṭūl*	**φ** *al-ᶜarḍ*
3	Mahadiyya Maghrib	42;0	32;30
4	Iskandariyya	61;57	30;18
5	Miṣr	63;20	30;20
6	Āmid	73;40	33;0
7	Marāgha	82;0	36;20
8	Tabrīz	82;0	38;0
9	Ardabīl	82;30	38;0
10	Bulghār	90;0	49;30
11	Kūfa	79;30	31;30
12	Madā'in	72;0	33;10
13	Baghdād	80;30	33;25
14	Baṣra	84;0	30;0
15	Iṣfahān	85;0	34;45
16	Sabzawār	91;30	36;5
17	Nīshābūr	92;30	36;21
18	Ṭūs	94;30	37;0
19	Harāt	94;33	34;30
20	Balkh	101;0	36;41
21	Badakhshān	104;24	37;10
22	Bukhārā	97;30	39;50
23	Samarqand	99;56	39;37
24	Kāshghar	106;30	44;0
25	Hurmūz	92;0	25;0

	Place Name *asmā’ al-buldān*	L *al-ṭūl*	φ *al-ᶜarḍ*
26	Aḥmadābād	108;40	23;15
27	Ujjayn	112;0	22;30
28	Amarkūt	105;0	25;0
29	Kābul	104;40	34;30
30	Mīwāt	117;10	34;50
31	Barāwan[362]	117;59	27;32
32	Hansī	102;25	29;15
33	Tānīsar	112;33	30;10
34	Pānīpatah	113;20	28;52
35	Dihlī	113;35	28;20 !
	Inner Circle		
36	Ajmīr	111;5	24;0 !
37	Kawāliyār	114;0	26;29
38	Kashmīr	108;0	35;0
39	Tubbat	110;0	40;0
40	Sarandīp	130;0	10;0
41	Bānārasī	117;20	26;50
42	Qannawj	115;50	26;50
43	Lahāwar	109;20	31;50
44	Qandahār	107;40	33;0
45	Mūltān	107;35	29;40

362 Error for Badā’ūn.

	Place Name ***asmā' al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***	
46	Sanbhal	115;0	28;10	
47	Kara	117;6	26;16	
48	Chanpānīr	108;45	22;30	
49	Kambāyat	109;10	22;20	
50	Jidda	76;0	21;0	
51	Bījābūr	105;30	17;20	
52	Dawlatābād	111;0	20;30	
53	Burhānpūr	109;0	20;31	
54	Jawnpūr	119;6	26;36	
55	Mānikpūr	118;10	26;49	
56	Awadh	118;6	27;22	
57	Darband Jīn	178;40	23;0	Canton, China
58	Pūruswar	115;15	31;10	

BACK

The rim of the upper half bears the altitude scales which are divided in 1° and 5° and labelled as 5—90; 90—5. The rim of the lower half has the scale of cotangents.

In the upper left quadrant are drawn 30 horizontal parallels, i.e., cosines for every 2 of the 60 parts of the Radius, with every fifth line dotted.

In the upper right quadrant are drawn five dotted declination arcs so that each of the six intermediary spaces represents a pair of zodiac signs. The latter are marked by their serial numbers (0 to 11) along the two radii. Upon these arcs of declination are plotted two graphs of the solar altitude at midday for the latitudes 27° and 32°, with the labels *khaṭṭ niṣf al-nahār ᶜarḍ 27°* and *khaṭṭ niṣf al-nahār ᶜarḍ 32°*.

In the lower half are two shadow squares, on the left for 7 feet and on the right for 12 digits with their scales divided accordingly in 7 or 12 parts. The labels are:

Vertical scale on the left: *ẓill aqdām maᶜkūs*

Horizontal scale on the left: *ẓill aqdām mustawī*

Horizontal scale on the right: *ẓill aṣābiᶜ mustawī*

Vertical scale on the right: *ẓill aṣābiᶜ maᶜkūs*

Inside the shadow squares are two semi-circular rows in which are inscribed the names of the 12 zodiac signs and those of the 28 lunar mansions.



Figure A061.2 – Back of the astrolabe (accession no. A-70)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

ALIDADE

The alidade has plain ends and a plain centre piece. The rim is divided in 31 divisions, each division halved and also subdivided into 5 units. The divisions are numbered in the most peculiar manner. On the left 40, 17, 17, 21, 40, 14, 10, 3, 43, 5, 9, 20, 27, 40, 14; similar jumble of *Abjad* symbols on the right as well. The alidade is clearly a replacement, made by a person who did not understand its function.

INSCRIPTION

In the space between the horizontal diameter and the semi-circular rows is engraved the maker’s inscription:

> *ᶜamal ḍiyā’ al-dīn muḥammad ibn mullā qā’im muḥammad ibn mullā*
> *ᶜīsā ibn mullā allāhdād asṭurlābī humāyūnī lāhūrī*
> *sanah 1057 hijrī.*
> ‘The work of Ḍiyā’ al-Dīn Muḥammad, son of Mullā Qā’im Muḥammad, son of Mullā ᶜĪsā, son of Mullā Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, [in] the year 1057 Hijrī.’

PROVENANCE

E. S. David 1940; purchased by Adler in 1940.

BIBLIOGRAPHY

Pingree 2009, no. 16, pp. 69-72.

A062⊙ ASTROLABE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1059 AH (AD 1649-50)

Diameter 185 mm

Lucknow, Darul Uloom Nadwatul Ulama

CCA 1126; Répertoire 7



Figure A062.1 – Front of the Astrolabe (photo by S. R. Sarma)

This exquisitely crafted astrolabe is one of the masterpieces produced by Ḍiyā’ al-Dīn.

Components

Body with *kursī* (d. 185, h. 261, t. 9), shackle and ring, rete (d. 161) for ca. 40 stars, 5 plates (d. 161), alidade (165 x 13 x 3) with a sighting tube; the pin, nut, and washer are not original but added later.



Figure A062.2 – The *kursī* of the Astrolabe (photo by Dr Owen Cornwall)

Front

The ring has a diamond cross-section; the shackle also has a diamond cross-section and a trifoliate shape. The outlines of the *kursī* (ogees rising from the body on either side, followed by a lobe and another ogee and a trifoliate finial) are generally the same as in many other astrolabes by Ḍiyā’ al-Dīn, but the fretwork here is the most intricate and the surface engravings are most impressive; there is no doubt that this one of the most beautiful *kursīs* fashioned by the hand of this astrolabe maker. The limb is divided in 1° and 5° and labelled from 5 to 360.

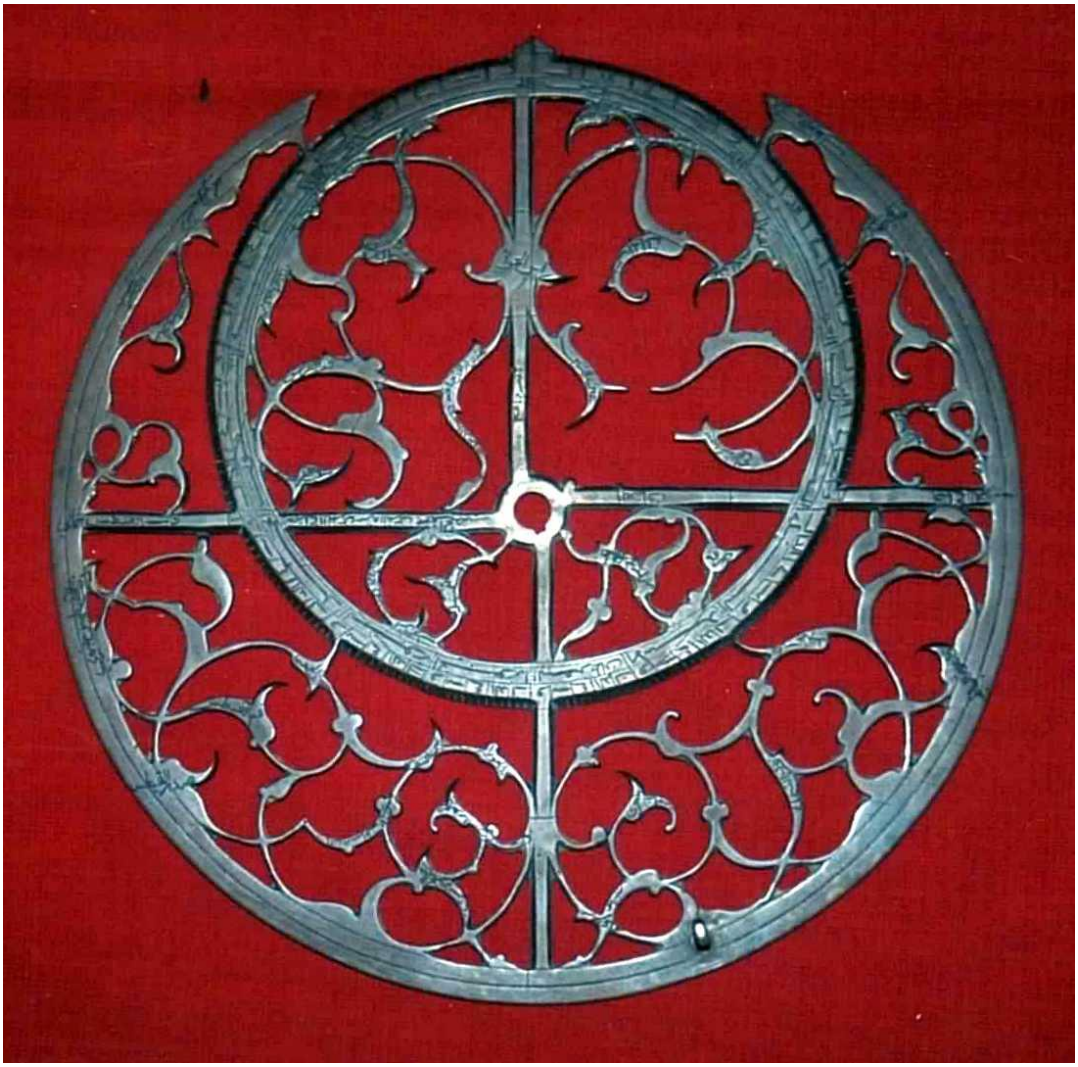


Figure A062.3 – The rete of the astrolabe (photo by S. R. Sarma)

RETE

The two rings of the Tropic of Capricorn and ecliptic are held together by the equinoctial as well as solstitial bars, both completely represented, and both with a counter-change at the centre. The spaces inside these circles are filled with an almost symmetrical pattern of vines making spirals and circles. From the vines arise a number of tulip flowers with flared petals, one or both tips of these petals forming named star pointers. However, the star names are engraved in such tiny characters that it is hardly possible to decipher the star names, although one could, of course, guess them from their positions. In the upper left quadrant, close to the apex, there is a break in one or two vines.

The ecliptic circle is divided into the 12 zodiac signs and labelled with their names. Each sign is subdivided into units of 6° and these units are numbered 6, 12 … 30. On

the sloping edge of the ecliptic circle, these units of 6° are further subdivided into units of 2°.

There is a rectangular handle on the circumferential band a little to the right of the north point.

PLATES

There are five plates with the following functions:

Table A062-1 Plates

	φ	Longest day
1a	22°	13;21 hours
1b	25°	13;25 hours
2a	27°	13;43 hours
2b	32°	14;8 hours
3a	34°	14;22 hours
3b	36°	14;30 hours
4a	38°	14;40 hours
4b	40°	14;50 hours
5a	Plate of ecliptic coordinates	
5b	Plate of horizons	

On plates 1 to 4, altitude lines are drawn for every 2° with each fifth circle dotted; azimuth lines for every 6° below the horizon with each fifth dotted and extended above the horizon. Seasonal hours are indicated by plain lines. Dotted lines for equal hours are drawn from the western horizon on all plates except 1a where they are drawn from both the western and eastern horizons. All the lines are numbered.

On plate 5a, which carries a label designating it as *ṣafīḥat mīzān al-ᶜankabūt,* the arcs of celestial longitudes are drawn for every 6° and every fifth (30°) which marks the boundary between two successive zodiac signs is dotted. Along the ecliptic circle

the names of the signs are engraved and also the numerical values of the subdivisions of the signs. The circles of the celestial latitudes are drawn for every 3°.



Figure A062.4 – Plate of horizons (photo by Owen Cornwall)

Plate 5b carries the plate of horizons with the label *ṣafīḥa āfāqī*. Here are drawn four sets of half-horizons for every degree of latitude from 4° to 66;30°. These are distributed in the following manner:

3	7	11	…	55	59	63
4	8	12	…	56	60	64
5	9	13	…	57	61	65
6	10	14	…	58	62	66;30

These horizons are numbered at both the ends. The horizons which lie inside the equator are labelled as *afāq sharqī* (eastern horizons) under each one of the four sets.

Along the vertical and horizontal diameters, declination scales are incorporated between the equator and the tropics. These are divided in 2° each and labelled in 6s as 6, 12, 18, 23;30. The scales which are between the equator and the Tropic of Cancer, i.e., to the north of the equator, carry labels *taqsīm mayl kullī shamālī* (degrees of the maximum declination north) and those situated between the equator and the Tropic of Capricorn, i.e., to the south of the equator have labels stating *taqsīm mayl kullī janūbī* (degrees of maximum declination south).



Figure A062.5 – Geographical gazetteer, the upper section (photo by S. R. Sarma)

GEOGRAPHICAL GAZETTEER

On the inner side of the mater is engraved a geographical gazetteer in four circles, providing the names, longitudes and latitudes of 120 localities. The localities are arranged according to regions from Maghreb in the west up to Hind in east; but in Hind just two localities, Agra and Delhi, are mentioned! The data is inscribed in a zigzag manner and the spaces between the four circles are filled with the names of the regions. Thus the engraving is densely cluttered and quite difficult to read.

Ḍiyā’ al-Dīn arranged the gazetteer according to regions in two other astrolabes both larger than this; A072 of 1067/1656 with a diameter of 312 mm carries a gazetteer

of 210 localities; the other astrolabe (A093), made some time after 1648 with a diameter of 526 mm accommodates a gazetteer of 259 localities.

These gazetteers are based Ulugh Beg’s geographical tables.[363] But in these astrolabe gazetteers, the headings containing the names of the regions are not correctly engraved. In the table below, the headings will be reproduced as in the astrolabe; variations from Ulugh Beg’s tables will be noticed in footnotes. The identification or modern names of the localities listed here will be provided in the description of astrolabe A070.

Table A062-2 Geographical Gazettee

	Place Name	L	φ
	First Circle		
Iqlīmhā Maghrib (the region of Maghreb)			
1	Sūs Āqṣā	15;32	32;0
2	Fars Qaṣba Ṭanja[364]	18;0	22;0
3	Tāhart ᶜUliyā’	30;30	19;0
4	Tāhart Suflis	36;0	31;30
5	Siljāsa	37;0	31;30
6	Qīzān	48?;0	31;40
7	Mahadiyya Maghrib	42;0	32;30
8	Ṭarābulus	45;0	32;0
Andalus (Andalusia)			
9	Qurṭaba dar al-Mulk Andalus	38;26	35;0

363 Cf. Sédillot 1853, pp. 257-271.

364 The correct name is ‘Fas’ (modern Fez); Ulugh Beg gives the latitude as 32;0° which is the correct value.

	Place Name	L	φ
10	Bajja az Barbar[365]	65;0	14;0
Sūdān (Sudan)			
11	Jarmī Dar al-Mulk Habasha	65;0	9;30
12	Darqala	53;60	14;30
Miṣr (Eqypt)			
13	Qūs az Qaṣba Miṣr	61;30	24;30
14	Iskandariyya	61;54	30;18
15	Miṣr	63;20	30;20
16	Dumyāṭ	63;30	31;25
Yaman (Yemen)			
17	Qulzum az Kanār Darya[366]	64;0	29;30
18	ᶜAdan	76;0	11;0
19	Sanᶜā’ Dār al-Mulk Yaman	77;0	14;30
ᶜUmān (Oman)			
20	Zabīd	74;20	14;10
21	Ṣajā Qaṣba ᶜUmān	84;0	14;20
Ḥijāz (Hejaz)			
22	Madīnat Rasūl ᶜAlayhi al-Salām	74;20	25;0
23	Makka Mubārak	77;10	21;40

365 It is wrongly included in Andalus; it should be placed in the next region of Sudan.

366 Qulzūm (modern Suez) should be placed in Egypt above.

	Place Name	L	φ
24	Tā’if	77;30	21;20
Baḥrayn (Bahrain)			
25	ᶜAyāma[367]	82;30	23;0
26	Hajar Baḥrayn	83;0	25;35
27	Ḥasā Baḥrayn	83;30	24;0
28	Qaṭīfa ᶜArīn	74;0	25;0
Iqlīmhā Shām (the region of Syria)			
29	Bayt al-Maqdis az Filistīn	66;30	31;50
30	Asqalān az Filistīn	66;30	32;25
31	Ramla az Filistīn	66;50	32;10
32	Qaysāriyya	66;30	32;30
33	Tibariyya	68;0	32;0
34	Ṣawar	68;30	32;40
35	Ṣaydā	68;35	32;40
36	Ṭarābulus	69;40	34;0
37	Dimashq	70;0	33;15
38	Baᶜalbak	70;15	33;15
39	Ḥalab	72;10	35;50
40	Ṭarṭūs	68;40	36;42
Thughūr Rūm (the border lands of the Byzantines)			
41	Rūmiya Kabrī	85;27	41;50
42	ᶜAmmūriyya	64;0	43;45

[367] This place belongs to Hejaz above.

	Place Name	L	φ
43	Arz al-Rūm	72;0	39;40
44	Arzinkān	76;0	38;0
45	Sīwās	71;40	39;0
46	Sumaysāṭ	72;35	40;0
47	Qālīqalā	73;25	39;0
	Second Circle		
Jazīra (the region of ancient Mesopotamia)			
48	Raqqa	73;15	36;0
49	Rās al-ᶜAyn	74;0	36;50
50	Mārdīn	74;0	37;15
51	ᶜĀna	76;30	34;0
52	Mawṣil	77;0	34;30
Armīn (Armenia)			
53	Arbīl[368]	72;20	35;0
54	Takrīt	78;20	34;30
55	Amid	73;40	38;0
Adarabyjān (Azerbaijan)			
56	Marāgha	82;0	37;20
57	Tabrīz	82;0	38;0
58	Ardabīl	82;30	38;0
Irān (Iran)			
59	Mūqān	83;0	38;0

[368] It should be included in the group above.

	Place Name	L	φ
60	Bardaᶜa	83;0	38;0
Kharkh (western shore of the Tigris river?)[369]			
61	Shamākhī Qaṣba Shirwān	84;30	40;50
62	Bāb al-Abwāb	85;0	43;0
Alān			
63	Alān	83;0	44;0
Rūs			
64	Kūsāna Madīnat Rūs	87;0	43;0
65	Sāmarra’	79;0	34;0
Bulghār			
66	Bulghār	90;0	49;30
67	Saqsīn	86;30	43;0
ᶜArāqayn (the two Iraqs)[370]			
68	Kūfa	79;30	31;30
69	Madā’in	72;0	33;10
70	Baghdād	80;0	33;25
71	Wāsiṭ	81;30	32;20
72	Baṣra	84;0	30;0
Khūzistān (a region in Iran)			
73	Arjān	86;30	29;32

369 Ulugh Beg has the heading Armenia once more here, in which are included Balkūya, Shamākhī and Bāb al-Abwāb.

370 Ulugh Beg has just ᶜIrāq here.

	Place Name	L	φ
74	Shābūr	86;15	30;10,0 !
Fārs (a province of Iran)			
75	Kāzirūn	87;0	29;15
76	Fīrūzābād	87;15	28;10
77	Shīrāz	88;30	29;36
ᶜIrāq			
78	Yazd	89;0	32;0
79	Shahrazūr	82;4	32;30
80	Qirmāsīn	43;0	34;30
81	Nahāwand	83;15	34;20
82	Hamadān	83;0	35;10
	Third Circle		
Iqlīmhā tatimma ᶜIrāq (continuation of the regions of Iraq)			
83	Karkh	84;45	34;0
84	Sāwa	85;0	35;0
85	Qazwīn	85;0	36;0
86	Iṣfahān	86;40	32;25
87	Kāshān	86;0	34;0
Dīlmān			
88	Qumm	85;40	34;45
89	Rayy	86;20	35;0
Kīlān (Gilan, a province of Iran)			
90	Ṭāliqān	85;45	36;10
91	Husūm az Jīlān	85;10	37;0

	Place Name	L	φ
Ṭabaristān (or Tapuria, southern coastal region of the Caspian Sea)			
92	Amul Qaṣba Ṭabaristān	88;20	36;15
93	Astarābād	89;35	36;50
Qūmish (a region in Iran)			
94	Dāmghān	88;55	36;20
95	Bisṭām	89;30	36;10
Khurāsān (Khorasan, a region in Iran)			
96	Sabzawār	91;30	36;0
97	Nīshābūr	92;30	36;21
98	Ṭūs	92;30	32;0
99	Ṭabas Kīlakī	92;0	33;0
100	Tūn	92;30	34;30
101	Harāt	94;20	34;32
102	Sarakhs	94;30	37;0
103	Marw al-Rūd	97;0	36;30
104	Fāriyāb	99;0	36;45
105	Balkh	101;0	36;41
	Fourth Circle		
Iqlīmhā Māwrā al-Nahr (the region of Transoxonia)			
106	Bukhārā	90;30	39;50
107	Samarqand	99;16	39;32
108	Khujand	100;35	41;55
109	Kāshghar	106;30	44;0
Kirmān (a province of Iran)			

	Place Name	L	φ
110	Hurmūz	92;0	25;0
111	Narmāshīr	94;20	29;0
Zābalistān (a region in Afghanistan)			
112	Ghazna Qaṣba Zābalistān	104;20	33;35
113	Banjāhīr Kābulistān	104;40	35;0
Makrān			
114	Kīj az Makrān	99;0	28;0
115	Jalq az Makrān	99;0	30;0
Sind			
116	Mansūra Qaṣba Sind	105;0	overwritten illegible
117	Qandahār	107;40	33;0
118	Lahāwar	109;20	31;50
Hind			
119	Akra	114;0	27;0
120	Dihlī	113;35	28;39

BACK

The rim of the two upper quadrants carries altitude scales which are divided in 1° and 5° and labelled as 5—90; 90—5.

In the upper left is a sexagesimal trigonometric quadrant, with 60 horizontal parallels with every fifth highlighted with dots. These are numbered in 5s along the vertical radius.

In the upper right is a solar quadrant with 30 declination arcs, one for each 10° of solar longitude. The names of the corresponding zodiac signs and the numerical values of their subdivisions are inscribed along the two radii. Upon these arcs are plotted two

graphs displaying the meridian altitude of the sun throughout the year at the latitudes 27° and 32°, with the labels *khaṭṭ niṣf al-nahār bi-ᶜarḍ 27* and *khaṭṭ niṣf al-nahār bi-ᶜarḍ 32* respectively.

In the lower half, just below the horizontal diameter are drawn two shadow squares, on the left for a base of 12 and on the right for a base of 7. The vertical and horizontal scales are divided and numbered accordingly and are endowed with the following scales; vertical scale on the left: *ẓill sullam aṣābiᶜ maᶜkūs* (scale of the reverse shadows in digits); horizontal scale on the left: *ẓill sullam aṣābiᶜ mustawī* (scale of the direct shadows in digits); horizontal scale on the right: *ẓill sullam aqdām mustawī* (scale of the direct shadows in feet); and vertical scale on the right: *ẓill sullam aqdam maᶜkūs* (scale of the reverse shadows in feet).



Figure A062.6 – Back of the Astrolabe (photo by S. R. Sarma)

Inside the shadow squares, there are two rectangular tables. The table on the left carries the heading *jadwal faḍl al-dawr* (table of excess revolution). This is the time measured in degrees of daily rotation (360° = 24h) by which the solar year exceeds 365 days. The table shows the multiples of the excess in minutes and seconds. The serial numbers in the first and the third columns are represented by the standard Arabic /

Persian numerals, while the differences in the second and third columns are expressed in the *Abjad* notation.

Table A062-3 Excess of Revolution

1	87 33	10	155 31
2	175 6	20	61 2
3	262 39	30	106 33
4	350 12	40	262 10
5	77 45	50	57 35
6	164 19	60	213 6
7	252 52	70	08 37
8	340 25	80	164 8
9	67 58	90	319 39

The table on the right has the title *jadwal arbāb muthallathāt laylī wa nahārī* (table of the regents of the triplicities, nocturnal and diurnal). There are four sub-tables arranged according to the four elements fire, earth, air and water.

Here the regents of the day and the regents of the night are in the same column; the first two rows show the sign and the day regent, while the next two rows mention the sign and the night regent. Thus Aries has the sun as the regent in the daytime and Jupiter as the regent at night.

Table A062-4 Triplicities and Regents

nārī (fiery)				*tarabī* (earthy)		
Aries	Taurus	Gemini		Cancer	Leo	Virgo
Sun	Jupiter	Saturn		Venus	Moon	Mars
Aries	Leo	Sagittarius		Taurus	Virgo	Capricorn
Jupiter	Sun	Saturn		Moon	Venus	Mars
hawā’ī (airy)				*māhī* (watery)		
Libra	Scorpio	Sagittarius		Capricorn	Aquarius	Pisces
Saturn	Mercury	Jupiter		Venus	Mercury	Moon

Gemini	Libra	Aquarius		Cancer	Scorpio	Pisces
Mercury	Saturn	Jupiter		Mars	Venus	Moon

The shadow squares are enclosed in a series of 8 concentric semi-circular scales. The two outermost scales on the rim are the cotangent scales and their subdivisions. The scale on the left is in digits; the unequal divisions here are numbered clockwise from the vertical diameter as 1, 2, 3, …18, 24, 30, … 60, followed by the label *ẓill aṣābiʿ mabsūṭ.* The scale on the right is in feet; the unequal divisions here are numbered anti-clockwise from the vertical diameter as 1, 2, 3, … 12, 18, 24, …60, followed by the label *ẓill aqdām mabsūṭ.*

The two semi-circular rows which follow contain the names of the 12 zodiac signs and the names of the 28 lunar mansions, showing their interrelationship.

The next two rows display the limits of the signs (*ḥudūd*) while the last two rows exhibit the decans (*wujūh*) and their regents.

ALIDADE

The alidade has ornate ends and an ornate centre-piece. The upper register on the right hand side carries a scale numbered in 6s from the centre to the tip as 6, 12, 18 … 60. This scale matches with the divisions of the vertical radius of the upper left quadrant, but unusually, the alidade is not graduated in single units.

The lower register on the right has unequal divisions numbered from 1 to 6 from the sighting plate onwards and again numbered from 7 to 12 in the reverse direction. When the alidade is used as a sundial with the sighting plate on the right as the gnomon, the shadow thrown by the sighting plate across the length of the alidade is measured on this scale in seasonal hours.

The right arm of the alidade is engraved with declination arcs together with the names of the six pairs of signs as in the upper right quadrant.

The sighting plates are equipped with two holes each. A sighting tube passes through the larger holes. It is difficult to say whether the tube was original or added later. At present the tube is slightly bent. [371]

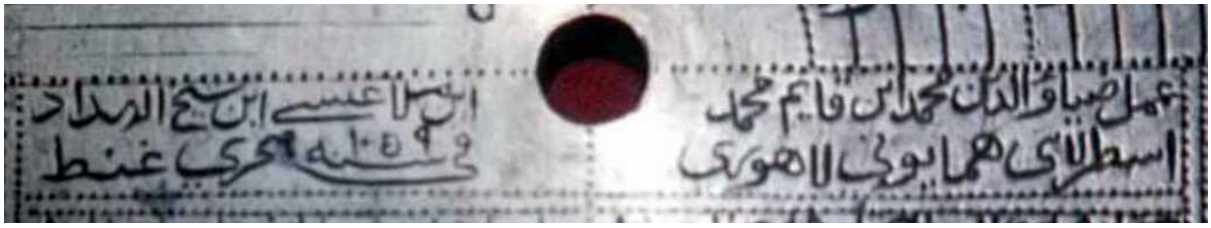


Figure A062.7 – Astrolabe maker’s signature and date (detail of Figure A048.4)

INSCRIPTION

Immediately below the horizontal diameter is the astrolabe maker’s signature, where the year of manufacture is given in common Arabic/Persian numerals as well as in the *Abjad* notation:

> *ᶜamal ḍiyā’ al-dīn muḥammad ibn qā’im muḥammad*
> *ibn mullā ᶜīsā ibn shaykh allāhdād*
> *asṭurlābī humāyūnī lāhūrī*
> *fī sanah 1059 hijrī gh-n-ṭ*
> ‘The work of Ḍiyā’ al-Dīn Muḥammad, son of Qā’im Muḥammad, son of Mullā ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the year 1059 Hijrī, [in *Abjad* 1000+50+9] 1059.’

BIBLIOGRAPHY

Nadvi 1935.

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371 There are some of astrolabes by Ḍiyā’ al-Dīn where it is difficult to decide whether the sighting tube is original. However, the sighting tube is original in Ḍiyā al-Dīn’s east-west astrolabe (A090).

A063 ASTROLABE BY ḌIYĀ AL-DĪN MUḤAMMAD, 1059 AH (AD 1649-50)

Diameter 190 mm

PLU: ex-London, Sotheby's (Catalogue 14 April 2010, lot 119)



Figure A063.1 – Front of the astrolabe (© Sotheby's)

This highly ornate astrolabe by Ḍiyā' al-Dīn was not noticed previously until it came up for auction at Sotheby's of London in 2010.

Components

Body with *kursī* (d. 190, h. 285), shackle and ring, rete, 5 plates, alidade, pin and horse.

Front

The trifoliate shackle has bases shaped like tear drops. The *kursī* is very elaborately reticulated and engraved. The profiles consist of an ogee rising from the limb, followed by a lobe and another ogee, topped by trifoliate finial. The horizontal petals of the trefoil stretch out and curve into sharp points. The same motif is repeated below in the middle of the *kursī* and also in the rete at its north point. The surface on both sides of the *kursī* is filled with very ornate engravings.

The limb is divided in 1° and 5° and labelled from 5 to 360.

Rete

The two rings of the Tropic of Capricorn and ecliptic are held together by the equinoctial bar which has counter changes at its intersection with the ecliptic. The spaces between the two rings are filled with an intricate and symmetrical floral design of tulips with flared petals on long curved stems. A part of the tracery below the ecliptic ring is broken off and the Capricorn ring is slightly distorted on the lower left. The star names are inscribed in very small letters and cannot be deciphered.

Plates

There are five plates to serve latitudes 22° and 25°; 27° and 28°; 32° and 36°; 0° + 90° and ?; plate of ecliptic coordinates and plate of horizons. On the first three plates, altitude circles are drawn for each 2° and azimuth circles for each 6°.

Geographical Gazetteer

The gazetteer carries the names, longitudes and latitudes of 108 localities in Greater Iran and India.

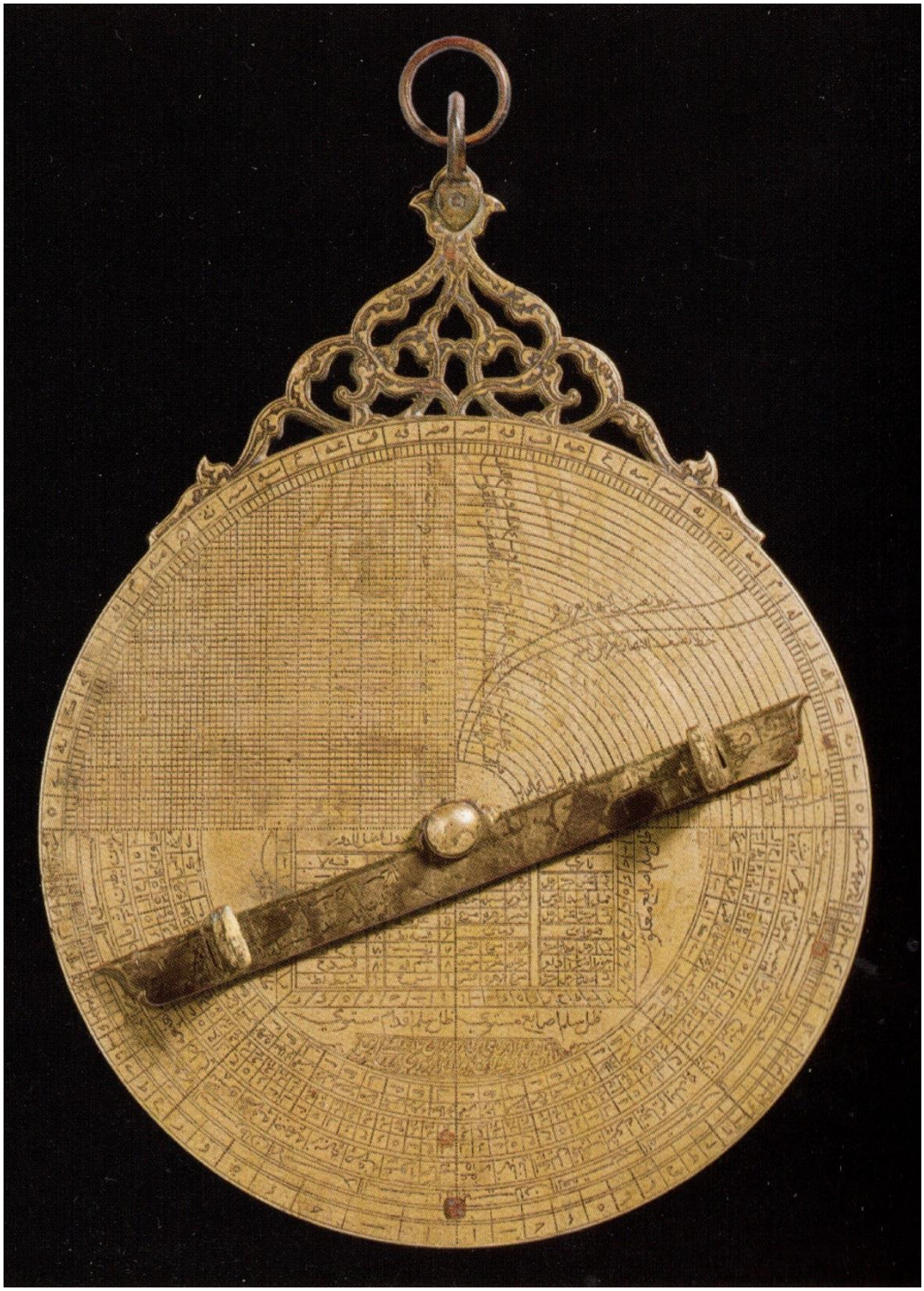


Figure A063.2 – Back of the astrolabe (© Sotheby’s)

BACK

The rim of the two upper quadrants bears altitude scales which are divided in 1° and 5° and labelled as 5—90; 90—5. The rim on the lower half carries cotangent scales.

In the upper left is a sexagesimal trigonometric quadrant with 60 horizontal and 60 vertical parallels, with each fifth highlighted with dots. The horizontal lines are numbered in 5s along the vertical radius. In the upper right is a solar quadrant with 30

declination arcs, one for each 6° solar longitude. The names of the corresponding zodiac signs are inscribed along the two radii, together with their subdivisions. Upon these are superimposed two sigmoid curves displaying the meridian altitude of the sun throughout the year at the latitudes of 27° (Agra) and 32° (Lahore). These carry the labels *khaṭṭ niṣf al-nahār bi-ᶜarḍ 27* (line of midday at latitude 27°) and *khaṭṭ niṣf al-nahār bi-ᶜarḍ 32* (line of midday at latitude 32°) respectively.

In the lower half, just below the horizontal diameter are drawn two shadow squares, on the left for a base of 7 and on the right for a base of 12. The vertical and horizontal scales are divided and numbered accordingly, and accompanied by the following labels: vertical scale on the left: *ẓill sullam aqdām maᶜkūs* (the scale of reverse shadows in feet); horizontal scale on the left: *ẓill sullam aqdām mustawī* (the scale of direct shadows in feet); *ẓill sullam aṣābiᶜ mustawī* (the scale of direct shadows in digits); and *ẓill sullam aṣābiᶜ maᶜkūs* (the scale of reverse shadows in digits).

Inside the shadow squares, there are two rectangular tables. On the left a table with the heading *jadwal faḍl al-dawr* (table of excess of revolution) showing the multiples of the difference (in minutes and seconds) between the approximately correct length of the tropical year and 365 days. On the right is a table displaying the triplicities and their diurnal and nocturnal regents, in four sub-tables, each devoted to an element: *nārī* (fiery), *tarābī* (earthy), *hawā'ī* (airy) and *māhī* (watery). Probably there is a heading *jadwal arbāb muthallathāt laylī wa nahārī* (table of the nocturnal and diurnal regents of the triplicities), but it is obscured by the alidade in the available photo.[372]

The shadow squares are enclosed in a series of 8 concentric semi-circular scales; counting from the outside, these represent the following:

1-2: cotangent scales and their subdivisions

3-4: zodiac signs and lunar mansions, showing their interrelationship

5-6: table of the limits (*ḥudūd*) of the signs

7-8: table of the decans (*wujūh*) and their regents.

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372 The catalogue mentions only the table on the left and not the one on the right.

ALIDADE

The alidade has ornate ends and an ornate centre-piece. The right hand side carries a sexagesimal scale, numbered in 5s from 5 to 60 from the centre to the end to match the divisions on the upper left quadrant. The left hand side bears a zodiac scale with the names of pairs of signs in each division to match the solar quadrant in the upper right.

INSCRIPTION

Below the shadow squares is the maker’s inscription with the following purport:

> ‘Made by Ḍiyā’ al-Dīn, son of Qā’im Muḥammad, son of Mullā ʿĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the year 1059 Hijrī.’

The year translates to AD 1649-50.

BIBLIOGRAPHY

Sotheby’s, London, auction catalogue, 14 April 2010, lot 119, pp. 82-83.

A064 ASTROLABE BY ḌIYĀ AL-DĪN MUḤAMMAD, 1060 AH (AD 1650-51)[373]

Diameter 314 mm

PLU; ex-New York, The Brooklyn Museum (# X638.2)

CCA 3555; Répertoire 8



Figure A064.1 – Front of the astrolabe (Image courtesy of the Brooklyn Museum; object reported as stolen to The Art Loss Register, Inc. 1999, former collection of the Brooklyn Museum x638.2.)

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[373] Entry based on Savage-Smith 1992a.

This astrolabe was published for the first time by Emilie Savage-Smith in her comprehensive study of the 'Celestial Mapping' with a detailed listing of the stars on the rete, a valuable diagram of the rete and photos of the rete, gazetteer, back and the plate for latitude 29. Upon my request, the Brooklyn Museum kindly sent me a clear photo of the front and photocopies of the plates for latitudes 22°, 25°, 27° and 31;50°, but expressed their inability to provide photos of the gazetteer and the back. In the absence of good photos of these, the gazetteer and especially the back cannot be described completely. Now the Museum informs me that the astrolabe was stolen in 1999.

COMPONENTS

Body with *kursī* (d. 314), shackle and ring, rete for 53 stars, 4 plates. Alidade, pin and horse are missing.

FRONT

Plain ring, shackle of trifoliate shape but with plain circular bases; very finely pierced *kursī* with profiles made up of ogees and lobes and a trifoliate finial. The limb is divided in 1° and 5° and labelled from 5 to 360.

RETE

The two circles of Capricorn and ecliptic are held together by the equinoctial bar with counter changes at its two intersections with the ecliptic. The space inside these two circles is filled with an elaborate floral tracery connecting the 53 star pointers. The ecliptic circle is divided into the 12 signs of the zodiac and labelled with their names; each sign is divided into groups of 5° and labelled as 5, 10, 15, 20, 25, 30; this is quite unusual, the general practice being to divide the signs into groups of 6°. The sloped edge is divided into 1°. The names of the 53 stars engraved on the star pointers were deciphered and identified by Emilie Savage-Smith. These are reproduced here with slight modifications.

Table A064-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus al-Janūbī*	β Ceti
2	*Baṭn al-Ḥūt*	β Andromedae
3	*Fam al-Qayṭus*	γ Ceti
4	*Ṣadr al-Qayṭus*	π Ceti
5	*Rās al-Ghūl*	β Persei
6	*Mirfāq al-Thurayyā*	α Persei
7	*Masāfat al-Nahr*	γ Eridani
8	*ᶜAyn al-Thawr*	α Tauri
9	*ᶜAyyūq*	α Aurigae
10	*Rijl al-Jawzā' al-Yusrā*	β Orionis
11	*Yad al-Jawzā' al-Yusrā*	γ Orionis
12	*Yad al-Jawzā' al-Yumnā*	α Orionis
13	*Rijl al-Jawzā' al-Yumnā*	κ Orionis
14	*Shiᶜrā Yamānī*	α Canis Majoris
15	*Rās al-Taw'am al-Muqaddam*	α Geminorum
16	*Shiᶜrā Shāmī*	α Canis Minoris
17	*Ṭarfat al-Safīna*	ρ Puppis
18	*Maᶜlaf*	M44 Cancri
19	*Fard al-Shujāᶜ*	α Hydrae
20	*Qalb al-Asad*	α Leonis
21	*Ẓahr al-Dubb al-Akbar*	α Ursae Majoris
22	*Qā'idat al-Bāṭiya*	α Crateris

	Star Name	Identification
23	*Ẓahr al-Asad*	δ Leonis
24	*Ṣarfa*	β Leonis
25	*Anwar al-Farqadayn*	β Ursae Minoris
26	*ᶜAnāq*	ζ Ursae Majoris
27	*Janāḥ al-Ghurāb*	γ Corvi
28	*Simāk Aᶜzal*	α Virginis
29	*Simāk al-Rāmiḥ*	α Bootis
30	*Kiffa Janūbī*	$\alpha^{1,2}$ Librae
31	*Kiffa Shamālī*	β Librae
32	*Nayyir al-Fakkah*	α Coronae Borealis
33	*ᶜUnuq al-Ḥayyah*	α Serpentis
34	*Qalb al-ᶜAqrab*	α Scorpii
35	*Rijl al-Ḥawwā al-Yamīnī al-Muqaddam*	ρ Ophiuchi
36	*Rās al-Jāthī*	α Herculis
37	*Rās al-Ḥawwā*	α Ophiuchi
38	*ᶜAyn al-Tinnīn*	γ Draconis
39	*Yad al-Ḥawwā al-Yumnā al-Muqaddam*	δ Ophiuchi
40	*Nasr Wāqiᶜ*	α Lyrae
41	*ᶜIsābat al-Rāmī*	ρ Sagittarii
42	*Minqār al-Dajājah*	β Cygni
43	*Nasr al-Ṭā’ir*	α Aquilae
44	*Qarn al-Jadī al-Thānī*	α Capricorni
45	*Dhanab al-Dulfīn*	ε Delphini

	Star Name	Identification
46	*Dhanab al-Dajājah*	α Cygni
47	*Fam al-Faras*	ε Pegasi
48	*Dhanab al-Jadī*	δ Capricorni
49	*Mankib Sākib al-Mā'*	α Aquarii
50	*Sāq Sākib al-Mā' Janūbī*	δ Aquarii
51	*Dhanab al-Qayṭus Shamālī*	ι Ceti
52	*Mankib al-Faras*	β Pegasi
53	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are four plates. The Brooklyn Museum kindly sent me photocopies of the four plate faces; Savage-Smith published a fifth plate face. The plate of horizons with the label *ṣafīḥa āfāqī* can be seen below the rete in the photo of the front sent by the Brooklyn Museum. No information is available about the remaining two plate faces; one of these could be the plate of ecliptic coordinates. It is also not known how these six plates are interrelated.

Table A064-2 Plates

	φ	Longest Day hours	*ghaṭīs*	correct value in *ghaṭīs*
1	22°	13;21 hours	33 *karhā*	33;17,30
2	25°	13;35 hours	33 (!) *karīha*	33;56,15
3	27°	13;43 hours	---	
4	31;50°	14;7 hours	---	
5	29	13;52 hours	34 *karhā*	34;40
6	Plate of horizons			

	φ	Longest Day hours	*ghaṭīs*	correct value in *ghaṭīs*
7	?			
8	?			

On the plates calibrated for a particular latitude, altitude circles are drawn for every 1°, with each fifth dotted. Azimuth arcs are drawn for every 6°, above and below the horizon on the plates for 22° and 29°, and only below the horizon on the remaining plates. Each fifth azimuth arc is dotted.

Plain lines for seasonal hours are drawn. On the plates for 27° and 31;50°, lines for equal hours are drawn from the western and eastern horizons. On the plates for 22° and 25°, plain lines for equal hours as counted from the western horizon are drawn; in addition, dotted lines for *ghaṭīs* as counted from the western horizon are drawn. On these three plates, the duration of the longest day is also given in complete *ghaṭīs* (*karhā* or more correctly *karīhā*), ignoring the fractions.

Geographical Gazetteer

The gazetteer is engraved in four circles providing, besides the usual place name, longitude and latitude, also the duration of the longest day (*al-sāᶜāt*), for 260 localities. However, the duration ignores minutes and gives only the hours. The gazetteer does not commence exactly at the top, below the zero of the degree scale, but strangely 7° to the left, below 353°. The style of presentation and of calligraphy is totally different from the other astrolabes by Ḍiyā’ al-Dīn.

Back

The rim of the upper half contains altitude scales which are divided in 1° and 5° and labelled 5—90; 90—5.

In the upper left is a trigonometric quadrant with 60 horizontal parallels, with every fifth dotted; these are numbered in 5s along the vertical radius. In the upper right is a solar quadrant with 60 equally spaced concentric declination arcs, with every fifth dotted; the names of the corresponding zodiac signs are written along the two radii.

Moreover, radial lines are also drawn for every 5°. Upon this grid are plotted three graphs of solar meridian altitude for the latitudes 27°, 29° and 32° with the usual labels.

In the lower half are the shadow squares, on the left for a base of 7 feet and on the right for a base of 12. These enclose a large rectangular table of multiples of excess revolution with the heading *jadwal faḍl al-dawr*. Below this is a smaller table which cannot be identified.

The shadow squares are encircled by 10 semi-circular rows. The first 8 rows contain, as in other large astrolabes by Ḍiyā' al-Dīn, the cotangent scales, the names of the 28 lunar mansions and the names of the corresponding 12 zodiac signs, the limits of signs, the decans and their regents.

These are followed by two more semi-circular rows which cannot be deciphered in the faint reproduction which is available. There seem to be two separate tables on the left and right. In the table on the left, one row carries the names of the signs from Libra to Pisces.

Inscription (according to the Répertoire)

Directly below the horizontal diameter is the astrolabe maker's signature:

> *ʿamal [aqall] al-ʿibād mullā ḍiyā' al-dīn muḥammad ibn mullā qā'im muḥammad ibn ḥāfiẓ ʿīsā ibn shaykh allāhdād asṭurlābī humāyūnī sanah 1060.*
>
> 'The work of [the weakest of] the servants [of God], Mullā Ḍiyā' al-Dīn, son of Mullā Qā'im Muḥammad, son of Ḥāfiẓ ʿĪsā, son of Shaykh Allāhdād, the astrolabe maker to [the Emperor] Humāyūn in the year 1060 [Hijrī].'

The inscription strangely omits *aqall* in the standard phrase of humility *aqall al-ʿibād.* Ḍiyā' al-Dīn adds the attribute *mullā* to his name and as well as to his father's, while the grandfather is styled *ḥāfiẓ* and the great-grandfather *shaykh.* The Hijrī year translates to AD 1650-51.

Provenance

The museum informs me, through their mail of 21 March 2016, that the astrolabe was stolen in 1999.

Bibliography

Savage-Smith 1992a.

A065 ASTROLABE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1061 AH (AD 1650-51)

Diameter 210 mm

PLU, ex-London, Christie's (catalogue 24 September 1992, lot 113)

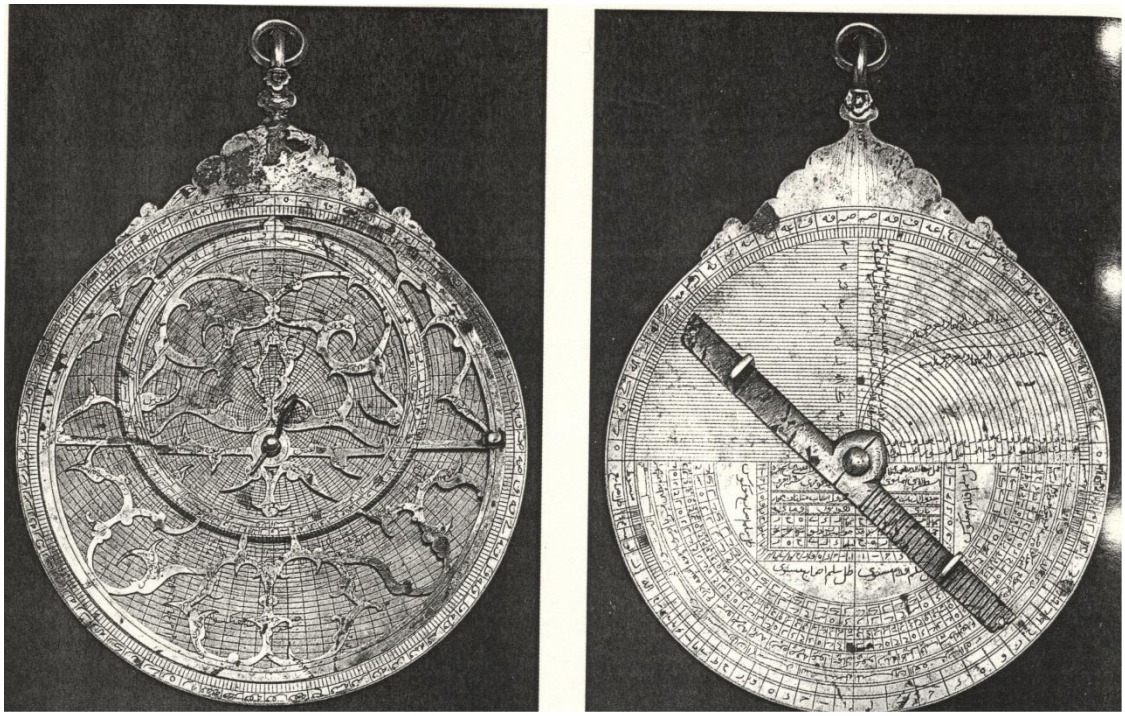


Figure A065.1 – Front and back of the astrolabe (© Christie's, London)

COMPONENTS

Body (d. 210) with *kursī,* ring and shackle, rete, 5 plates, alidade and pin. The alidade is a replacement; the wedge is missing.

FRONT

Plain ring, shackle with trifoliate form and trifoliate bases; the *kursī* is solid, with profiles made up of two ogees with a lobe in between, finial trifoliate. The catalogue says that there is a faint engraving on the surface of the *kursī* and also on the edge of the body. The limb is divided in 1° and 5° and labelled from 5 to 360. Inside the limb, there is a plug at the south point, which is rather unusual.

RETE

The Capricorn ring and the ecliptic ring are held together by the equinoctial bar which has counter changes at its two intersections with the ecliptic ring. The ecliptic ring is divided into the 12 zodiac signs and labelled with their names, each sign is subdivided into units of 6° each which are numbered separately in each sign from 6 to

30. The edge of the ecliptic ring appears to be calibrated for 1°. There are about 40 named star pointers.

PLATES

The catalogue says: 'two original **plates,** two later replacements'. But the illustration on the facing page shows 5 plates, with the following particulars.

1. Plate of horizons with four notches at the four cardinal points; four sets of half-horizons, but not declination scales, nor a label mentioning the name of the plate.
2. Plate of ecliptic coordinates with latitude circles for every 2° and longitude circles for each 6°. Above the north point, there is the label *ṣafīḥat mīzān al-ᶜankabūt.*
3. Plate for latitude 32°. Altitude circles for every 2°, azimuth arcs below the horizon for every 6°, lines for seasonal hours and for equal hours from the western horizon. In the middle of the plate is engraved *al-ᶜarḍ 32* and *sāᶜāt 14;8.*
4. Plate for latitude 23°. Altitude circles for every 3°, azimuth arcs above the horizon for each 9°, lines for seasonal hours and lines for equal hours drawn from the western horizon. In the middle of the plate is engraved, in much larger letters than in in the previous plate, *ᶜarḍ 23.* The maximum duration of daylight cannot be read.
5. Plate probably for latitude 36°; the circles as above. The latitude and the daylight hours are engraved, but cannot be read.

Possibly the nos. 4 and 5 are replacements. Plates 2-5 have notches at the south point to fit into the plug placed at the south point in the limb. It is unusual that the plate of horizons and the plate of ecliptic coordinates are engraved on two separate plates.

GEOGRAPHICAL GAZETTEER

The catalogue says 'inner face with qibla directions and localities,' but the photo of the gazetteer on p. 39, shows clearly the argument as *asmā al-buldān* (place names), *al-ṭūl* (longitude) and *al-ᶜarḍ* (latitude) for 108 localities. There are no *qibla* directions.

BACK

The rim of the two upper quadrants carries altitude scales divided in 1° and 5° and labelled as 5—90; 90—5. In the upper left quadrant are 60 horizontal parallels, which are numbered in 5° along the vertical radius from 5 to 60. In the upper right quadrant are drawn 30 quarter circles, one for each 6° of solar longitude. The names of the corresponding zodiac signs are inscribed along the two radii, together with the

subdivisions of the signs. Two sigmoid graphs of the midday altitude of the sun throughout the year at latitudes 27° and 32° are drawn along with the usual labels.[374]

In the lower half are drawn shadow squares, on the left for a base of 12 and on the right for a base of 7. The scales are accompanied by the usual labels.

Within the shadow squares there are two rectangular tables. The table on the left displays the triplicities and their diurnal regents while that on the right shows the triplicities and their nocturnal regents.

The rim of the lower half carries the cotangent scales, on the left in digits and on the right in feet. These are followed by six semi-circular rows containing the names of the 12 signs, the names of the 28 lunar mansions, the limits of the signs, the decans and their regents.

INSCRIPTION

Immediately below the horizontal diameter is inscribed the astrolabe maker’s signature together with the year of manufacture 1061 Hijrī (= AD 1650-51).

BIBLIOGRAPHY

Christie’s, London, auction catalogue, 24 September 1992, lot 113, pp. 38-39.

374 The catalogue describes the quadrant erroneously: ‘the upper right quadrant with scale for unequal hours’.

A066⊙ ASTROLABE BY ḌIYĀ AL-DĪN MUḤAMMAD, 1062 AH (AD 1651-52)

Diameter 149 mm

Cardiff, National Museum of Wales (# 39.573/2)

CCA 1107; Répertoire 10



Figure A066.1 – Front of the astrolabe (photo by S. R. Sarma)

COMPONENTS

Body with *kursī* (d. 149, h. 197, t. 7), shackle and ring, rete (d. 135) for about 37 stars, 4 plates and alidade. The original pin and horse are lost. The components are held together by a modern bolt and nut.

FRONT

The ring is plain and the shackle trifoliate. The *kursī* is elegant with fretwork and ornate patterns engraved on the surface. The profiles are made up of a lobe between two ogees and topped by trefoil. The limb is divided in 1° and 5° and labelled from 5 to 360.



Figure A066.2 – Rete of the astrolabe (photo by S. R. Sarma)

RETE

The Capricorn and ecliptic ring are held together by an equinoctial bar which has counter changes at the centre, at vernal equinox, and, most unually, in the eastern

segment as well. The solstitial bar is shown completely, not as a continuous strip, but with a series of oval frames.

The ecliptic circle is divided into the 12 signs and labelled with their names; each sign is divided into 5 parts and the parts numbered as 6, 12, 18, 24, 30.

There are about 37 named star pointers which are joined by frames of diverse shapes. The star pointer Vega is shown as a bird inside a cage-like oval frame.

Plates

Four plates nest inside the mater; there is still space for more plates; perhaps one or two plates are missing, in particular a fifth plate with ecliptic coordinates and multiple horizons.

Table A066-1 Plates

	φ	Longest day
1a	22°	13;22 hours
1b	25°	13;35 hours
2a	18°	13;12 hours
2b	29°	13;55 hours
3a	27°	13;43 hours
3b	36°	14;32 hours
4a	24°	13;25 hours
4b	32°	14;8 hours

Geographical Gazetteer

On the inner surface of the mater is engraved a geographical gazetteer in three circles with the names, longitudes and latitudes of 69 localities.

Back

The rim of the two upper quadrants bears altitude scales which are divided in 1° and 5° and labelled as 5—90; 90—5.

In the upper left are drawn 60 horizontal parallels with every fifth highlighted with dots. These are numbered along the vertical radius from 5 to 60.



Figure A066.3 – Back of the astrolabe (photo by S. R. Sarma)

Eighteen equally spaced declination arcs are drawn in the upper right quadrant, so that the spaces between the arcs represent 10° of solar longitude. Along the two radii

are inscribed the names of the corresponding zodiac signs and the degrees of the three decans. Upon this grid are drawn two graphs of solar meridian altitude for the latitudes 27° and 32° with the usual labels.

In the lower half are shadow squares, on the left for a base of 7 feet and on the right for a base of 12 digits. On the left the vertical and horizontal scales are divided into 7 parts each and the parts are numbered from 1 to 7. On the right the scales are divided into 6 parts each and parts are numbered 2, 4, … 12. In adjoining scales, these parts are halved to produce 12 parts in all. The scales are accompanied by the usual labels.

The shadow squares are enclosed in 8 concentric semi-circular rows. The outermost row carries the cotangent scales, on the left for feet and on the right for the digits. The scale on the left bears the numbers 1, 2, 3, … 12, 18, 24, 30, 36, 42, 48, 60, followed by the label *ẓill aqdām mabsūṭ*. The right half also bears the same numbers, but followed by the phrase *ẓill aṣābiᶜ mabsūṭ*. The next semi-circular row carries the subdivisions (of 1 unit) of the cotangent scale.

The next two rows are engraved respectively with the names of the signs of the zodiac and the names of the lunar mansion and thus show the correlation between these two sets of units. Thereafter, two rows display the limits of the signs and the last two rows the decans and their regents.

Within the shadow squares is a table showing the multiples of the difference between the approximately correct length of the tropical year and 365 days, but its name *faḍl al-dawr* is not engraved.

Alidade

The alidade has ornate ends and an ornate centre-piece. Unusually, it is graduated only on the right hand side with a sexagesimal scale, numbered in 5s from 5 to 60. The left hand side is completely blank. The sighting plate on the left is missing.

Inscription

Just below the horizontal diameter is engraved the astrolabe maker's name and his genealogy. The year of manufacture is added below the shadow squares.

ṣanᶜat ḍiyā' al-dīn muḥammad
ibn qā'im muḥammad ibn mullā ᶜīsā

ibn shaykh allāhdād asṭurlābī

humāyūnī lāhūrī

fī sanah 1062 hijrī

‘The work of Ḍiyā’ al-Dīn Muḥammad, son of Qā’im Muḥammad, son of Mullā ʿĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the year 1062 Hijrī.’ The year corresponds to AD 1651-52.

A067⊙ ASTROLABE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1062 AH (AD 1651-52)[375]

Diameter 266 mm

Hyderabad, Salar Jung Museum (#112/2/xxxv)



Figure A067.1 – Front of the astrolabe (photo by S. R. Sarma)

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[375] I had the privilege of accompanying Professor David King when he examined this astrolabe in 1991. This description is partly based on his notes. I copied the gazetteer on a subsequent visit.

It is one of Ḍiyā’ al-Dīn’s large astrolabes with a finely crafted *kursī*, a gazetteer of 156 places, and as many as eight solar meridian altitude curves.

Components

Body with *kursī* (d. 266, h. 306, t. 13), shackle and ring, rete for 52 stars, 6 plates. The original alidade, pin and horse are missing. These are replaced by a crude alidade with a sighting tube, a modern threaded bolt and a winged nut. Moreover, a semi-circular loop is attached to the ring at a later point. On the back, two long strips were hammered onto the profile of the *kursī* on the left and over the altitude scale on the right (see Figure A067.3). In the latter place the divisions of the scale are carefully re-engraved on the strip. These appear to be repairs of later times.

Front

The shackle is trifoliate. The simple fretwork in the *kursī* is highly elegant, producing five tulip flowers, an upright one in the middle with an upside-down flower on either side. The flared petals of two larger tulips form the profiles with lobes and ogees; it is reminiscent of some of Muqīm’s astrolabes (A021; A049). The finial is trifoliate.

The limb is divided in 0;20°, 1°, 3° and numbered in 3s from 3° to 360°.

Rete

The equinoctial bar on the rete is complete and is counter-changed at the centre and at the two points of intersection with the ecliptic. The ecliptic is divided into signs, each sign is further divided in groups of 6° and then in single degrees. The rete displays a large number of star pointers, representing the positions of as many as 52 stars. These pointers are joined by a tracery of a highly accomplished and almost symmetrical floral pattern. There is a handle on the outer periphery of the rete at a place nearly midway between the north and west points.

The following are the star names engraved on the star pointers.



Figure A067.2 – Rete of the Astrolabe (photo by S. R. Sarma)

Table A067-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus J[anūbī]*	β Ceti
2	*Baṭn al-Ḥūt*	β Andromedae
3	*Rijl al-Musalsala*	γ Andromedae
4	*Mu’akhkhar al-Sharṭayn*	γ Arietis
5	*Fam al-Qayṭus*	γ Ceti
6	*Ṣadr al-Qayṭus*	π Ceti

	Star Name	Identification
7	*Rās al-Ghūl*	β Persei
8	*Kaff al-Jadhmā’*	α Ceti
9	*Tālī Masāfat al-Nahr*	γ Eridani
10	*ᶜĀyn al-Thawr*	α Tauri
11	*ᶜAyyūq*	α Aurigae
12	*Rijl al-Jawzā’ al-Yusrā*	β Orionis
13	*Yad al-Jawzā’ al-Yusrā*	γ Orionis
14	*Rijl al-Jawzā’ al-Yumnā*	κ Orionis
15	*Yad al-Jawzā’ al-Yumnā*	α Orionis
16	*Shiᶜrā Yamānī*	α Canis Majoris
17	*Ṭarfat al-Safīna*	ρ Puppis
18	*Shiᶜrā Shāmī*	α Canis Minoris
19	*Miᶜlāf*	M44 Cancri
20	*Fard al-Shujāᶜ*	α Hydrae
21	*Rās al-Asad*	μ Leonis
22	*Ẓahr Dub al-Akbar*	α Ursae Majoris
23	*Qāᶜidat al-Bāṭiya*	α Crateris
24	*Ẓahr al-Asad*	δ Leonis
25	*Ṣarfa*	β Leonis
26	*Janāḥ al-Ghurāb*	γ Corvi
27	*Simāk Aᶜzal*	α Virginis
28	*ᶜAnāq*	ζ Ursae Majoris
29	*Simāk Rāmiḥ*	α Bootis
30	*Kaffa J[anūbī]*	α Librae

	Star Name	Identification
31	*Kaffa Sh[amālī]*	β Librae
32	*Nayyir Fakkah*	α Coronae Borealis
33	*ᶜUnuq al-Ḥayyah*	α Serpentis
34	*Rukbat ḥ-w-s-r-y* (?)	
35	*Rās al-Jāthī*	α Herculis
36	*ᶜĀyn al-Tinnīn*	γ Draconis
37	*Rās al-Ḥawwā*	α Ophiuchi
38	*Yad al-Ḥawwā al-Yumnā al-Muqaddam*	δ Ophiuchi
39	*Nasr Wāqiᶜ*	α Lyrae
40	*Minqār al-Dajājah*	β Cygni
41	*Nasr al-Ṭā’ir*	α Aquilae
42	*Dhanab al-Dulfīn*	ε Delphini
43	*Dhanab al-Dajājah*	α Cygni
44	*Dhanab al-Jady*	δ Capricorni
45	*Fam al-Faras*	ε Pegasi
46	*Mankib Sākib al-Mā’*	α Aquarii
47	*Sāq Sākib al-Mā’*	δ Aquarii
48	*Dhanab al-Qayṭus Sh[amālī]*	ι Ceti
49	*Mankib al-Faras*	β Pegasi
50	*Kaff al-Khaḍīb*	β Cassiopeiae
51	*Surrat al-Faras*	δ Pegasi
52	*Janāḥ al-Faras*	γ Pegasi

PLATES

There are six plates with the following specifications.

Table A067-2 Plates

	φ	Longest Day hours	*ghaṭīs*	correct *ghaṭīs*
1a	17°	13;07	32;37	32;47,30
1b	19°	13;15	32;55	33;7,30
2a	21°	13;16,56	33;12,20	correct
3a	27°	13;43	34;17	34;27,30
2b	29°	13;58,56	34;52,20	34;57,20
3b	32°	14;8	35;20	correct
5a	35°	14;22	35;55	correct
6a	40°	14;52		
4a	30°+44°			
5b	0°+90°			
4b	Plate of ecliptic coordinates			
6b	Plate of horizons			

On the plate faces serving a single terrestrial latitude, altitude circles are drawn for every 1° and each sixth line is dotted. Azimuth circles are plotted below the horizon for each 6°. Lines for seasonal hours are drawn. On some plates, there are also dotted lines for equal *ghaṭīs* drawn from the western horizon and numbered from there in *Abjad* notation. On plate faces 3a, 3b, 5a the *ghaṭīs* are numbered in standard Arabic/Persian numerals. Because two and half *ghaṭīs* (of 24 minutes each) make one hour (60 minutes), certain *ghaṭīs* are divided into two parts to synchronize with the equal hours. Thus *ghaṭī* numbers 3, 8, 13, 18, 23, 28 are halved so that time can be measured in both the *ghaṭī* and equal hours from these lines.

On these plates, below the Tropic of Cancer, are engraved the value of the latitude and the maximum duration of the daylight at this latitude in hours, as is the usual

practice. In six cases, the duration of the longest day is also mentioned in *ghaṭīs* and *palas* (spelt *kahrī* and *pal* respectively). However, in four cases the values in *ghaṭīs* are not correct as shown in the table above.[376]

Plate 4a has a double projection to serve two latitudes 30° and 44°. Here altitude circles are drawn for every 2° and every fifth is highlighted with dots. There are lines for seasonal hours and dotted lines for equal hours drawn from the western horizon.

Three sets of circles are engraved on plate 5b. In the upper left are altitude circles for each 2° and azimuth arcs for each 6° for latitude 0°. In the upper right are altitude circles for each 2° above and below horizon for latitude 90°. In the lower half are drawn azimuth circle for each 2° and lines for seasonal hours at latitude 0°. Under the horizontal diameter in the east is engraved *lā ᶜarḍ lah* (there is no latitude) and *sāᶜāt 12* (maximum duration 12 hours) and in the west *ᶜarḍ tisᶜūn* (latitude 90).

GEOGRAPHICAL GAZETTEER

On the inner side of the mater, a geographical gazetteer of 156 localities is engraved with their longitudes and latitudes in four concentric circles.

Table A067-3 Geographical Gazetteer

	Place Name *al-bilād*	**L** *al-ṭūl*	**φ** *al-ᶜarḍ*
	First Circle		
1	Sāwa	85;0	35;0
2	Qazwīn	85;0	36;0
3	Iṣfahān	86;40	32;25
4	Kāshān	86;0	34;0
5	Qum	85;40	34;45
6	Rayy	86;20	35;0
7	Tāliqān	85;45	36;10

[376] It is incomprehensible why errors occur in this simple conversion where 1 hour of 60 minutes = 2.5 *ghaṭīs* of 24 minutes. Such errors can be seen in other Indo-Persian as well as in Sanskrit astrolabes.

	Place Name *al-bilād*	**L** *al-ṭūl*	**φ** *al-ᶜarḍ*
8	Astarābād	89;35	36;50
9	Jurjān	90;0	36;50
10	Sumnān	88;0	36;0
11	Dāmqān	88;55	36;20
12	Busṭām	89;30	36;10
13	Sarwār	91;30	36;5
14	Nīshābūr	92;30	36;21
15	Ṭūs	92;30	36;0
16	Turshīz	92;0	36;0
17	Tūn	92;30	35;0
18	Qā’in	93;20	33;40
19	Harāt	94;20	34;30
20	Sarakhs	94;30	37;0
21	Marw	97;0	37;40
22	Fāriyāb	99;0	36;45
23	Balkh	101;0	36;41
24	Andarāb	103;45	36;0
25	Badakhshān	104;24	37;10
26	Hazār Asf	95;0	41;0
27	Bukhārā	97;30	39;50
28	Samarqand	99;56	39;37
29	Ṭarāz	99;50	44;31
30	Khujand	100;35	41;55
31	Kāshghar	106;30	44;0

	Place Name ***al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
32	Khutan	107;0	42;0
33	Quraqūrūm	115;0	46;0
34	Khān Bāligh	124;0	46;0
35	Hurmūz	92;0	25;0
36	Maymand	104;40	35;0
37	Rabāt Amīr	105;0	34;0
38	Daybul	82;30	25;?
39	Nahlawāra	106;0	17;0
40	Mūltān	107;35	29;40
41	Qandahār	107;40	33;0
42	Lahāwar	119;20	31;50
43	Qūz	115;50	26;35
44	Bānārasī	117;20	26;55
45	Sarāndīp	130;0	10;0
46	Tubbat	110;0	40;0
47	Kashmīr	108;0	35;0
48	Ḥaḍrat Dihlī	113;35	28;0
49	Akra	115;0	26;43
50	Kawāliyār	115;0	26;29
51	Ajmīr	111;5	26;0
52	Ujjayn	32;0	22;30
53	Aḥmadābād	103;40	28;55
54	Kābul	104;40	35;0
55	Siyālkūta	109;20	33;0

	Place Name *al-bilād*	**L** *al-ṭūl*	**φ** *al-ᶜarḍ*
56	Pānīpatah	118;20	28;12
57	Jidda	76;0	21;0
58	Bījāpūr	108;30	17;20
59	Mandū	111;25	22;15
60	Kūlkanda	114;50	27;8
61	Bahrūj	109;45	21;20
62	Juyul	106;40	19;0
63	Kanbāyat	109;20	22;20
	Second Circle		
64	ᶜAdan	76;0	11;0
65	Madīnat Rasūl ᶜAlīyat al-Salām	75;20	25;0
66	Makka Muᶜazzam	77;10	21;40
67	Tā’if	77;30	21;20
68	Bayt al-Maqdis	66;30	31;50
69	Ṭarābulus	69;40	34;0
70	Dimashq	70;0	33;15
71	Baᶜalbak	70;45	33;15
72	Ḥamaṣ	70;45	34;0
73	Ḥalab	72;10	35;10
74	Ṭarsūs	68;40	36;42
75	Malṭiya	71;0	37;0
76	Azran al-Rūm	77;0	39;40
77	Arzinkān	76;0	38;0
78	Sīwās	71;40	39;0

	Place Name ***al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
79	Qūnya	66;30	41;0
80	Raqah	73;15	36;0
81	ᶜĀna	76;30	34;0
82	Mawṣil	77;0	34;30
83	Arjīs	77;0	38;30
84	Salmās	79;15	37;40
85	Khuway	79;40	37;40
86	Ūrmiya	79;45	37;0
87	Nakhjawān	81;15	38;40
88	Tabrīz	82;0	38;0
89	Ardabīl	82;30	38;0
90	Mūqān	83;0	38;0
91	Bardaᶜa	83;0	40;30
92	Pākīya	84;30	39;30
93	Shamākhī Qaṣba Shirwān	84;30	40;50
94	Bāb al-Abwāb	85;0	43;0
95	Bulghār	90;0	49;30
96	Kūfa	79;30	31;30
97	Madā’in	72;0	33;10
98	Baghdād	80;0	33;25
99	Baṣra	84;0	30;0
100	Rāmhurmūz	85;45	31;30
101	Arḥān	86;30	35;30
102	Fīrūzābād	87;30	28;10

	Place Name *al-bilād*	**L** *al-ṭūl*	**φ** *al-ᶜarḍ*
103	Shīrāz	88;0	29;36
104	Iṣṭakhr	88;30	30;0
105	Yazd	89;0	32;40
106	Shahrazūr	82;20	32;30
107	Zankān	83;40	36;30
108	Abhar	84;30	36;45
109	Hamadān	83;0	35;10
110	Karaj	84;45	34;0
	Third Circle		
111	Jazīra Mahrāj	150;0	1;0
112	Darqala	63;0	14;30
113	Bajja az Barbar	65;0	14;0
114	Mārbūhūshā	73;0	14;0
115	Mahjam	74;15	17;15
116	Dabīd	74;0	14;10
117	Sharja	74;40	14;50
118	Sūs Aqṣā	15;30	24;0
119	Dargha	21;18	25;10
120	Ajmīm	61;30	27;15
121	Aqṣar	61;40	24;15
122	Maᶜadan Zumurad	66;15	21;0
123	Natmā	67;15	25;40
124	Maᶜadan Dahab	67;35	21;45
125	Asfī	12;15	30;15

	Place Name ***al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
126	Saṭmāsah	20;0	21;30
127	Marrakish	21;15	29;15
128	Tādlā	22;0	30;15
129	Najrān	77;0	19;15
130	Damār	77;15	13;30
131	Sanᶜā’ dār al-Mulk Yaman	77;0	14;30
132	Sarīn	77;15	20;0
133	Halī bin Yāqūt	77;20	18;30
134	Ẓafār min al-Yaman	77;35	13;20
135	Aydhāb	68;0	21;0
136	ᶜAllāqī	69;0	26;0
137	Qaṣīr	69;0	26;0
138	Qaṭīf	74;0	25;0
139	Qīrwān	41;0	31;40
140	Mahdiya	42;0	32;30
141	Miṣr	63;20	30;20
	Fourth Circle		
142	Ṣāhil Bahr Awqayānūs	11;00	0;0
143	Ghana Maᶜadan al-Dhahab	39;0	10;0
144	Sufālat Azzanj	60;0	2;30
145	Wāsiṭ Bahr Kūrī	63;0	9;0
146	Jarmī Dār al-Mulk Ḥabasha	65;0	9;30

	Place Name *al-bilād*	**L** *al-ṭūl*	**φ** *al-ᶜarḍ*
147	Zaghāwa	66;0	1;10
148	Hadiya	66;0	2;0
149	Zaylaᶜ	71;0	8;0
150	Muqadishū	72;0	2;0
151	Barbara az Bilād Zanj	78;0	6;30
152	Shibām Qaṣba Haḍramawt	81;15	12;30
153	Mirbāṭ	82;0	12;0
154	Jazīra Lāmrī Maᶜaran al-Bū al-Fūd	137;0	9;0
155	Jabāl Qāmrūn Maᶜadan al-Baqm	135;0	10;0
156	Jazīra Kalah	147;0	8;0

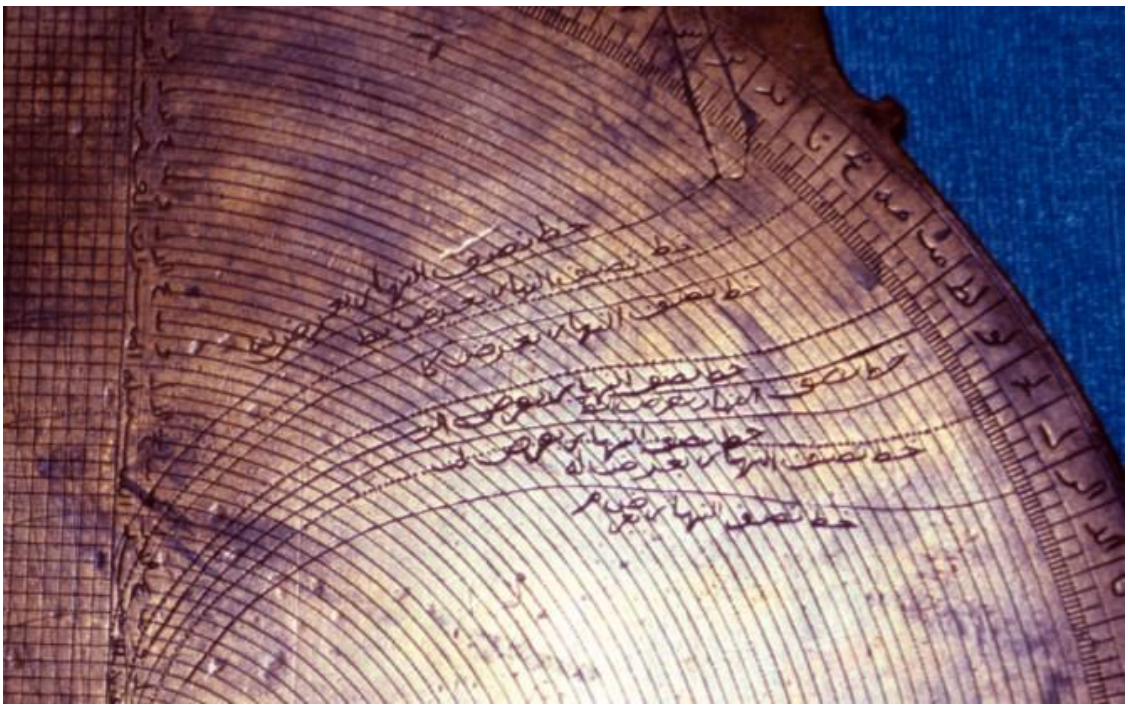


Figure A067.3 – Upper right quadrant with eight curves of the midday altitude of the sun. Note the repair in the altitude scale at the top (photo by S. R. Sarma)

BACK

On the back, the upper half of the rim is divided in 0;20°, 1°, 3° and numbered in 3s as 3—90; 90—3.

In the upper left quadrant is a sexagesimal sine-cosine graph with 60 horizontal and 60 vertical parallels and radial lines at each 6° and also at 45°. There are 9 concentric quarter circles which are at equal distances.

The solar quadrant in the upper right contains declination arcs for each 3° of solar longitude. The names of the corresponding zodiac signs are inscribed along the two radii and the numerical values of the subdivisions are numbered in 6s as 6, 12, 18, 24, 30. Upon these quarter circles are plotted eight curves of the solar meridian altitude for latitudes 15°, 19°, 21°, 27°, 29°, 32°, 35° and 40°.



Figure A067.4 – Lower half of the back (photo by S. R. Sarma)

Shadow squares are drawn in the lower half, on the left for a base of 7 and on the right for 12 and also for 60. The scales are divided and numbered accordingly. In the two inner corners of the squares is the label *ẓill sullam.* The vertical scale on the left is accompanied by the label *aqdām maᶜkūs* and the horizontal scale by *aqdām mustawī.* The horizontal scale on the right, divided in 12 digits and 60 parts carries the label *sittaynī wa aṣābiᶜ mustawī* and the vertical scales *sittaynī wa aṣābiᶜ maᶜkūs.*

Within the shadow squares are six semi-circular rows containing the names of the 28 lunar mansions, the 12 signs of the zodiac, the table of limits (*ḥudūd*) and the table of decans (*wujūh*).

These semi-circular rows enclose two rectangular tables which are engraved just below the horizontal diameter. On the left is the table called *faḍl al-dawr* (excess of revolution) and on the right is the table of triplicities and their nocturnal and diurnal regents (*arbāb muthallathāth al-layl wa al-nahār*).

The rim of the lower half contains the cotangent scales, on the left in feet (*al-aqdām*) and on the right in digits (*al-aṣābiᶜ*).

ALIDADE ETC

The original alidade is replaced by a sighting tube of crude workmanship, so also the pin and the horse.

INSCRIPTION

The maker’s signature is engraved in three lines just above the six semi-circular rows containing astrological tables and reads as follows:

> *ᶜamal ḍiyā’ al-dīn muḥammad ibn mullā qā’im muḥmmad ibn*
> *hāfiẓ ᶜīsā ibn shaykh allāhdād*
> *asṭurlābī humāyūnī*
> ‘The work of Ḍiyā’ al-Dīn Muḥammad, son of Mullā Qā’im Muḥammad, son of Hāfiẓ ᶜĪsā, son of Shaykh Allāhdād, the astrolabe maker to [the Emperor] Humāyūn.’

The year of manufacture is given in three eras at three different places: below the shadow squares is engraved *sanah 1062 hijrī*; to the east of the shadow square *sanah 1021 qadīmī* and to the west *sanah 1963 rūmī*.

The Hijrī year 1062 is from 13 December 1651 to 30 November 1652.

The Qadīmī year1021 is from 15 October 1651 to 13 October 1652.

The Rūmī year 1963 is from 11 October 1651 to 10 October 1652.

Therefore, the present astrolabe was completed sometime between 13 December 1651 and 10 October 1652.

BIBLIOGRAPHY

Sarma 1996a, pp. 17-20, plates 6-7.

A068⊙ ASTROLABE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1064 AH (AD1653-54)

Diameter 108 mm

Oxford, Museum of the History of Science (# 38862)

CCA 2533; Répertoire 11

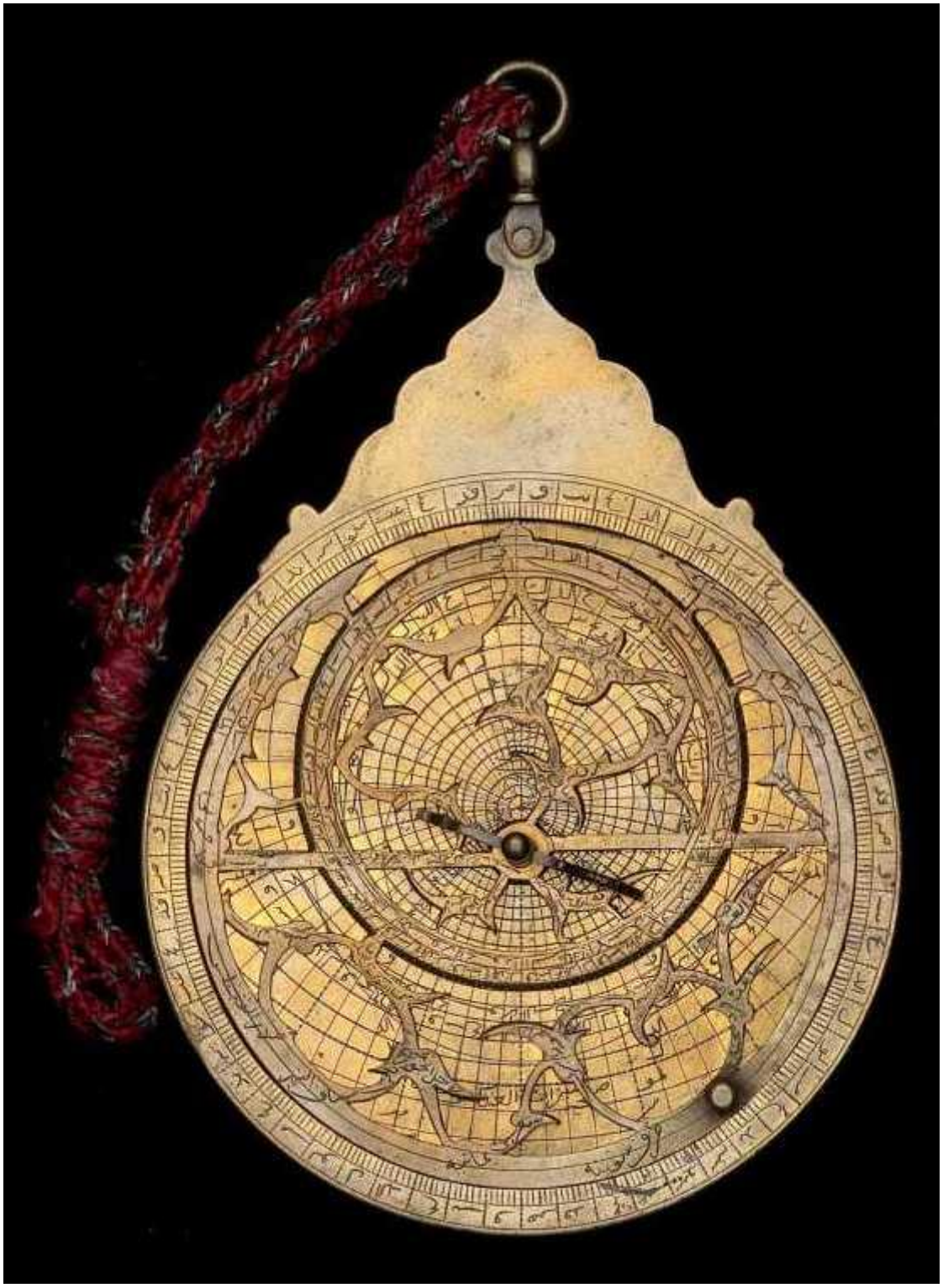


Figure A068.1 – Front of the astrolabe (© Museum of the History of Science, Oxford)

COMPONENTS

Body with *kursī* (d. 108, h. 147, t. 6), shackle, ring and cord, rete (d. 96) for 39 stars, 5 plates (d. 96), alidade, pin and horse.

FRONT

The ring is small with an octagonal cross section; the shackle is trifoliate. To the ring is attached a cord plaited of silver thread and white and red silk. The *kursī* is high and solid with a plain and smooth surface. The profiles are made up of ogees at the base and top with a lobe in between; the finial is trifoliate.

The limb is divided in 6° and 1° and labelled separately for each quadrant as 6—90; 6—90; 6—90; 6—90. Plain lines separate 1° while dotted lines mark 3°.



Figure A068.2 – Rete of the Astrolabe (© Museum of the History of Science, Oxford)

RETE

The two circles of the Tropic of Capricorn and ecliptic are held together by the equinoctial bar which has one counter change at the centre. The ecliptic circle is divided into the 12 signs of the zodiac and labelled with the names of the signs. Each sign is divided into units of 6° and these units are numbered 6, 12, … 30. The edge of the ecliptic circle is graduated in 3°. There is a sturdy handle on the outer ring midway between the north and west points.

The star pointers are joined by an asymmetric arrangement of vines, from which the star pointers emerge like thorns and in a few cases like flowers.

Table A068-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus Janūbī*[377]	β Ceti
2	*Baṭn al-Ḥūt*	β Andromedae
3	*Ṣadr al-Qayṭus*	π Ceti
4	*Kaff al-Jadhmā*	α Ceti
5	*Rās al-Ghūl*	β Persei
6	*Tālī Masāfat al-Nahr*	γ Eridani
7	*ᶜAyn al-Thawr*	α Tauri
8	*ᶜAyyūq*	α Aurigae
9	*Yad al-Jawzā’ Yusrā*	γ Orionis
10	*Rijl al-Jawzā’ Yumnā*	κ Orionis
11	*Shiᶜrā Yamānī*	α Canis Majoris
12	*Shiᶜrā Shāmī*	α Canis Minoris
13	*Tarafat Safīna*	ρ Puppis

377 The labels of *Dhanab al-Qayṭus Janūbī* and *Dhanab al-Qayṭus Sh[amālī]* are interchanged.

	Star Name	Identification
14	*Fard al-Shujā^{c}*	α Hydrae
15	*Qalb al-Asad*	α Leonis
16	*Rās al-Asad*	μ Leonis
17	*Ẓahr dub Akbar*	α Ursae Majoris
18	*Qā^{c}idat al-Bāṭiya*	α Crateris
19	*Ṣarfa*	β Leonis
20	*^{c}Anāq*	ζ Leonis
21	*Janāḥ al-Ghurāb*	γ Corvi
22	*Simāk A^{c}zal*	α Virginis
23	*Simāk Rāmiḥ*	α Bootis
24	*Kiffa Janūbī*	α Librae
25	*Nayyir Fakkah*	α Coronae Borealis
26	*^{c}Unuq al-Ḥayyah*	α Serpentis
27	*Qalb al-^{c}Aqrab*	α Scorpii
28	*Rās al-Jāthī*	α Herculis
29	*Rās al-Ḥawwā*	α Ophiuchi
30	*Yad al-Ḥawwā al-Yumnā*	δ Ophiuchi
31	*Nasr Wāqi^{c}*	α Lyrae
32	*Minqār al-Dajājah*	β Cygni
33	*Dhanab al-Dajājah*	α Cygni
34	*Dhanab al-Jadī*	δ Capricorni
35	*Sāq Sākib al-Mā’ Janūbī*	δ Aquarii
36	*Dhanab al-Qayṭus Shamālī*	ι Ceti
37	*Mankib al-Faras*	β Pegasi

	Star Name	Identification
38	*Surrat Faras*	δ Pegasi = α Andromedae
39	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are five plates with the following features.

Table A068-2 Plates

	φ	Longest day
1a	22°	13;22 hours
1b	25°	13;35 hours
2a	27°	13;43 hours
2b	29°	13;53 hours
3a	32°	14;8 hours
3b	36°	14;32 hours
4a	0° + 90°	
4b	18° + 72°	
5a	Plate of ecliptic coordinates	
5b	Plate of horizons	

On plates 1 to 3, altitude circles are drawn for every 3°, with every fifth line dotted. Azimuth arcs are traced for every 10° below the horizon; those for 30° are dotted and drawn above and below the horizon. There are plain lines for seasonal hours; dotted lines for equal hours from the western and the eastern horizons on plate 1, and from the western horizon on plates 2 and 3.

On plate 4a are combined projections for latitudes 0° and 90°, and on 4b combined projections for 18° and 72°. This plate has notches at the south and north points so that it can be used for both the latitudes engraved on each side.[378]

Plate 5 carries the label *ṣafīḥat mīzān al-ᶜankabūt* on the obverse and *ṣafīḥa āfāqiya* on the reverse.

Geographical Gazetteer

The gazetteer is engraved in two concentric circles, with much space between them. The letters are written so that their tops are towards the centre of the plate. The gazetteer commences at the south point, but the argument is engraved to the right of the vertical diameter. Thus the argument is at the end of the row and not at the beginning as is the general practice. The gazetteer contains place names, longitudes and latitudes, in this order, of 46 localities.

Table A068-3 Geographical Gazetteer

	Place Name ***asmā’ al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
	Outer Circle		
1	Makka Muᶜaẓẓam	77;10	21;40
2	Madīnat Musharrafa	75;20	25;0
3	Miṣr	63;20	30;20
4	Tabrīz	82;0	28;0
5	Bulghār	90;0	49;30
6	Kūfa	79;30	31;30
7	Madā’in	72;0	33;10
8	Baghdād	80;30	33;25

[378] In fact, all such plates having double projections ought to have two notches, but it is rarely done. Likewise the plates of horizons with four sets of half-horizons should have four notches so that all the four sets can be used, but this too rarely done.

	Place Name ***asmā’ al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
9	Baṣra	84;0	30;0
10	Shīrāz	83;0	29;36
11	Yazd	89;0	32;30
12	Iṣfahān	86;40	32;25
13	Ṭūs	94;30	37;0
14	Balkh	101;0	36;41
15	Bukhārā	97;30	39;50
16	Samarqand	99;59	39;37
17	Hurmūz	92;0	25;0
18	Aḥmadābād	108;0	23;15
19	Ujjayn	112;0	22;30
20	Kābul	104;40	34;30
21	Pānīpatah	113;20	28;52
22	Shāhjahānābād	113;35	28;39
23	Akbarābād	114;0	26;43
24	Ajmīr	111;5	24;0
25	Kawāliyār	114;0	26;0
26	Kashmīr	108;0	35;0
27	Tubbat	110;0	40;0
	Inner Circle		
28	Qannawj	115;50	26;50
29	Lahāwar	109;20	31;50
30	Qandahār	107;40	33;0
31	Mūltān	107;35	29;40

	Place Name *asmā’ al-buldān*	**L** *al-ṭūl*	**φ** *al-ᶜarḍ*
32	Tatta	102;30	25;10
33	Jidda	76;0	21;0
34	Pījāpūr	105;30	blank
35	Kalkanda	115;39	18;4
36	Dawlatābād	111;0	20;30
37	Jawnpūr	119;6	26;36
38	Manṣūra Sind	105;0	27;40
39	Kol	114;20	28;4
40	Burhānpūr	109;8	20;31
41	Bahrūj	111;5	21;20
42	Sirhind	111;33	30;30
43	Patna	120;15	26;40
44	Dhaka	130;0	27;0
45	Ilāhābād	112;34	26;50
46	Sūrat	110;50	20;15

BACK

The rim on the upper half carries the altitude scales which are divided in 1° and 6°, and labelled as 6—90; 90—6.

In the upper left quadrant are drawn 30 horizontal parallels, i.e., cosines of 2 of 60 parts of the Radius, with every third line highlighted with dots. Along the vertical radius, these lines are numbered as 6, 12, …60.

In the upper right quadrant are drawn six dotted declination arcs and the related signs of the zodiac are marked by their serial numbers (0 to 11) along the two radii; along the vertical radius, starting from the centre as 3, 4, 5, 6, 7, 8 (Cancer to Sagittarius; i.e., from summer solstice to winter solstice) and along the horizontal radius, starting

from the periphery as 9, 10, 11, 0, 1, 2 (Capricorn to Taurus, i.e. from winter solstice to summer solstice). On this grid are plotted two sigmoid graphs of solar meridian altitude for the latitudes 27° and 32° with the usual labels.

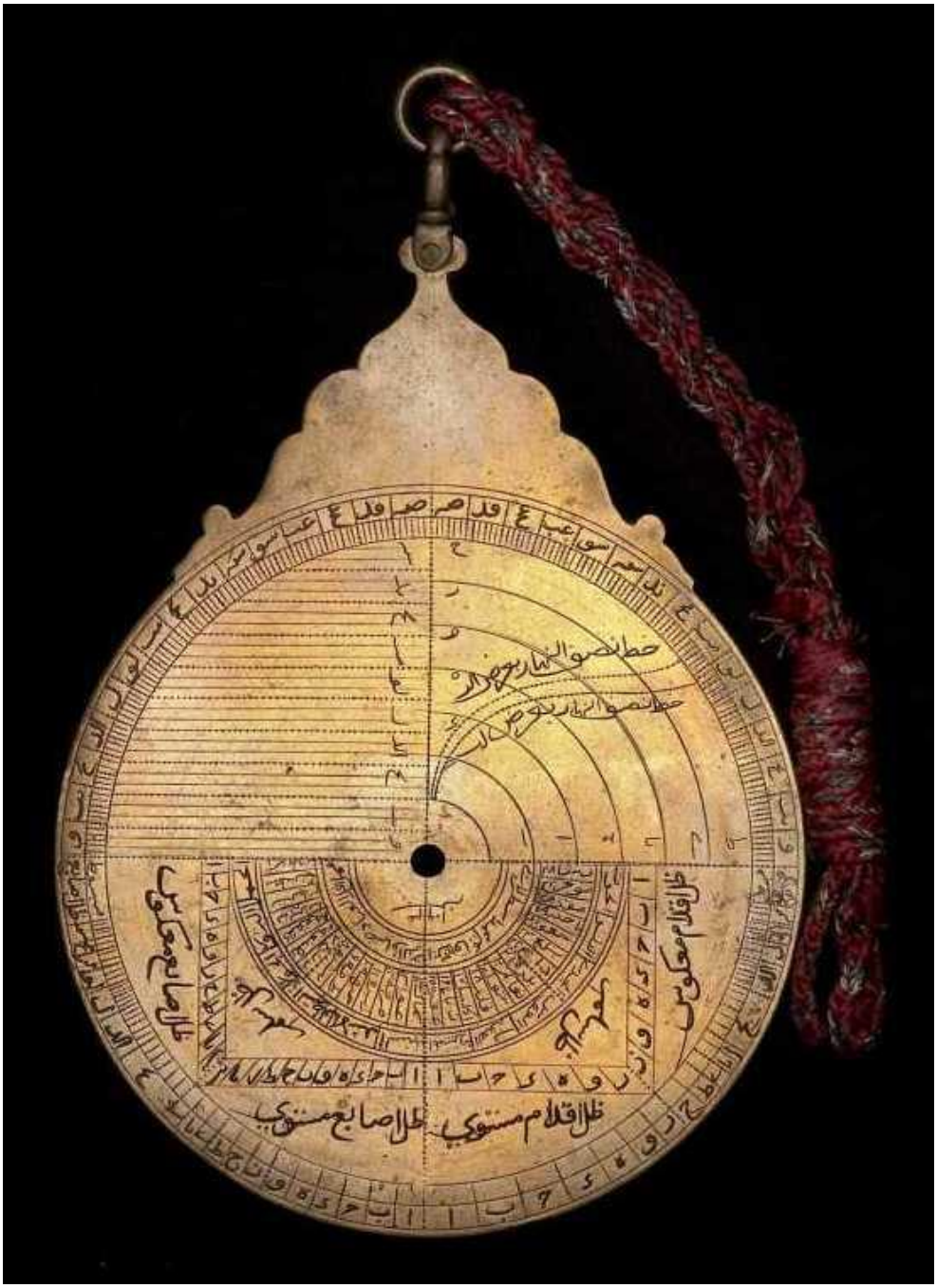


Figure A068.3 – Back of the astrolabe (© Museum of the History of Science, Oxford)

In the lower half are drawn the shadow squares, on the left for a base of 12 digits and on the right for a base of 7 feet. The scales on the left are divided into 12 parts and numbered from 1 to 12; the scales on the right are divided into 7 parts and numbered from 1 to 7. In both the corners, there is an identical legend *ẓill sullam.* The four scales are accompanied by the following labels:

Vertical shadow on the left *ẓill aṣābiʿ maʿkūs*
Horizontal shadow on the left *ẓill aṣābiʿ mustawī*
Horizontal shadow on the right *ẓili aqdām mustawī*
Vertical shadow on the right *ẓill aqdām maʿkūs*

Inside the shadow squares, there are two semi-circular rows displaying the correlation between the zodiac signs and the lunar mansions: in the outer row are written the names of the zodiac signs and in the inner semicircle the names of the corresponding 28 lunar mansions.

The rim on the lower half has the cotangent scales and their subdivisions in two consecutive rows. The unequal divisions on the left are numbered as 1, 2, 3, … 12, 18, 24, 30, 36, 42, 48, 54, 60, followed by the label *ẓill aṣābiʿ*. In the right half, divisions are numbered in the same manner, but followed by the label *ẓill aqdām.*

Alidade

The plain and ungraduated alidade is a replacement. The pin with a lotus-shaped head and the horse with mouth, eyes and mane clearly drawn are original.

Inscription

The two semi-circular rows of zodiac signs and lunar mansions are followed by a semi-circular panel which carries the astrolabe maker’s signature in an abridged form:

> *ʿamal aqall al-ʿibād ḍiyā’ al-dīn ibn qā’im muḥammad asṭurlābī*
> *sanah 1064*
> ‘The work of the least of the servants [of God], Ḍiyā’ al-Dīn, son of Qā’im Muḥammad, the astrolabe maker; the year 1064 [Hijrī].’

Provenance

Ex. Coll. Nicolas Landau
Coll. J. A. Billmeir, Elstead (Surry)

Bibliography

Maddison 1957, no. 163, pp. 23-24.

A069 ASTROLABE BY ḌIYĀ AL-DĪN MUḤAMMAD, 1064 AH (AD 1653-54)

Diameter ?

PLU, ex. Habibganj Collection

CCA 1118; Répertoire 12

In his pioneering survey of the Lahore family of astrolabe makers, Nadvi 1935, p. 628, states that an astrolabe by Ḍiyā' al-Dīn Muḥammad was 'in the Library of Nawab Sadar Yar Jung, Maulâna Habîbu'r-Rahmân Khân Sherwânî (Habib Ganj, District Aligarh). The date and inscriptions are thus:

> *ᶜamal aqall al-ᶜibād ḍiyā' al-dīn muḥammad ibn qā'im muḥammad ibn mullā ᶜīsā ibn shaykh allāhdād asṭurlābī humāyūnī lahūrī fī sanah 1064 h*
>
> 'The work of the humblest creature Zîa'u'd-dîn Muḥammad, son of Qâim Muḥammad, son of Mullâ 'Isâ, son of Sheykh Allâh-Dâd, Astrolâbî , Humâyûnî, Lahôrî, in 1064 A.H.)'

A large collection of manuscripts and historical artefacts belonging to this family was gifted to Aligarh Muslim University in 1960; this collection is now well known as the 'Habibganj Collection' in the Maulana Azad Library of Aligarh Muslim University. The astrolabe, however, did not reach Aligarh Muslim University, nor was it with the family. It disappeared somewhere in the process of transfer and since then there has been no trace of it.

Besides the text of the signature and the year of production provided by Nadvi, no other details about this astrolabe are available.

A070 ASTROLABE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1064 AH (AD 1653-54)

Diameter 103 mm

PLU: ex-London, Sotheby's (Catalogue 1 April 2009, lot 102)

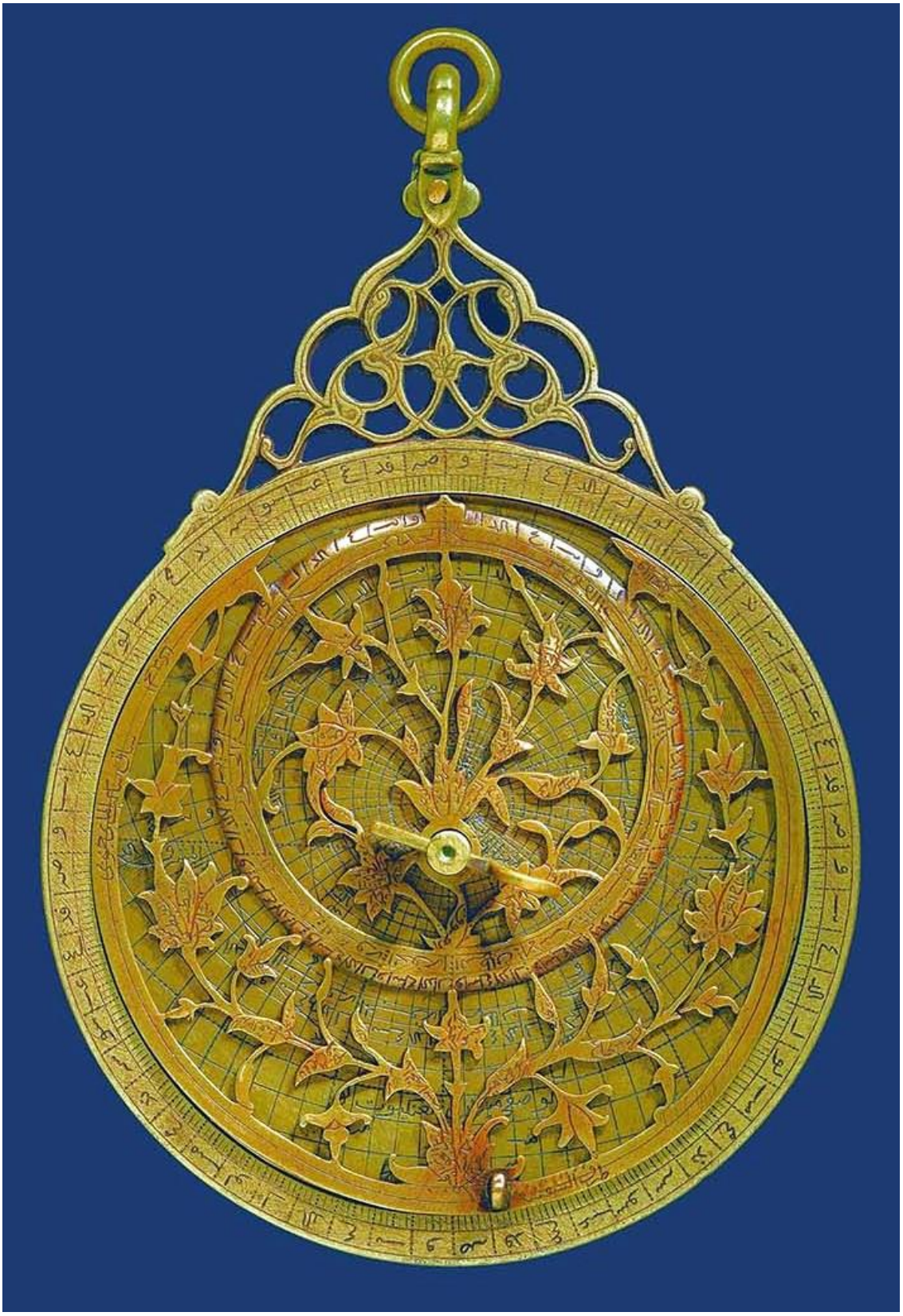


Figure A070.1 – Front of the astrolabe (© Sotheby's, London)

Components

Mater with *kursī* (d. 103, h. 160), shackle and ring, rete, 4 plates, alidade, pin and horse.

Front

Simple ring, trifoliate shackle, and finely reticulated *kursī.* The profiles with ogees with a lobe in between and topped by a trifoliate finial stand out as a frame around a design with three-petalled flower at the centre. The limb is graduated in 1° and 6°, and labelled in 6s from 6 to 90 separately in each quadrant as 6—90; 90—6; 6—90; 90—6.

Rete

Unusually the equinoctial bar is not represented in the rete. The rings of Capricorn and ecliptic are held together by the floral tracery which joins the star pointers. The tracery between the two rings is like a realistic flowering bush branching off to the left and right with large leaves and flowers. The tracery inside the ecliptic ring represents a smaller bush arising from the central ring with its branches spreading all around.

The ecliptic ring is divided into the 12 signs of zodiac and labelled with their names; each sign is further subdivided into groups of 6° and numbered accordingly.



Figure A070.2 – Rete of the astrolabe (© Sotheby’s. London)

PLATES

There are four plates. Obverse sides of three plates serve the latitudes of 32°, 34° and 36°. It is not known which latitudes are served by the other sides of these three plates. On the back there are curves for the midday altitude of the sun at latitudes of 27° and 32°. Therefore there should be two plate faces serving the latitudes 27° and 32°. The sixth plate face appears to carry a double projection of two latitudes. The fourth plate carries the plate of ecliptic coordinates on one side and the plate of horizons on the other.

GEOGRAPHICAL GAZETTEER

There is a gazetteer for 54 localities in Greater Iran and India.

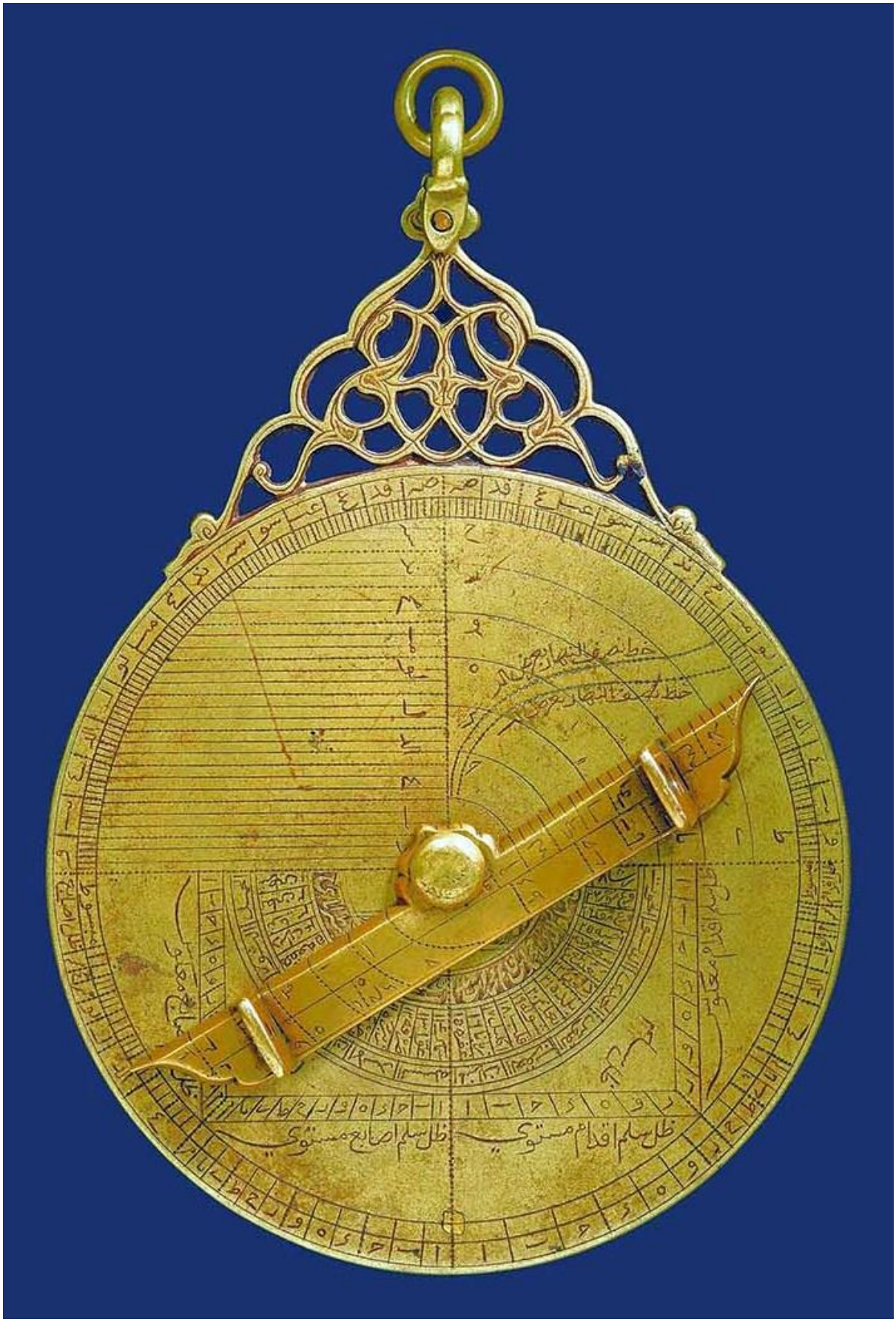


Figure A070.3 – Back of the astrolabe (© Sotheby’s, London)

BACK

The rim of the upper half carries the altitude scales divided in 1° and 6°, and labelled as 6—90; 90—6, while the rim of the lower half bears the cotangent scales in feet and digits.

There is a trigonometric grid in the upper left with 30 horizontal parallel lines; these are numbered in 6s along the vertical radius. In the upper right is the solar quadrant which is divided by declination circles into six zones, each representing a pair of zodiac signs. The signs are marked by their serial numbers along the two radii. Two dotted sigmoid curves are traced in this quadrant for the midday altitude of the sun throughout the year at the two latitudes of 27° and 32° with the usual labels.

In the lower half there are shadow squares for 12 digits on the left and 7 feet on the right with the usual labels. Inside the shadow squares are three semi-circular rows. The outermost is engraved with the names of the 12 zodiac signs and the middle one with the names of the 28 corresponding lunar mansions along with their serial numbers.

ALIDADE

The alidade has ornate ends with sharply pointed tips and an ornate centre-piece with five lobes. It carries on the right hand side a sexagesimal scale in the upper register and a scale of unequal hours in the lower register; on the left, it is marked with a zodiac scale and the serial numbers of the signs.

INSCRIPTION

Inside the shadow squares, the innermost semi-circular row and a horizontal row are engraved with the astrolabe-maker’s signature and the date of manufacture of the astrolabe in embossed letters.

> *ʿamal ḍiyā’ al-dīn muḥammad ibn qā’im muḥammad ibn mullā ʿīsā ibn shaykh allāhdād asṭurlābī humāyūnī lāhūrī fī sanah 1064 hijrī.*
>
> ‘The work of Ḍiyā’ al-Dīn Muḥammad, son of Qā’im Muḥammad, son of Mullā ʿĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the year 1064 Hijrī [= AD 1653-1654].’

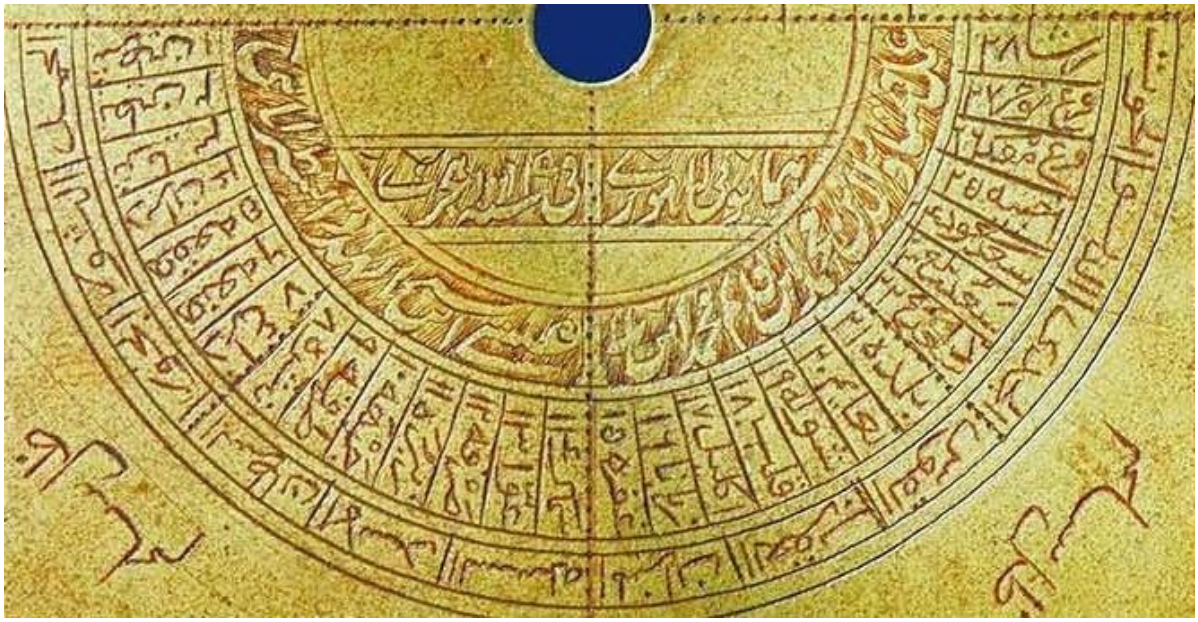


Figure A070.4 – Astrological table and the signature of the astrolabe maker (© Sotheby’s, London)

BIBLIOGRAPHY

Sotheby’s, London, *Arts of the Islamic World*, auction catalogue, 01 April 2009, lot 102.

A071⊙ ASTROLABE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1064 AH (AD 1653-54)

Diameter 63.5 mm

Cologne, PC



Figure A071.1 – Front of the astrolabe (photo by the owner)

It is one of the smallest astrolabes. Ḍiyā’ al-Dīn himself made yet a smaller astrolabe with a diameter of 52 mm in 1074/1663-64, but of it only the mater survives (A083). His uncle Muḥammad Muqīm made a still smaller astrolabe with a diameter of 45mm (A050), but in this astrolabe, the rete, alidade, one plate, pin and horse are not original, while all the parts in Diya’s astrolabe are original, except for the horse. Despite the small size, all the numbers and letters are engraved distinctly on the present astrolabe. Indeed, it is a real jewel with all the miniature components meticulously crafted.

Components

Mater (d. 63.5, h. 90, t. 4.5) ring, shackle, rete for 23 stars, 5 plates, alidade, pin and wedge. Wedge is a crude modern replacement.

Front

The *kursī* is large; it is elegantly reticulated with a trifoliate ornament in the middle; the profiles are made up of ogees at the base and at the top with a lobe in the middle; there are decorative lines on the surface on the front as well as on the back. The finial is trifoliate, so also the shackle. The ring is large. The rim is divided in 2° and 6° and labelled clockwise in 6s, from 6 to 90, separately in each quadrant.

Rete

In the rete, the Capricorn ring and the ecliptic ring are held together by the equinoctial bar which has three counter changes. The solstitial bar is partly shown above and below the ecliptic ring. The ecliptic ring is divided by dotted lines into the 12 signs of the zodiac and labelled with their names. Each sign is divided into 5 units, and the divisions are marked on the edge of the ecliptic, but not numbered. A knob to turn the rete is affixed on the Capricorn ring, about 40° to the east of the north point. There is triangular Capricorn index.

There are 23 star pointers which are joined by an almost symmetric tracery. Two star names (nos. 6 and 12) engraved near the centre appeared to have been worn off and cannot be clearly deciphered.



Figure A071.2 – Rete of the astrolabe (photo by Ananda Sarma)

Table A071-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus [Janūbī]*	β Ceti
2	*Fam al-Qayṭus*	γ Ceti
3	*Ṣadr al-Qayṭus*	π Ceti
4	*Masāfat al-Nahr*	γ Eridani
5	*ᶜAyn al-Thawr*	α Tauri

	Star Name	Identification
6	*[ᶜAyyūq]*[379]	α Aurigae
7	*Yad al-Jawzā’ al-Yumnā*	α Orionis
8	*Shᶜirā Yamānī*[380]	α Canis Majoris
9	*Shᶜirā Shāmī*	α Canis Minoris
10	*Rās al-Taw’am al-Muqaddam* (?)	α Geminorum
11	*Qāᶜidat al-Bāṭiya*	α Crateris
12	*Ẓahr [al-Dubb al-Akbar]* (?)	α Ursae Majoris
13	*Simāk Aᶜzal*	α Virginis
14	*Kiffa Janūbī*	α Librae
15	*ᶜUnuq al-Ḥayyah*	α Serpentis
16	*Rās al-Jāthī*	α Herculis
17	*Nasr Wāqiᶜ*	α Lyrae
18	*Nasr Tā’ir*	α Aquilae
19	*Dhanab al-Jadī*	δ Capricorni
20	*Fam al-Faras*	ε Pegasi
21	*Mankib al-Faras*	β Pegasi
22	*Sāk Sākib al-Mā’ J[anūbī]*	δ Aquarii
23	*Dhanab al-Qayṭus [Shamālī]*	ι Ceti

379 The name is completely rubbed off.

380 The name is engraved on the Capricorn ring; but the star pointer, curved like a tiger’s claw, is above.



Figure A071.3 – The plates (row 1: rete and the plate of ecliptic coordinates;
row 2: plate for latitude 40°and plate for latitude 27°;
row 3: plate for latitude 32° and plate for 22°)
(photo by Ananda Sarma)



Figure A071.4 – Reverse sides of the plates (row 1: reverse of the rete and the plate of horizons;
row 2: plate for latitude 36°and plate for latitude 29°;
row 3: plate for latitude 34° and plate for 24°)
(photo by Ananda Sarma)

PLATES

There are five plates. On all plates the circles of the two tropics and equator are drawn; the horizontal and vertical diameters are marked with dotted lines.

Table A071-2 Plates

	φ	Longest day
1a	22°	13;22 hours
1b	24°	13;35 hours
2a	27°	13;43 hours
2b	29°	13;52 hours
3a	32°	14;8 hours
3b	34°	14;20 hours
4a	36°	14;32 hours
4b	40°	14;54 hours
5a	Plate of ecliptic coordinates	
5b	Plate of horizons	

Plates 1 to 4 serve latitudes from 22° to 40°. Here altitude circles are traced for every 6° and numbered on both sides of the meridian; every fifth altitude circle is highlighted with dots. Azimuth arcs are drawn below the horizon for every 10° and numbered in a straight line parallel to the horizontal diameter; azimuth arcs for every 30° are drawn both above and below the horizon and the lower part is highlighted with dots. In the lower half, there are plain lines for seasonal hours which are numbered from the western horizon to the eastern, above the circle of equator. Equal hours are indicated by dotted curves which are drawn from the western horizon; these are also numbered from the western horizon to the eastern, a little above the circle of Capricorn.

The value of the latitude and the duration of the daylight hours are engraved at the middle of the plate. Below the oblique horizon are the labels *al-mashriq* in the east and *al-maghrib* in the west.

The obverse side of the fifth plate carries the projections for the latitude of 66;30°. Here the horizon coincides with the ecliptic and the zenith with the ecliptic pole. On this plate, latitude circles are drawn for every 6°, from 6° to 90° N and from 6° to 48° S. These are numbered on either side of the meridian. Every fifth circle, representing 30°, is dotted. The circles of longitude, radiating from the zenith, are traced for every 10°. These are numbered as 10, 20, 30, separately in each zodiac sign. Every third of these, representing the boundaries between the signs of the zodiac, are dotted. The names of the six signs from *al-Ḥamal* to *al-Sunbula* are engraved outside the ecliptic circle in the lower half of the plate. The names of the remaining six signs from *al-Mīzān* to *al-Ḥūt* are engraved inside the ecliptic circle in the upper half of the plate. Finally, the designation of the plate *Ṣafīḥat Mīzān al-ᶜAnkabūt* is engraved between the horizon and the north point.

On the reverse side of this plate are traced four sets of half-horizons for latitudes from 6° to 66° at intervals of 8° in the following manner:

6	14	22	…	46	54	62
8	16	24	…	48	56	64
10	18	26	…	50	58	66
12	20	28	…	52	60	

The latitude values are engraved at the beginning and end of each half-horizon. Declination scales drawn along the four radii between the equator and the two tropics. The scales are divided in 3° and 6° and numbered in 6s from 6 to 24. The name of the plate *ṣafīḥa āfāqī* is written in large letters. This plate should have four notches at the four cardinal points so that the four sets of half-horizons can be made use of. But there is a notch only at the north point as in all other plates.



Figure A071.5 – Geographical Gazetteer (photo by Ananda Sarma)

GEOGRAPHICAL GAZETTEER

The inner side of the mater bears the geographical gazetteer of 15 localities with their longitudes and latitudes.

Table A071-3 Geographical Gazetteer

	Place Name *asmā’ al-buldān*	**L** *al-ṭūl*	**φ** *al-ᶜarḍ*
1	Makka Muᶜaẓẓam	77;10	21;40
2	Madinat Musharrafa	75;20	25;0
3	Yazd	89;0	32;30
4	Iṣfahān	86;40	32;25
5	Bukhārā	94;30	39;50
6	Balkh	101;0	36;41
7	Kābul	104;40	34;30
8	Qandahār	107;40	33;0
9	Multān	104;35	29;40
10	Kashmīr	103;0	35;0
11	Lahāwar	109;20	31;50
12	Shāhjahānābād	113;35	28;39
13	Ajmīr	111;5	26.0
14	Akbarābād	115;0	26;46
15	Burhānpūr	109;0	20;31



Figure A071.6 – Back of the astrolabe (photo by the owner)

BACK

The rim of the upper half carries the altitude scales divided in 2° and 6° and numbered in 6s as 6—90; 90—6. In the upper left is the trigonometric quadrant with 20 horizontal parallels, alternate lines are dotted and numbered in 6s along the vertical radius from 6 to 60. In the upper right is the solar quadrant which is divided in 6

segments by 5 quarter circles. The related zodiac signs are marked by serial numbers along the two radii. Along the vertical radius from the centre to the periphery are the numbers 3, 4, 5, 6, 7 and 8 (i.e., from the summer solstice to the winter solstice) and along the horizontal radius from the periphery to the centre are the numbers 9, 10, 11, 0, 1 and 2 (i.e., from the winter solstice to the summer solstice). Two dotted curves of the solar meridian altitude at latitudes 29° (Delhi) and 32° (Lahore) are superimposed in this quadrant with labels *khaṭṭ niṣf al-nahār bi-ᶜarḍ* 29 and *khaṭṭ niṣf al-nahār bi-ᶜarḍ* 32 respectively.

In the lower half are shadow squares, on the left for a base of 6 and 12, and on the right for a base of 7. The scales on both sides are divided and numbered accordingly. The four scales carry the following labels.

Vertical scale on the left: *ẓill aṣābiᶜ maᶜkūs*

Horizontal scale on the left: *ẓill aṣābiᶜ mustawī*

Horizontal scale on the right: *ẓill aqdām mustawī*

Vertical scale on the right: *ẓill aqdām maᶜkūs*

The rim on the lower half is engraved with cotangent scales. The unequal divisions on the scale on the left are numbered clockwise from the meridian as 1, 2, 3, 4, 5, 6, 8, 10, 12, 18, 24, 30, 36, 42, 48, 60 and followed by the label *ẓill aṣābiᶜ mabsūt.*

The unequal divisions on the scale on the right are numbered counter-clockwise from the meridian as 1, 2, 3, 4, 5, 6, 7, 8, 10, 12, 18, 24, 30, 36, 42 and followed by the label *ẓill aqdām mabsūt.* Inside these cotangent scales, there are two semi-circular rows engraved with the names of the 12 zodiac signs and the names of the corresponding 28 lunar mansions.

ALIDADE ETC

The alidade is endowed with ornate ends and an ornate centre-piece. The upper register on the right hand side carries a scale numbered in 6s from the centre to the tip as 6, 12, 18 … 60. The edge is divided in groups of 3 units. This scale matches with the divisions of the vertical radius of the upper left quadrant.

The lower register on the right has unequal divisions numbered from 1 to 6 from the sighting plate onwards and again numbered from 7 to 12 in the reverse direction. When the alidade is used as sundial with the sighting plate on the right as the gnomon,

the shadows thrown by the sighting plate across the length of the alidade are measured on this scale.

The left arm of the alidade is engraved with declination arcs together with six pairs of signs marked by their serial numbers as in the upper right quadrant.

The pin has a broad round head. The wedge is a crude replacement.



Figure A071.7 – Alidade (photo by S. R. Sarma)

INSCRIPTION

In the space below the shadow squares and above the semicircular scales is the maker’s inscription:

> *ᶜamal aqall al-ᶜibād ḍiyā’ al-dīn muḥammad fī sanah 1064 hijrī*
>
> ‘The work of the least of the servants [of God], Ḍiyā’ al-Dīn Muḥammad, in the year 1064 Hijrī.’

The year corresponds to 1653-54.

A072⊙ ASTROLABE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1067 AH (AD 1656-57)[381]

Diameter 308 mm

Jaipur, Jai Singh's Observatory

CCA 75=2702; Répertoire 14



Figure A072.1 – Front of the astrolabe (photo by S. R. Sarma)

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[381] I had the privilege of accompanying Professor David King when he examined this astrolabe in 1991. This description is partly based on his notes. I copied the gazetteer on a subsequent visit.

This is an exquisitely crafted astrolabe; probably the largest standard astrolabe made by Ḍiyā’ al-Dīn, second only to his huge *Zarqālī* universal astrolabe (A091). Both these and several other Mughal astrolabes were acquired by Jai Singh and were in his personal collection. In his work *The Astronomical Observatories of Jai Singh,* G. R. Kaye refers to this astrolabe as ‘Jaipur B’. This and an equally large zoomorphic astrolabe, which is unsigned but can be attributed to Ḍiyā’ al-Dīn’s uncle Muḥammad Muqīm (A051), which Kaye designates as ‘Jaipur A’, formed the basis for Kaye’s pioneering discussion of the construction and use of the astrolabe in the book mentioned above (pp. 17-26).



Figure A072.2 – The *kursī* of the astrolabe (photo by S. R. Sarma)

COMPONENTS

Body with *kursī* (d. 308, h. 410, t. 10), shackle and ring, rete (d. 285) for 52 stars, 5 plates (d. 285), alidade, pin and horse.

FRONT

The ring is massive with an octagonal cross section and the shackle is equally massive in trifoliate form also with an octagonal cross section. The profiles of the *kursī* are formed by two lobes between ogees below and above and topped by a trifoliate finial. Framed inside the ornately engraved rim is an arrangement of five flowers and buds and leaves. The limb is graduated in 0;20°, 1° and 5° and labelled in 5s from 5 to 360. The

Abjad numbers are embossed in relief inside a small cartouche against a finely hatched background. The edge is also decorated with ornate cartouches in which some poem is inscribed in letters embossed in relief.



Figure A072.3 – Rete of the astrolabe (photo by S. R. Sarma)

RETE

This is perhaps the most beautiful rete crafted by Ḍiyā’ al-Dīn and looks like the floral compositions in *pietra dura* on the walls of the Taj Mahal. The two broad rings of the Tropic of Capricorn and the ecliptic are held together by the slender equinoctial bar which has counter changes at its two intersections with the ecliptic. The space inside these rings is filled with a tracery which resembles flowering plants. From the north point on the peripheral ring arises one plant and spreads its thin branches, full of flowers

and leaves, to the left and to the right and upwards as it crosses the ecliptic ring and reaches up to the central ring. From the central ring rises another plant and spreads inside the ecliptic ring. The tips of some of these leaves and flower petals constitute the pointers to the stars whose names are engraved on the leaves and petals.

The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names in embossed letters against a finely hatched background. Each sign is divided into groups of 6° and numbered from 6 to 30. The units are further subdivided into single degrees on the edge of the ecliptic ring.

Table A072-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus J[anūbi]*	β Ceti
2	*Baṭn al-Ḥūt*	β Andromedae
3	*Rijl al-Musalsala*	γ Andromedae
4	*Fam al-Qayṭus*	γ Ceti
5	*Ṣadr al-Qayṭus*	π Ceti
6	*Rās al-Ghūl*	β Persei
7	*Mirfaq al-Thurayyā*	α Persei
8	*Tālī Masāfat al-Nahr*	γ Eridani
9	*ᶜAyn al-Thawr*	α Tauri
10	*Al-ᶜAyyūq*	α Aurigae
11	*Rijl Jawzā’ Yusrā*	β Orionis
12	*Yad Jawzā’ Yusrā*	γ Orionis
13	*Yad Jawzā’ Yumnā*	α Orionis
14	*Rijl Jawzā’ Yumnā*	κ Orionis
15	*Shiᶜrā Yamānī*	α Canis Majoris
16	*Shiᶜrā Shāmī*	α Canis Minoris

	Star Name	Identification
17	*Rās al-*xw’xi??	?
18	*Nathra Saḥābi*	ε Cancri
19	*Fard al-Shujāᶜ*	α Hydrae
20	*Qalb al-Asad*	α Leonis
21	*Rās al-Asad*	μ Leonis
22	*Ẓahr Dubb Akbar*	α Ursae Majoris
23	*Qāᶜidāt al-Bāṭiya*	α Crateris
24	*Ẓahr al-Asad*	δ Leonis
25	*Janāḥ al-Ghurāb*	γ Corvi
26	*Al-Ṣarfa*	β Leonis
27	*ᶜAnāq*	ζ Ursae Majoris
28	*Simāk Aᶜzal*	α Virginis
29	*Simāk Rāmiḥ*	α Bootis
30	*Kiffa Sh[amālī]*	β Librae
31	*Nayyir Fakkah*	α Coronae Borealis
32	*ᶜUnuq al-Ḥayyah*	α Serpentis
33	*Rukbat al-Ḥawwā al-Yusrā*	ζ Ophiuchi
34	*Rās al-Jāthī*	α Herculis
35	*ᶜAyn al-Tinnīn*	γ Draconis
36	*Rās al-Ḥawwā*	α Ophiuchi
37	*Yad al-Hawwā’ al-Yumnā al-Muqaddam*	ρ Ophiuchi
38	*Nasr Wāqiᶜ*	α Lyrae
39	*ᶜUsana al-Rāmi*	?
40	*Minqār al-Dajājah*	β Cygni

	Star Name	Identification
41	*Nasr al-Ṭā’ir*	α Aquilae
42	*Dhanab al-Dulfīn*	ε Delphini
43	*Dhanab al-Dajājah*	α Cygni
44	*Dhanab al-Jadī*	δ Capricorni
45	*Fam al-Faras*	ε Pegasi
46	*Mankib Sāqib al-Mā’*	α Aquarii
47	*Sāq Sāqib al-Mā’*	δ Aquarii
48	*Dhanab al-Qayṭus Sh[amālī]*	ι Ceti
49	*Mankib al-Faras*	β Pegasi
50	*Surrat al-Faras*	δ Pegasi
51	*Janāḥ al-Faras*	γ Pegasi
52	*Kaff al-Khadīb*	β Cassiopeiae

PLATES

There are five plates. On the first four plates, altitude circles are drawn for every 1° with each sixth highlighted with dots. Azimuth lines are drawn for every 6°, below the horizon on plates 1, 3 and 4 and above and below the horizon on plate 2. Lines for seasonal hours are numbered in *Abjad* numerals. Dotted lines are drawn for *ghaṭīs* and numbered in common Arabic/Persian numerals. On plate 1, these are drawn both from the western and eastern horizons and numbered from 1 to 16 from each horizon up to the meridian. On plates 2, 3 and 4 these are drawn from the western horizon and numbered from there from 1 to 35. Because two and half *ghaṭīs* (of 24 minutes each) make one hour (60 minutes), *ghaṭīs* numbered 3, 8, 13, 18, 23, 28 are divided into two parts to synchronize with the equal hours. Thus from these lines time can be measured in both the *ghaṭīs* and equal hours, for 2 ½ gh = 1h; 5 gh = 2 h, 7 ½ gh = 3 h; 10 gh = 4 h; 12 ½ = 5 h, and so on.

On all these plates, i.e., 1 to 4, the maximum duration of the daylight at the relevant latitude is given in hours and minutes and also in *ghaṭīs* and *palas*. These units are inscribed as *karī-hā* and *pala-hā (hā* plural particle). However, certain *ghaṭī* values are not correct. The following table shows the *ghaṭī* values as engraved on the plates in column 3 and the correct values in column 4.

Table A072-2 Plates

	φ	Maximum duration of the daylight		
		hours	*ghaṭīs*	correct *ghaṭīs*
1a	22°	13;21	33;22	33;22,30
1b	25°	13;35	33;57	33;32,30
2a	27°	13;43	34;17	34;27,30
2b	29°	13;52	34;40	correct
3a	32°	14;8	35;20	correct
3b	34°	14;20	35;50	correct
4a	36°	14;32	36;20	correct
4b	38°	14;43	36;47	36;47,30
5a	Tablet of horizons			
5b	Plate of ecliptic coordinates			

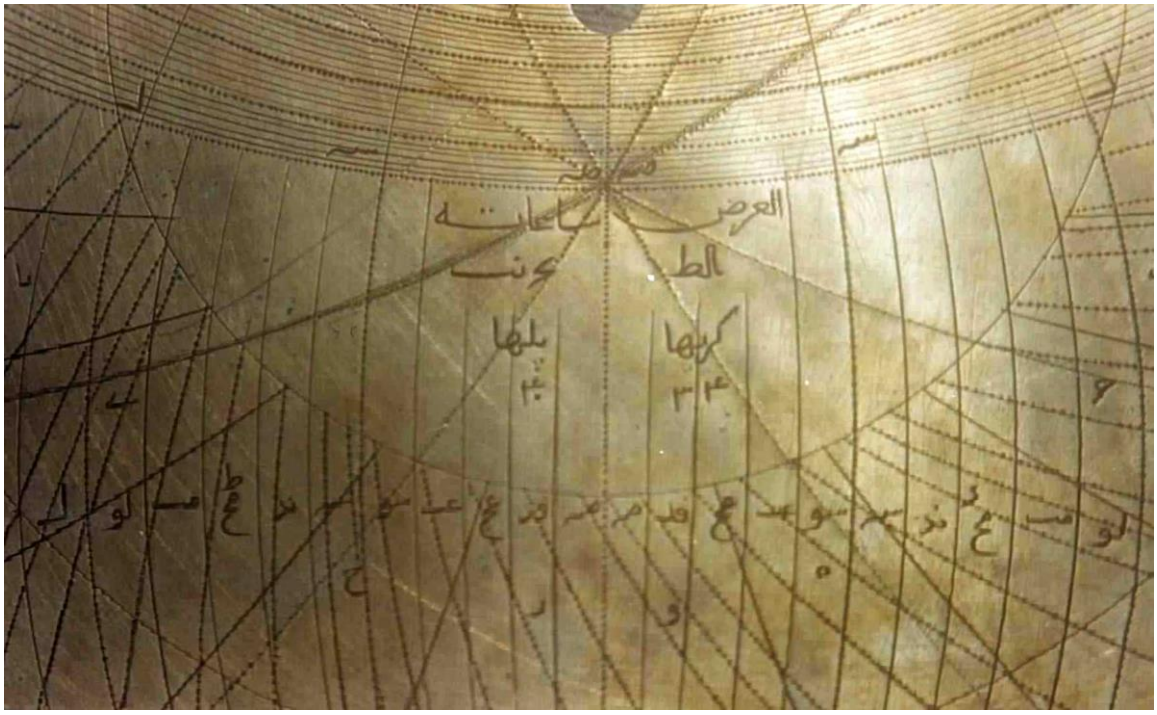


Figure A072.4 – Plate 2b for latitude 29°. Note the *ghaṭī* values at the centre and the lines for equal hours and for ½ *ghaṭīs* below. (photo by S. R. Sarma)

In 5a, half-horizons are drawn for every 1° from 1° to 90°. Along the radii are declination scales with the divisions marked as 3, 6, 9, 12, 15, 18, 21, 23;30 and labels *taqsīn mayl kullī shamālī* or *janūbī,* ‘division of the maximum declination north’ or ‘south’.

Geographical Gazetteer

On the inner side of the mater is engraved a geographical gazetteer with the names, longitudes and latitudes of 210 localities in six concentric circles. Here the localities are arranged according to regions, starting from the Maghreb in the west and reaching up to Sind and Hind in the east. Only two other Lahore astrolabes follow this arrangement and both of them are by Ḍiyā’ al-Dīn (A062 and A093). About this gazetteer, Kaye remarks as follows:

> The list of names on ‘Jaipur B’ (figure 13) is interesting as being copied from Ulugh Beg’s table … The number of towns is the same, but the astrolabe designer left out some of the western places [e.g., those in the country of Rum and some of those of Shām (Syria)], and added some extra towns for

> India. Otherwise the names, the order and the latitudes and longitudes are the same.[382]

Kaye is not quite right in saying that ‘the number of towns is the same’ because Ulugh Beg’s table has 278 localities while the present astrolabe has just 210 localities.[383] Otherwise Kaye is right: the names, the order and the latitudes and longitudes are the same. But there is one problem which Kaye did not notice. The headings mentioning the regions are slightly shifted on the astrolabe with the result that Bajjah az Barbar (008) is placed in Andalus and not in Sudan where it rightly belongs, Suez (015) is mentioned under Yemen and not under Egypt and so on. This shift in the headings could not have been due to the carelessness of the engraver, for it occurs also in two other astrolabes by Ḍiyā’ al-Dīn. It must have occurred already in the source manuscript/s used by Ḍiyā’ al-Dīn.

In the table below the headings are retained as they are engraved on the astrolabe. The correct positions according to the Ulugh Beg’s table are mentioned in footnotes. We have added modern names wherever it is possible.

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382 Kaye 1918, p. 26.

383 Cf. Sédillot 1853, pp. 257-271; see also Kennedy 1987a, pp. 560-564 where the entries are arranged alphabetically.



Figure A072.5 – The geographical gazetteer, upper half, placed upside-down to facilitate easy reading (photo by S. R. Sarma)

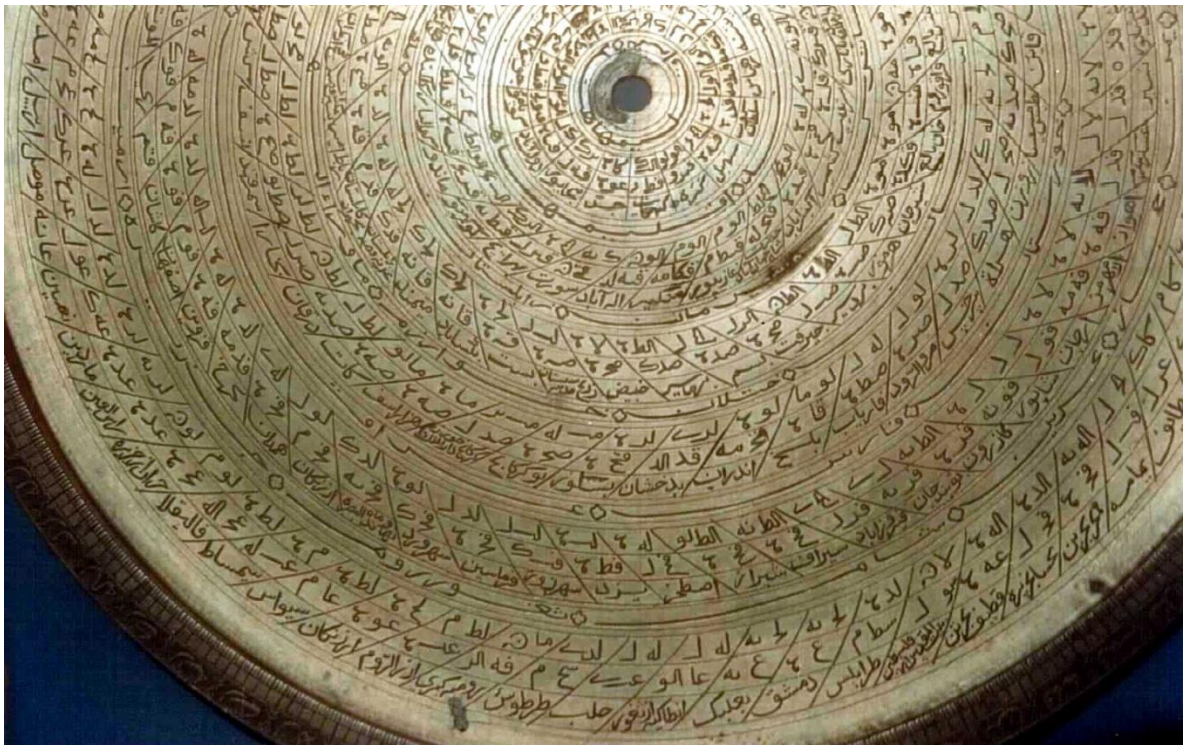


Figure A072.6 – Geographical gazetteer, lower half (photo by S. R. Sarma)

Table A072-3 Geographical Gazetteer

	Place Name (*asmā’ al-buldān*)	L (*al-ṭūl*)	φ (*al-ᶜarḍ*)	Identification/ Modern Name
	First Circle			
Iqlīmhā Maghrib[384] (the region of the Maghreb)				
1	Sūs Aqṣā	15;30	32;0	Sus al-Aksa, Morocco
2	Fārs Qaṣbah Tanjah[385]	18;00	22;0	Fez, Morocco
3	Tāhart ᶜŪliyā’	35;30	29;0	Upper Tahart
4	Tāhart Suflī az Afrīqah	36;0	29;0	Lower Tahart in Africa
5	Mahadiyya	42;0	32;30	Mahdiya, Tunisia
6	Ṭarābulus Maghrib	45;0	32;0	Tripoli, Libya
Andalus (Andalusia)				
7	Qurṭaba Dār al-Mulk Andalus	38;26	35;0	Cordova, Spain
8	Bajja az Barbar[386]	65;0	14;0	Beja, Sudan
Sūdān (Sudan)				
9	Jarmī Dār al-Mulk Habasha	65;0	9;30[387]	Jarmi, capital of Abyssinia
10	Durqula Shahr Nūbah	53;40	14;30	Dunqula, town in Nubia

384 Ulugh Beg, Maghrib

385 The correct name is Fas. Ulugh Beg gives the latitude as 32° which is the correct value.

386 It is wrongly included in Andalus; it belongs to the next region Yemen.

387 Ulugh Beg 9;0.

	Place Name (*asmā’ al-buldān*)	L (*al-ṭūl*)	φ (*al-ᶜarḍ*)	Identification/ Modern Name
Miṣr (Egypt)				
11	Qūṣ az Qaṣbah Miṣr[388]	61;30	24;30	Qus, Egypt
12	Iskandariyya	61;54	30;58	Alexandria, Egypt
13	Miṣr	63;20	30;20	Cairo, Egypt
14	Dumyāṭ	63;30	31;25	Damietta, Egypt
Yaman (Yemen)				
15	Qulzum az Kanār Darya[389]	64;0	29;30	Suez on the Red Sea, Egypt
16	ᶜAdan	76;0	11;0	Aden, Yemen
17	Ṣanᶜā’ Dār al-Mulk Yaman	77;0	14;30	Sanaᶜa, Yemen
Hijāz (Hejaz, western part of Saudi Arabia on the coast of the Red Sea)				
18	Madīnat Rasūl ᶜAlīyat al-Salām	75;20	25;0	Medina, Saudi Arabia
19	Makka Mubārak	77;10	21;40	Mecca, Saudi Arabia
20	Ṭāᶜif	77;30	21;20	Taif, Saudi Arabia
Bahrayn (Bahrain)				
21	Yamāma[390]	82;30	23;30	Al-Yamama, Saudi Arabia
22	Hajar Baḥrayn	83;0	25;0	Al-Hajar, Bahrain

388 Ulugh Beg has ‘Qūs az Saᶜīd Aᶜūlia.’

389 Qulzum should be placed in Egypt.

390 It should be in Hejāz.

	Place Name (*asmā’ al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-ᶜarḍ*)**	**Identification/ Modern Name**
23	Ḥasā Jazīra	83;30	24;0	Al-Ahsa = Hofuf, Saudi Arabia
24	Qaṭīf Bahrayn	75;0	25;0	Qatif, Saudi Arabia
Shām (Syria)				
25	Bayt al-Maqdis az Filisṭīn	66;30	31;50	Jerusalem, Israel
26	Ṭarābulus	69;40	34;0	Tripoli, Lebanon
27	Dimashq	70;0	33;15	Damascus, Syria
28	Baᶜalbak	70;15	33;15	Baalbek, Lebanon
29	Anṭākiya az Thaghūr	71;26	35;30	Antioch = Antakya, Turkey
30	Ḥalab	72;10	35;30	Aleppo, Syria
31	Ṭarṭūs	68;40	34;10	Tarsus, Turkey
Thughūr Rūm (the border lands of the Byzantines)				
32	Rūmiya Kabrī	85;27	41;50	The Grand Rome, Italy
33	Arz ar-Rūm	72;0	39;40	Erzurum, Turkey
34	Arzankān	76;0	38;0	Erzincan, Turkey
35	Sīwās	71;40	39;0	Sivas, Turkey
36	Sīmsāṭ	72;35	40;0	Samsat, Turkey
37	Qālīqalā	73;25	39;0	near Erzurum, Turkey
Jazīra (the region of ancient Mesopotamia)				
38	Ḥarrān az Jazīra	73;0	36;40	Harran, Turkey
39	Rās Alᶜaīn	74;0	36;50	Ras Alayn, Syria
40	Mārdīn	74;0	37;15	Mardin, Turkey

	Place Name (*asmā’ al-buldān*)	L (*al-ṭūl*)	φ (*al-ᶜarḍ*)	Identification/ Modern Name
41	Niṣībīn	75;20	37;0	Nisibin on Euphrates
42	ᶜĀna	76;30	34;0	Ana, on Euphrates
43	Mawṣil	77;0	34;30	Mosul, Iraq
44	Arbīl	77;20	35;0	Erbil, Iraq
Armīn (Armenia)				
45	Amid	73;40	38;0	Amid, Turkey
46	Malāzjird	75;0	38;45	Malzjird, Armenia
47	Anī	79;0	41;0	Ani, Armenia
Adarbayjān (Azerbaijan)				
48	Urmiya	79;45	37;0	Urmiya, Iran
49	Marand	80;45	37;50	Marand, Iran
50	Marāgha	82;0	37;20	Maragha, Iran
51	Tabrīz	82;0	38;0	Tabriz, Iran
52	Ardabīl	82;30	38;0	Ardabil, Iran
Irāq[391]				
53	Mūqān	83;0	38;0	
54	Bardaᶜa	83;0	40;30	Barda, Azerbaijan
Karaj				
55	Tiflis Dār al-Mulk al-Khāzim	83;0	43;0	Tiflis, Georgia
Alān				

391 Ulugh Beg has Iran here, so also A062; but the astrolabe has clearly Iraq.

	Place Name (*asmā’ al-buldān*)	L (*al-ṭūl*)	φ (*al-ᶜarḍ*)	Identification/ Modern Name
56	Alān	83;0	44;0	in Degestan, Russia
57	Salqān	83;30	39;50	
58	Balkūya[392]	84;30	39;30	Bakaway, Caspian coast
59	Shamākhī Qaṣba Shirwān	84;30	40;50	Shamakhi, Azerbaijan
	Second Circle			
Rūs (Russia)				
60	Bāb al-Abwāb	85;0	43;0	Debent, Dagestan, Russia
61	Kūsāna Madīnat Rūs	87;0	43;0	Kumana, Russia
Bulghār (The Bulghars)				
62	Saqīn	86;30	43;0	Saqsīn, medieval city in the Volga delta
63	Bulghār	90;0	49;30	The Bulghars
ᶜArāqayn (the two Iraqs)[393]				
64	Kūfa	79;30	31;30	ancient city in ruins, Iraq
65	Madā’in	72;0	33;10	Al-Mada’in, Iraq
66	Baghdād	82;0	33;24	Baghdad, Iraq
67	Wāsiṭ	81;30	32;20	Wasit, Iraq
68	Baṣra[394]	84;0	30;0	Basra, Iraq

[392] Ulugh Beg has the heading Armenia once more here, in which are included Balkūyah, Shamākhī and Bāb al-Abwāb.

[393] Ulugh Beg has just ᶜIrāq here.

[394] Ulugh Beg has a new heading here ‘Baṣra’ under which he places Basra and Abadan.

	Place Name (*asmā’ al-buldān*)	L (*al-ṭūl*)	φ (*al-ᶜarḍ*)	Identification/ Modern Name
69	ᶜAbādān	84;30	31;0	Abadan, Iran
Khūzistān (a region of Iran)				
70	Jundīsābūr	84;5	31;15	Gundeshapur, Iran
71	Tastīr	84;30	31;30	Tustar, Iran
72	ᶜAskar Mukram	84;30	31;15	Asker Mukram, Iran
73	Ahwāz	85;0	31;0	Ahwaz, Iran
74	Rāmhurmūz	85;45	31;0	Ram Hormoz, Iran
75	Arjān[395]	86;30	30;30	Arrajan, Fars Province, Iran
76	Shāpūr[396]	86;55	30;0	Sabur, Iran
Fārs (Persia, a province of Iran)				
77	Kāzirūn	87;0	29;15	Kazerun, Iran
78	Nūbandjān	87;15	30;10	Nawbandgan, Iran
79	Fīrūzābād	87;30	28;10	Firouzabad, Iran
80	Sīrāf	88;0	29;55	Siraf, Iran
81	Shīrāz	88;0	29;36	Shiraz, Iran
82	Iṣṭakhr	88;30	35;0	Persepolis, Iran
ᶜIrāq[397]				
83	Yazd[398]	89;0	32;0	Yazd, Iran

395 Ulugh Beg includes it in Fars.

396 Ulugh Beg includes it in Fars.

397 Ulugh Beg has ‘Jabāl’ as the heading here.

398 This place should be included in Iran.

	Place Name (*asmā’ al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-ʿarḍ*)**	**Identification/ Modern Name**
84	S[h]ahrazūr	82;20	32;30	(Kurdistan, Iraq)
85	Qirmāsīn	83;0	34;30	Kirmanshah, Iran
86	Saharward	83;20	36;0	Shahrud, Iran
87	Nahāwand Māh al-Baṣra	83;15	34;20	Nahavand, Iran
88	Arzinkān	83;40	36;30	Erzincan, Turkey
89	Hamadān	83;0	35;10	Hamadan, Iran
90	Karaj	84;45	34;0	Karaj, Iran
91	Qazwīn	85;0	35;0	Qazvin, Iran
92	Iṣfahān	86;40	32;25	Isfahan, Iran
93	Kāshān	86;0	34;0	Kashan, Iran
94	Qumm	85;40	35;45	Qom, Iran
95	Rayy	86;20	35;0	Shahr Rey, Iran
Dīlmān[399]				
96	Alamūt	85;37	36;21	Alamut, Iran
97	Ṭāliqān	85;0	36;10	Taloqan, Afghanistan
Kīlān (Gilan province, Iran)				
98	Hūsum az Jīlān	85;10	34;0	
99	Dīma Qaṣba Damāwand	87;20	37;10	
Ṭabaristān				
100	Amul Qaṣba Ṭabaristān	88;20	36;15	Amol, Northern Iran

[399] Ulugh reads *Dīlān.*

	Place Name (*asmā’ al-buldān*)	L (*al-ṭūl*)	φ (*al-ᶜarḍ*)	Identification/ Modern Name
101	Astarābād	89;35	36;50	Gorgan, Iran
Jurjān[400]				
102	Abaskūn Qaṣba Jurjān	89;30	37;15	Port city on the Caspian Sea in the Middle Ages
103	Jurjān	90;0	36;50	
Qūmis (a city in northern Iran) [401]				
104	Samnān	88;0	36;0	Semnan, Iran
105	Dāmghān	88;55	36;20	Damghan, Iran
106	Basṭām	89;30	36;10	Bastam, Iran
	Third Circle			
Iqlīmhā Khurāsān (the region of Khurasan)				
107	Farāwa	90;0	39;0	
108	Sabzawār	91;30	36;5	Sabzewar, Iran
109	Nīshābūr	92;30	36;21	Nishapur, Iran
110	Ṭūs	92;30	37;0	Tus, Iran
111	Turshīz	92;0	35;0	Turshiz, Iran
112	Tabas Kīlakī	92;0	33;0	Tabas, Iran
113	Tūn	92;30	34;30	Ferdows, Iran
114	Qā’īn	93;20	33;40	Qaen, Iran
115	Ṭabas Masīnā	94;15	33;15	Tabas-e Masina, Iran
116	Zūzan	93;30	35;20	Zuzan, Eastern Iran

400 Ulugh Beg has ‘Kurkān’.

401 Ulugh Beg has ‘Qaws’.

	Place Name (*asmā’ al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-ʿarḍ*)**	**Identification/ Modern Name**
117	Harāt	94;20	34;30	Herat, Afghanistan
118	Sarakhs	94;30	37;0	Sarakhs, Iran
119	Marw ar-Rūd	97;0	36;30	Bala Murghab, Afghanistan
120	Fāryāb	99;0	35;30	Faryāb, Iran
121	Balkh	101;0	36;41	Balkh, Afghanistan
Khatlān[402]				
122	Andarāb	103;45	36;0	Andarab, Afghanistan
123	Badakhshān	104;24	37;10	Faizabad, Afghanistan
Khwārizm				
124	Bulūr[403]	108;0	37;0	??
125	Nūkarkānj	93;0	42;35	??
126	Kurkanj Dār al-Mulk Khwarizm	94;30	42;17	Gurganj, cap. Khwarizm
127	Hazār Asf	95;0	41;0	Hazar Asp, Iran
128	Kāt	95;0	41;36	ancient cap. Khwarizm
129	Darqān[404]	94;15	39;30	Darghan, near Hazar Asp, Iran
Mā Warā’ al-Nahr (Transoxonia)				
130	Bukhārā	97;30	39;50	Bukhara, Uzbekistan
131	Samarqand	99;16	39;37	Samarqand, Uzbekistan

402 Ulugh Beg reads Khīlān.

403 Engraved on the astrolabe as Buslūz.

404 Ulugh Beg includes it in Transoxonia.

	Place Name (*asmā’ al-buldān*)	L (*al-ṭūl*)	φ (*al-ᶜarḍ*)	Identification/ Modern Name
132	Nasaf	98;0	39;0	
133	Kish	99;30	39;30	Kish, Iran
134	Isfījāb az Shāsh	99;50	43;36	Sayram, South Kazakhstan
135	Usrūshana	100;0	40;0	Istaravshan, Tajikistan
136	Khujand	100;35	41;55	Sughd, Tajikistan
137	Binkat Qaṣba Shāsh	101;0	43;0	Binkath, main city Shash
138	Tūnkat Qaṣba Aylān	101;0	43;25	Tunkath, main city in Ilaq
139	Akhshikāt Qaṣba Farghāna	101;20	42;25	In Ferghana, Uzbekistan
140	Ūzkand	102;50	44;0	
141	Ūsh	102;20	43;20	
	Fourth Circle			
Tatimma Iqlīmhā Turk (continuation of the region of Turkistan)[405]				
142	Kāshghar[406]	106;30	44;0	Kashgar, China
143	Chāj vahū Shāsh[407]	109;0	42;30	??, in Shash
144	Khutan	107;0	42;0	Khotan, China
145	Almāligh	102;30	44;0	Turkish Central Asia
146	Qabāligh	108;0	44;0	Turkish Central Asia

405 It is not a ‘continuation,’ but a new heading!

406 Ulugh Beg includes it in Transoxonia.

407 Ulugh Beg includes it in Transoxonia.

	Place Name (*asmā’ al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-ʿarḍ*)**	**Identification/ Modern Name**
147	Awsh Klūrān	110;0	46;0	Turkish Central Asia
148	Pīsh Bāligh	111;0	45;50	Pochongtse, Uighur (in ruins)
149	Qarāqūrūm	112;0	46;0	Karakorum, Mangolia
150	Khān Bāligh	124;0	46;0	Beijing, China
Kirmān (Kerman Province, Iran)				
151	Shīrjān	90;20	29;30	Sirjan, Iran
152	Hurmūz	92;0	25;0	Hormuz, Iran
153	Bardsīr	92;30	29;50	Birdsir, Iran
154	Jīruft	93;0	27;30	Jiroft, Iran
155	Bam	94;0	28;30	Bam, Iran
156	Narmāsīr	94;20	29;0	Narmasir, Iran
157	Khabīs	93;0	31;0	Khabis, Iran
Zābalistān				
158	Zaranj Madīna Sijistān[408]	90;0	32;30	Zaranj, Afghanistan
159	Bust	100;0	33;0	Bost, Afghanistan
160	Takināābād	101;55	33;20	Takinabad, Afghanistan
161	Maymand	101;55	33;20	Maymand, Afghanistan
162	Ghazna Qaṣba Zābalistān	104;20	33;35	Ghazna, Afghanistan

[408] Ulugh Beg places it under the heading Zaranj

	Place Name (*asmā’ al-buldān*)	L (*al-ṭūl*)	φ (*al-ᶜarḍ*)	Identification/ Modern Name
163	Banjahīr az Kābulistān[409]	104;40	35;0	Banjahir, Afghanistan
164	Ribāṭ Amīr	105;0	34;0	
Makrān				
165	Basīr Qaṣba Makrān	98;0	26;15	
166	Kīj az Makrān	99;0	28;0	
167	Jālq az Makrān	99;0	30;0	Jalq, Pakistan
Sind				
168	Daybul wa Hūnah[410]	102;30	25;10	Debal, near Karachi, Pakistan
169	Manṣūra Qaṣba Sind	105;0	27;40	Brahmanabad, Pakistan
170	Tāna az Sāḥil Bahr Hind	102;0	39;20[411]	‘Tanah on the coast of The Sea of India’, Thane, Maharashtra
Hind[412]				
171	Nahlāwāra	102;30	22;0	Patan, Gujarat
172	Sawmnāt	106;0	17;0	Somnath, Gujarat

409 Ulugh Beg places this and the next locality under the heading ‘Kābūlistān’; the astrolabe does not have this reading.

410 Ulugh Beg includes it in Makrān.

411 The latitude is wrong; it should be 19;20° as given by Ulugh Beg. Astrolabe A093 gives the longitude and latitude correctly as given by Ulugh Beg and adds the maximum duration of daylight as 13;12 hours, which is correct for the latitude of 19;20°. However, both the astrolabes place it wrongly in the region of Makran, instead of in Hind.

412 Ulugh Beg lists just nine places in Hind (Tāna, Nahlāwāra, Sawmnāt, Multān, Qandahār, Lahāwar, Qannawj dār al-Mulk Hind, Banāras and Sarandīb); the rest here are derived from some other source.

	Place Name (*asmā’ al-buldān*)	L (*al-ṭūl*)	φ (*al-ʿarḍ*)	Identification/ Modern Name
	Fifth Circle			
Tatimma Iqlīmhā Hind (continuation of the region of Hind)				
173	Mūltān	107;35	29;40	Multan, Pakistan
174	Qandahār	107;40	33;0	Qandahar, Afghanistan
175	Lahāwar	109;20	31;50	Lahore, Pakistan
176	Qannawj Dār Mulk Hind[413]	102;50	26;35	Kannauj, UP, India
177	Bānārasī	117;20	26;55	Varanasi, UP, India
178	Sarandīp	130;0	10;0	Sri Lanka
179	Kashmīr	108;0	35;0	Srinagar, India
180	Akbarābād	114;0	26;43	Agra, India
181	Haḍrat Shāhjahānābād	113;0	28;39	Delhi, India
Tatimma Iqlīmhā Hind (continuation of the regions of Hind)				
182	Ghāzīpūr	119;40	26;40	Ghazipur, UP, India
183	Munkīr	121;45	26;40	Munger, Bihar, India
184	Ilāhābād	115;34	26;50	Allahabad, UP, India
185	Sūrat	108;50	20;15	Surat, Gujarat, India
186	Bahrā’ich	117;30	28;0	Bahraich, UP, India
187	Kūrakpūr	119;15	27;20	Gorakhpur, UP, India
188	Māndū	114;13	22;13	Mandu, MP, India
189	Kawāliyār	115;0	26;29	Gwalior, MP, India

413 Ulugh Beg refers to Kannauj as the capital city of India.

	Place Name (*asmā’ al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-ᶜarḍ*)**	**Identification/ Modern Name**
190	Kalkanda	114;39	18;4	Golconda = Hyderabad, India
191	Dhāka Bankālā	130;0	27;0	Dhaka, Bangladesh
192	Sanārkām	131;0	26;0	Sonār Gām, Bangladesh
193	Qakaj	-----	26;0	Overwritten illegible
194	Kūl	114;19	28;6	Aligarh, UP, India
195	Burhānpūr	109;0	20;31	Burhanpur, MP, India
	Sixth Circle			
Tatimma Iqlīmhā Hind (continuation of the region of Hind)				
196	Bahrūj	111;5	21;20	Bharuch, Gujarat, India
197	Sirhind	111;33	30;30	Sirhind, Panjab, India
198	Patna	120;45	26;40	Patna, Bihar, India
199	Rahtās	119;45	26;30	Rohtas, Bihar, India
200	Sulṭānkūt	104;0	33;0	Sultankot, UP, India
201	Sanbhal	115;0	28;4	Sambhal, UP, India
202	Kara	117;6	26;36	Kara, UP, India
203	Khanbāyat	109;4	22;20	Cambay, Gujarat, India
204	Jidda	76;0	21;0	Jeddah, Saudi Arabia
205	Bījāpūr	105;30	17;20	Bijapur, India
206	Dawlatābād	111;0	20;30	Daulatabad, India
207	Kūpāmā’u	116;33	26;45	Gopamau, India
208	Jawnpūr	119;6	26;36	Jaunpur, UP, India
209	Mānikpūr	118;10	26;49	Manikpur, UP, India

	Place Name (*asmā’ al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-ᶜarḍ*)**	**Identification/ Modern Name**
210	Aḥmadnakar	107;0	19;0	Ahmednagar, Maharashtra, India

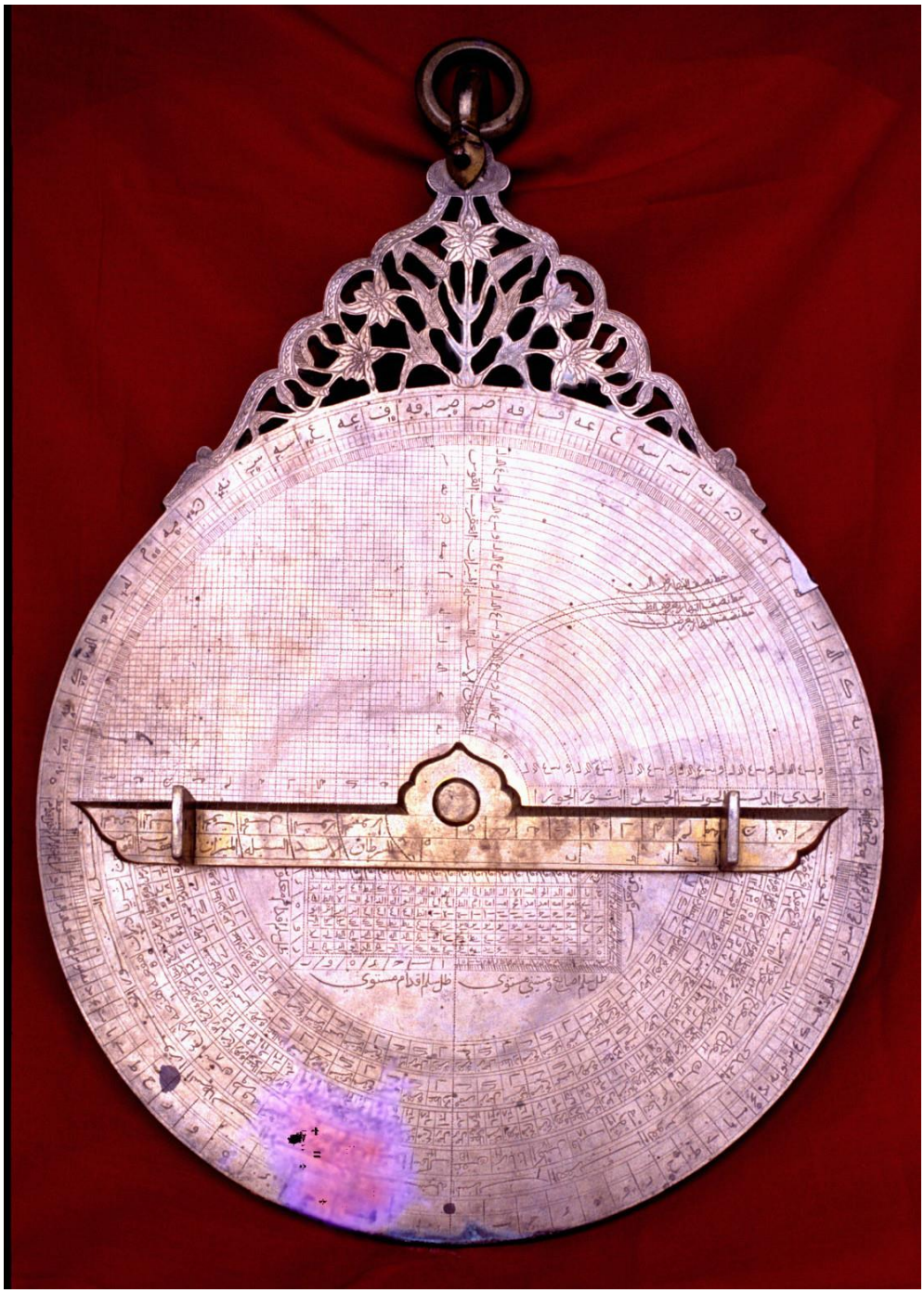


Figure A072.7 – Back of the astrolabe (photo by S. R. Sarma)

BACK

The rim of the two upper quadrants bears altitude scales which are divided in 0;20°, 1° and 5° and labelled in 5s as 5—90; 90—5 in *Abjad* letters. In addition, in the upper left quadrant, the groups of 5° are numbered also in the reverse direction, i.e., from the south point to the east point, in common Arabic/Persian numerals. This numbering in both directions is useful when measurements are done with the sine quadrant inscribed in the upper left.

In the upper left is the trigonometric quadrant with 60 horizontal and 60 vertical parallels, with every fifth line highlighted with dots. These parallel lines are numbered along the two radii in groups of five thus: 5, 10, … 60.

In the upper right is the solar quadrant with thirty equally spaced arcs of declination, where also every fifth line (marking the boundary of a zodiac sign) is dotted. The names of the related signs are engraved along the two radii, along with the numerical values of their subdivisions as 6, 12, 18, 24, 30, separately for each sign.

In this quadrant are plotted three sigmoid curves of the solar meridian altitude at the three latitudes of 27°, 29°, 32°, representing the three Mughal imperial capitals Agra, Delhi and Lahore. These curves are accompanied by labels reading *khaṭṭ niṣf al-nahār bi-ᶜarḍ* 27; … 29, … 32.

In the lower half are engraved the shadow squares, on the left for a base of 7 and on the right for a base of 12 and 60. The vertical and horizontal scales on the left are divided into 7 parts and numbered accordingly. The vertical and horizontal scales on the right are divided into 12 parts and numbered accordingly; here each is further subdivided into 5 units.

Vertical scale on the left: *ẓill sullam aqdām maᶜkūs*

Horizontal scale on the left: *ẓill sullam aqdām mustawī*

Horizontal scale on the right: *ẓill sullam aṣābiᶜ wa sittaynī mustawī*

Vertical scale on the right: *ẓill sullam aṣābiᶜ wa sittaynī maᶜkūs*

Inside the shadow squares, there is a table with the heading *zadwal sāᶜāt ṭulūᶜ burūj bi-ᶜarḍ baᶜḍī az bilād mulk al-Hind* (table of the times of rising of signs in the latitudes

of some of the localities belonging to the country of India).[414] This table provides the rising times of the signs at each degree of latitude from 20° to 39° which roughly corresponds to the extent of the Mughal empire from Burhanpur at 20° in the south up to northern Afghanistan at about 35° in the north.

Table A072-4 Rising Times of the Signs

Signs → **Latitudes**	**Aries** **Pisces** (h;m)	**Taurus** **Aquarius** (h;m)	**Gemini** **Capricorn** (h;m)	**Cancer** **Sagittarius** (h;m)	**Leo** **Scorpio** (h;m)	**Virgo** **Libra** (h;m)
20°	1;34	1;46	2;3	2;14	2;14	2;9
21°	1;34	1;45	2;3	2;15	2;14	2;10
22°	1;33	1;44	2;3	2;10	2;16	2;10
23°	1;32	1;44	2;2	2;10	2;16	2;9
24°	1;31	1;43	2;2	2;16	2;16	2;12
25°	1;30	1;42	2;2	2;16	2;17	2;13
26°	1;29	1;41	2;1	2;16	2;18	2;14
27°	1;28	1;40	2;1	2;17	2;19	2;15
28°	1;27	1;39	2;0	2;17	2;20	2;16
29°	1;26	1;38	2;0	2;17	2;21	2;18
30°	1;25	1;38	2;0	2;18	2;22	2;19
31°	1;25	1;37	1;39	2;18	2;23	2;20
32°	1;22	1;36	1;18	2;19	2;24	2;21
33°	1;21	1;35	1;18	2;19	2;25	2;22
34°	1;20	1;34	1;18	2;20	2;26	2;23

414 This table occurs only in three astrolabes by Ḍiyā’ al-Dīn, here and in A092 (from 20° to 40°) and in A093 (from 21° to 40°).

35°	1;19	1;33	1;18	2;20	2;27	2;24
36°	1;18	1;32	1;17	2;20	2;28	2;26
37°	1;16	1;31	1;17	2;21	2;29	2;27
38°	1;16	1;29	1;17	2;21	2;30	2;28
39°	1;14	1;28	1;16	2;22	2;31	2;30

The shadow squares are enclosed in 10 concentric semi-circular rows. The first two rows are engraved with the cotangent scales in digits and in feet and their subdivisions. In the next two rows are engraved the names of the 12 zodiac signs and the names and serial numbers (in common Arabic/Persian numerals) of the 28 lunar mansions respectively.

A table of limits occupies the rows 5 and 6. In row 5 are engraved the full names of the five planetary lords of each sign. In the next row are given the numerical limits of the five terms twice; the individual limits in *Abjad* and the cumulative limits in common Arabic/Persian numerals. For example, the data about the third sign *al-Jawzā’* (Gemini) is as follows. The cumulative limits are shown in *italics.*

ᶜAuṭārad (Mercury)	*Mushtarī* (Jupiter)	*Zuhrah* (Venus)	*Mirrīkh* (Mars)	*Zuḥal* (Saturn)
6 *6*	6 *12*	5 *17*	7 *24*	6 *30*

The rows 7 and 8 contain the table of the decans and their planetary regents. The last two rows give once again the decans, but with different planetary regents than the conventional ones. For example, the table related to the sign *al-Jawzā’* is as follows:

Mushtarī (Jupiter)	*Mirrīkh* (Mars)	*Shams* (Sun)
10°	20°	30°
ᶜAuṭārad (Mercury)	*Zuhrah* (Venus)	*Zuḥal* (Saturn)
10°	20°	30°

Alidade

The straight bar alidade has ornate ends and a matching ornate centre-piece. On the left side is engraved a zodiac scale to match the upper right quadrant on the back, with the names of the signs engraved in full. On the right hand side is a sexagesimal scale labelled in 5s from 5 to 60. In a lower register there is also a scale of seasonal hours to measure time when the alidade is used as a sundial with the sighting plate on the right as the gnomon. The wedge is nicely formed as a horse’s head.

Inscription



Figure A072.8 – Signature of the astrolabe maker (photo by S. R. Sarma)

Directly below the horizontal diameter is engraved the astrolabe maker’s signature in two lines and two segments, one on the right and the other on the left:

ᶜamal aqall al-ᶜibād ḍiyā’ al-dīn muḥammad ibn
shaykh qā’im muḥammad ibn mullā ᶜīsā ibn shaykh allāhdād
humāyūnī asṭurlābī lāhūrī
fī sanah 1067 hijrī julūs mubārak shah jahān 31

‘The work of the least of the servants [of God], Ḍiyā’ al-Dīn Muḥammad, son of Shaykh Qā’im Muḥammad, son of Mullā ᶜīsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the year 1067 Hijrī, in the blessed regnal year 31 of Shāh Jahān.’

PROVENANCE

It was acquired by Sawai Jai Singh in the first quarter of the eighteenth century along with some other masterpieces of the Lahore astrolabes. In about 1917 when G. R. Kaye was preparing his book on Jai Singh’s observatories, the astrolabe was with the Jaipur Museum; later, at some uncertain date, it was transferred to the Jaipur Observatory.

BIBLIOGRAPHY

Kaye 1918, p. 16 ff, where this astrolabe is designated as ‘Jaipur B (Astrolabe dated the 31st year of the reign of Shāh Jahān and A. H. 1067 (= A.D. 1657).’ Fig. 6 (front), Fig. 8 (back) and Fig. 13 (gazetteer).

Gunther 1932, no. 75, p. 206, figs. 104 (back), 105 (*kursī*) and 106 (front).

A073⊙ ASTROLABE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1068 AH (AD 1657-58)

Diameter 171 mm

Paris, PC.

Répertoire 16, 18[415]



Figure A073.1 – Front of the astrolabe (photo by S. R. Sarma)

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[415] The Répertoire lists this astrolabe twice; the description is the same in both cases, but the location varies; under 16, 'coll[ection] particulière, under 18, 'coll. Jean Soustiel'.

COMPONENTS

Body with *kursī* (d. 171, h. 218, t. 8), shackle and ring, rete (d. 158) for 45 stars, 5 plates, alidade, pin, washer and horse.

FRONT

Ring has an octagonal cross-section, the shackle is of trifoliate shape, the *kursī* pierced and engraved on the surface. Limb divided in 1° and 5° and labelled from 5 to 360.

RETE

The rings of Capricorn and Ecliptic are held together by the east-west equinoctial bar, which has counter changes at its two intersections with the ecliptic ring, and by the solstitial bar which is partly represented. The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names; each sign divided into groups of 6° and numbered as 6, 12, …30; these units are further subdivided into 1°.

There are 18 star pointers outside the ecliptic and 27 inside. These are joined by an elegant floral tracery consisting of branches, leaves and flowers with six petals each. A small *zawraqī* horizon for latitude 32° is placed inside the ecliptic ring. There is a handle at the west point and a triangular Capricorn index at the south point.



Figure A073.2 – Rete of the astrolabe (photo by S. R. Sarma)

PLATES

There are 5 plates.

Table A073-1 Plates

	φ	Longest day
1a	18°	13;12 hours
1b	22°	13;22 hours
2a	25°	13;35 hours
2b	27°	13;43 hours
3a	29°	13;52 hours
3b	32°	14;8 hours

	φ	Longest day
4a	35°	14;25 hours
4b	Special plate to be used with *zawraqī* horizon	
5a	Plate of ecliptic coordinates	
5b	Plate of horizons	

On plates 1, 2, 3 and 4a, altitude circles are drawn for each 1°, with every fifth dotted. Azimuth arcs are traced for each 6° below the oblique horizon, each fifth of these (30°) is dotted and extended above the horizon. In the lower half, there are plain lines for seasonal hours and dotted lines for equal hours which are drawn from the western horizon. Plate 4b is designed to be used along with the *zawraqī* horizon on the rete; it has two notches at the south and north points

Geographical Gazetteer

The geographical gazetteer on the inner side of the mater provides the names, longitudes and latitudes of 116 localities arranged according to climates. It is almost the same as the gazetteers in A082 for 128 localities and A088 for 124 localities, but for the addition and deletion of a few localities.



Figure A073.3 – Geographical gazetteer (photo by S. R. Sarma)

BACK

The rim of the two upper quadrants is divided in 1° and 5° and labelled twice; once in *Abjad* notation 5—90; 90—5; and again with common Arabic/Persian numerals in the reverse direction 90—5; 5—90.

The upper left quadrant has 60 vertical and 60 horizontal parallels with every fifth dotted. These are numbered in 5s along the vertical and horizontal diameters from 5 to 60, starting from the centre and reaching up to the arc.

The upper right quadrant is divided by 30 declination arcs, the intervening spaces representing 6° of solar longitude. The corresponding names of the zodiac signs and the numerical values of their subdivisions (6, 12, …30 for each sign) are written along the

two radii. On these arcs are drawn three curves to show the meridian altitudes of the sun at latitudes 27°, 29° and 32°, with the labels *khaṭṭ niṣf al-nahār bi-ᶜarḍ 27, khaṭṭ niṣf al-nahār bi-ᶜarḍ 29, khaṭṭ niṣf al-nahār bi-ᶜarḍ 32.*



Figure A073.4 – Back of the astrolabe (photo by S. R. Sarma)

In the lower half are engraved shadow squares, on the left for a base of 7 and on the right for a base of 12, with the usual divisions and labels. Inside the shadow squares are two rectangular tables, on the left the table of the excess of revolution (*faḍl al-dawr*) and on the right the table of triplicities.

The shadow squares are enclosed by 8 semi-circular rows.

Rows1-2, counted from outside, carry scales of cotangents and their subdivisions;

rows 3-4 the names of the 12 signs and the names of the 28 lunar mansions;

rows 5-6 the limits of signs (*ḥudūd*); and

rows 7-8 the decans and their regents (*wujūh*).

Inscription

Immediately below the horizontal diameter is the astrolabe maker’s signature:

ᶜamal aqall al-ᶜibād ḍiyā’ al-dīn muḥammad

ibn qā’im muḥammad ibn mullā ᶜīsā

ibn shaykh allāhdād asṭurlābī humāyūnī

lāhūrī fī sanah 1068 hijrī

‘The work of the least of the servants [of God], Ḍiyā’ al-Dīn Muḥammad, son of Qā’im Muḥammad, son of Mullā ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the year 1068 Hijrī.’

Provenance

The astrolabe was on loan to the Institut de Monde Arabe at Paris where I saw it in 1994 summer; I understand that it was subsequently returned to the private collector who owns it.

A074⊙ ASTROLABE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1069 AH (AD 1658-59)

Diameter 175 mm

Oxford, Museum of the History of Science (#53637)

CCA 77=1002; Répertoire 19

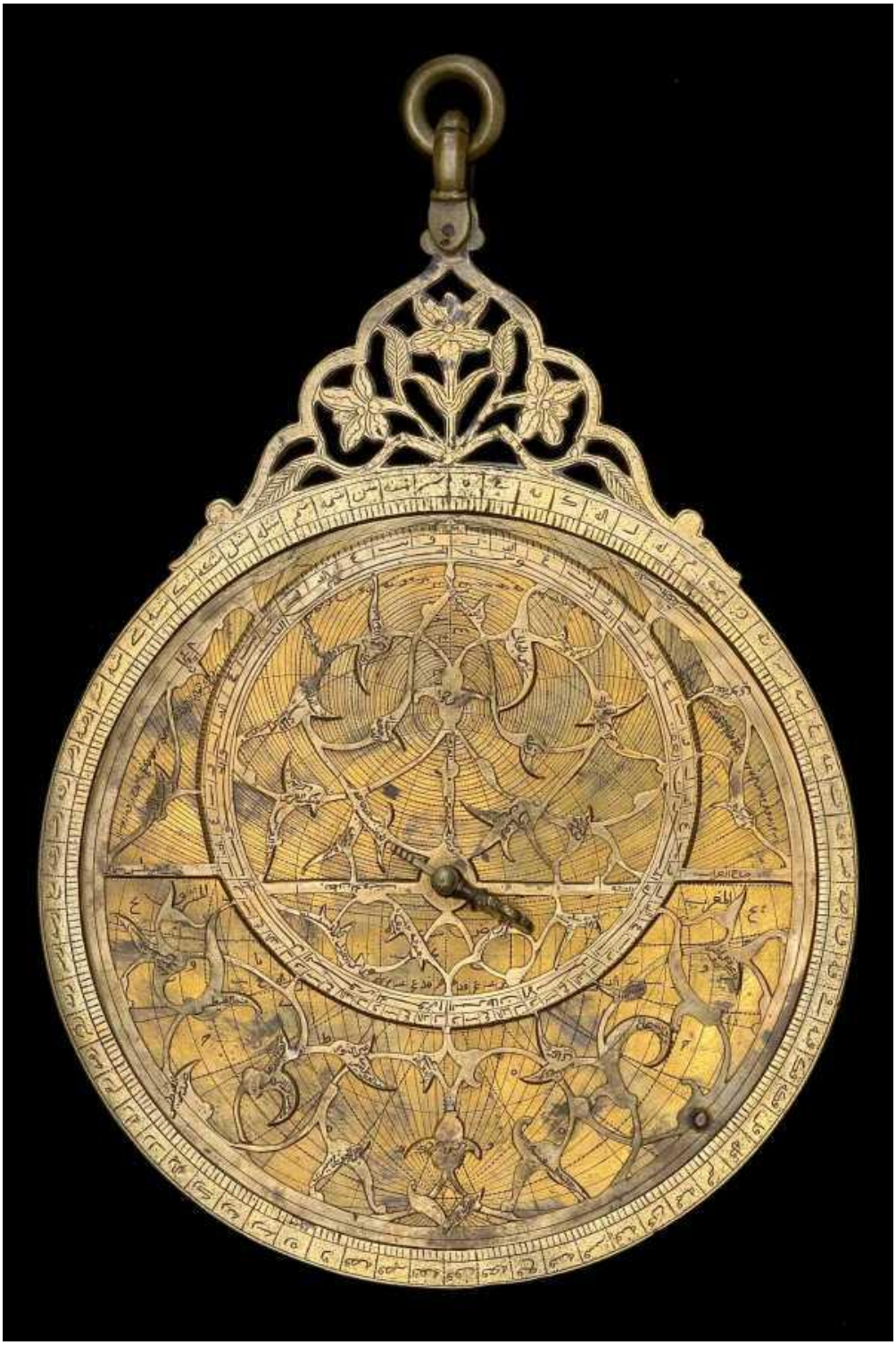


Figure A074.1 – Front of the Astrolabe (© Museum of the History of Science, Oxford)

Components

Body with *kursī* (d. 176, h. 233, t. 6), shackle and ring, rete (d. 158) for 57 stars, 5 plates (d. 158), alidade (162 x 15), pin and horse. The horse seems to be a replacement.

Front

The ring has an octagonal cross-section; the shackle is trifoliate. The profiles of the *kursī* are formed by ogees rising from the body of the astrolabe, followed by a lobe and one more ogee, and finally topped by a trifoliate finial. These profiles form the frame inside which is arranged a bouquet of three large flowers and six leaves. The petals of the flowers and the leaves are marked by engravings on the surface. The limb is divided in 1° and 5° and labelled from 5 to 360.

Rete

In the rete, the two rings of the Tropic of Capricorn and of the ecliptic are held together by the equinoctial bar which has counter changes at its two intersections with the ecliptic. The solstitial bar is also partly represented. The ecliptic ring is divided into the 12 signs of zodiac and labelled with their names. Each sign is subdivided into groups of 6° and numbered accordingly. On the sloping edge, an effort was made to divide it into 1°, but the divisions are not uniform.

There are 57 named star pointers which are joined by a floral tracery. At two points the tracery is broken and welded together.

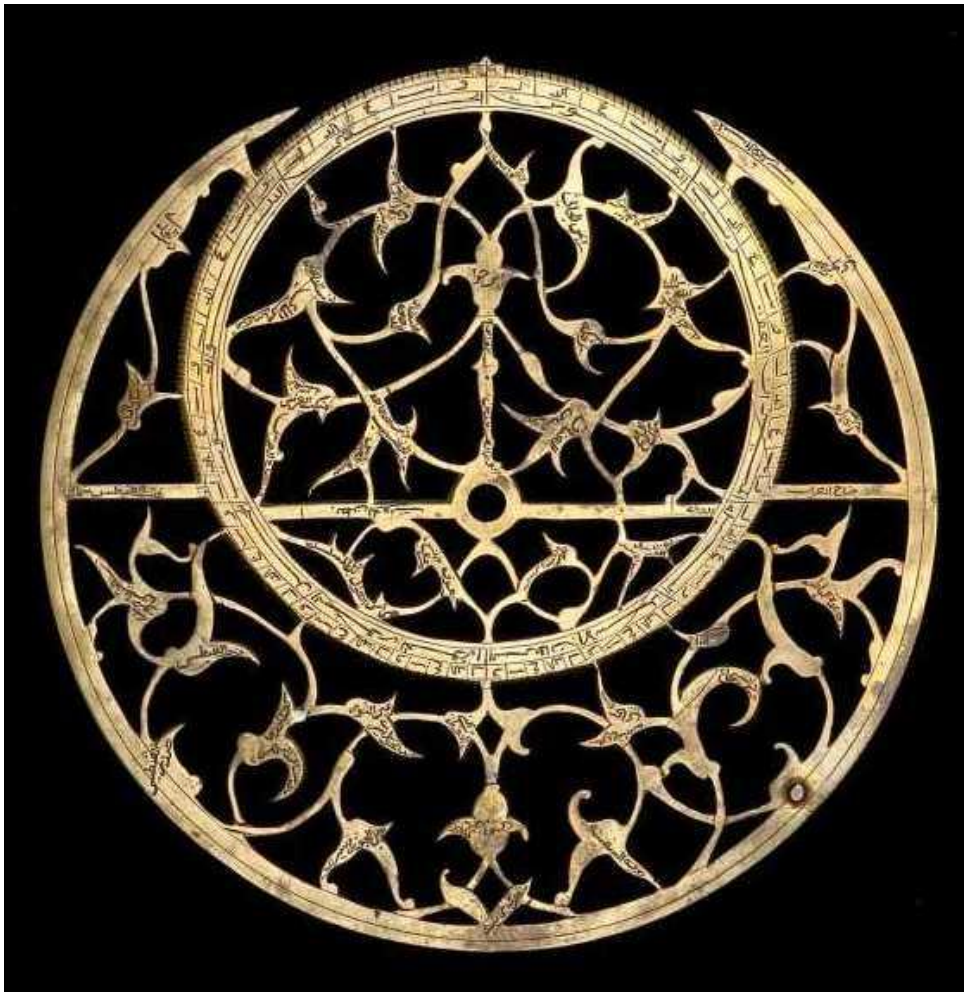


Figure A074.2 – Rete of the astrolabe (© Museum of the History of Science, Oxford)

Table A074-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus Janūbī*	β Ceti
2	*Batn al-Ḥūt*	β Andromedae
3	*Rijl al-Musalsala*	γ Andromedae
4	*Fam al-Qayṭus*	γ Ceti
5	*Ṣadr al-Qayṭus*	π Ceti
6	*Rās al-Ghūl*	β Persei
7	*Kaff al-Jadhmā*	α Ceti
8	*Mirfaq al-Thurayyā*	α Persei
9	*Tālī Masāfat al-Nahr*	γ Eridani

	Star Name	Identification
10	*ᶜAyn al-Thawr*	α Tauri
11	*Al-ᶜAyyūq*	α Aurigae
12	*Rijl al-Jawzā’ Yusrā*	β Orionis
13	*Yad al-Jawzā’ Yusrā*	γ Orionis
14	*Yad al-Jawzā’ Yumnā*	α Orionis
15	*Rijl al-Jawzā’ Yumnā*	κ Orionis
16	*Shiᶜrā Yamānī*	α Canis Majoris
17	*Shiᶜrā Shāmī*	α Canis Minoris
18	*Tarfat al-Safīna*	ρ Puppis
19	?	
20	?	
21	*Fard al-Shujāᶜ*	α Hydrae
22	*Qalb al-Asad*	α Leonis
23	*Ẓahr Dub Akbar*	α Ursae Majoris
24	*Qāᶜidat al-Bāṭiya*	α Crateris
25	*Ẓahr al-Asad*	δ Leonis
26	*Rās al-Asad*	μ Leonis
27	*Al-Ṣarfa*	β Leonis
28	*Al-ᶜAnāq*	ζ Ursae Majoris
29	*Janāḥ al-Ghurāb*	γ Corvi
30	*Simāk Aᶜzal*	α Virginis
31	*Simāk al-Rāmiḥ*	α Bootis
32	*Kiffa Janūbī*	α Librae
33	*Kiffa Shamālī*	β Librae

	Star Name	Identification
34	*Nayyir Fakkah*	α Coronae Borealis
35	*ᶜUnuq al-Ḥayyah*	α Serpentis
36	?	
37	*Qalb al-ᶜAqrab*	α Scorpii
38	*Rās al-Jāthī*	α Herculis
39	*Rās Ḥawwā*	α Ophiuchi
40	*ᶜAyn al-Tinnīn*	γ Draconis
41	*Yad al-Ḥawwā al-Yumnā al-Muqaddam*	δ Ophiuchi
42	*Anwar al-Farqadayn*	β Ursae Minoris
43	*Nasr al-Wāqiᶜ*	α Lyrae
44	*ᶜIṣābat al-Rāmi*	ρ Sagittarii
45	*Minqār al-Dajājah*	β Cygni
46	*Nasr Ṭā’ir*	α Aquilae
47	*Dhanab al-Dulfīn*	ε Delphini
48	?	
49	*Dhanab al-Dajājah*	α Cygni
50	*Fam al-Faras*	ε Pegasi
51	*Dhanab al-Jadī*	δ Capricorni
52	*Ṣāq Sākib al-Mā’ J[anūbī]*	δ Aquarii
53	*Dhanab al-Qayṭus Shamālī*	ι Ceti
54	*Mankib al-Faras*	β Pegasi
55	*Kaff al-Khaḍīb*	β Cassiopeiae
56	*Janāḥ al-Faras*	γ Pegasi
57	*Surrat al-Faras*	δ Pegasi

PLATES

There are five plates with the following specifications

Table A074-2 Plates

	φ	Longest day
1b	22°	13;22 hours
2a	25°	13;35 hours
2b	27°	13;43 hours
3a	29°	13;52 hours
3b	32°	14;8 hours
4a	35°	14;24 hours
4b	38°	14;44 hours
5a	Plate of ecliptic coordinates	
5b	Plate of horizons	

On plates 1 to 4, altitude circles are drawn for each 1° and every sixth is dotted. On plate 1a and 1b, these circles are numbered twice in two rows, one below the other, both on the left and right. On other plates, the circles are numbered in the usual manner both on the left and on the right. Azimuth arcs are drawn for every 6° below the horizon; every fifth arc (30°) is drawn above and below the horizon and dotted below the horizon.

Lines for seasonal hours are drawn on all plates. Lines for equal hours are drawn from the western and eastern horizons on plates 1a, 1b and 2b; on the rest from the western horizon.

On the plate of ecliptic coordinates (5a), the circles of celestial latitudes are drawn for every 2° and the arcs of the celestial longitudes for every 6°. The names of the zodiac signs and the numerical values of their subdivisions are engraved along the ecliptic circle. Above the north point is the label *ṣafīḥat mīzān al-ᶜankabūt.*

The reverse side of this plate (5b) is engraved with the plate of horizons and carries the label *ṣafīḥa āfāqī.* Here four sets of half horizons are engraved for every degree of latitude from 3 to 90°.

3	7	11	…	83	87	90
4	8	12	…	84	88	90
5	9	13	…	85	89	90
6	10	14	…	82	86	90

These are accompanied by declination scales, numbered as 6, 12, 18, 23;30 and labelled *taqsīm mayl kullī janūbī* (division or scale of the maximum declination south) or *taqsīm mayl kullī shamālī* (division or scale of the maximum declination north).

This is one of the rare horizon plates, for it has notches at all the four cardinal points so that all the four sets of horizons can be made use of.



Figure A074.3 – Geographical gazetteer (© Museum of the History of Science, Oxford)

GEOGRAPHICAL GAZETTEER

The gazetteer is engraved in three circles to provide the names, longitudes and latitudes of 89 places, arranged according to climates. The entries are engraved in a zig-zag manner.

Table A074-3 Geographical Gazetteer

	Place Names *asmā’ al-buldān*	**L** *al-ṭūl*	**φ** *al-ᶜarḍ*	
	Outer Circle			
[-I] *az khaṭṭ istiwā’ tā iqlīm awwal* (from the equator up to the first climate)				
1	Ṣāhil Baḥr Awqiyānūs	11;0	0;0	
2	Jazīrat Qanbala	21;0	3;0	Madagascar
3	Jamkūt	177;0	5;0	
4	Thala	180;0	5;0	
5	Kūkū	54;10	10;0	
6	ᶜAdan	76;0	11;0	
[I] *al-iqlīm al-awwal* (the first climate)				
7	Jabal	75;0	13;30	
8	Damār	77;15	13;30	
9	Bajja al-Barbar	10;0	14;0	
10	Dabīl	74;20	14;10	
11	Sanᶜā’ Dār al-Mulk Yaman	77;30	14;30	
12	Jind	75;30	14;30	
13	Sawmnāt	107.0	14;30	
14	Zatūn	114;0	17;15	
15	Bījāpūr	105;30	17;20	
16	Burhānpūr	103;0	20;30	

	Place Names ***asmā’ al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
17	Dawlatābād	111;0	20;30
[II] *al-iqlīm dūyam* (the second climate)			
18	Jadda	76;0	21;0
19	Makka Muᶜaẓẓam	77;10	21;40
20	Madīnat Musharrafa	75;20	25;0
21	Tā’if	77;30	21;20
22	Kanbāyat	109;20	22;20
23	Khaybar	75;20	24;20
24	Hurmūz	92;0	25;0
25	Ajmīr Haḍrat Khwājā[416]	111;5	26;0
26	Kawāliyār	114;0	26;29
27	Qannawj	115;50	26;35
28	Jawnpūr	119;6	26;36
29	Akbarābād Dar al-Khilāfat	114;0	26;43
30	Kara wa Mānikpūr	118;10	26;49
[III] *al-iqlīm siwum* (the third climate)			
31	Kūlkanda	114;19	18;4
32	Kūl Jalālī	114;19	28;4

[416] Haḍrat Khwājā is a refrence to the Sufi saint Khwājā Moinuddin Chishti whose mauloseum is in Ajmer.

	Place Names ***asmā’ al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
33	Haḍrat Shāhjahānābād	113;35	28;39
34	Pānīpatah	113;20	28;20
35	Shīrāz	88;0	29;36
36	Multān	107;35	29;40
37	Hānsī	112;25	29;45
38	Baṣra	84;0	30;0
39	Kirmān	91;30	30;5
	Middle Circle		
[III] *tatimma al-iqlīm siwum* (continuation of the third climate)			
40	Tānīsar	112;33	30;10
41	Iskandariyya	61;54	30;18
42	Miṣr	63;20	30;20
43	Sunām	112;25	30;30
44	Bayt al-Maqdis	66;30	31;50
45	Lāhūr Dār al-Salṭanat	109;20	31;50
46	Yazd	89;0	32;0
47	Iṣfahān	82;40	32;25
48	Qandahār	82;40	33;0
49	Madā’in	72;0	33;0
50	Dimashq	70;0	33;15
51	Baghdād	82;0	33;25
[IV] *al-iqlīm chahāram* (the fourth climate)			

	Place Names ***asmā’ al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
52	Kāshān	86;0	34;0
53	Mawṣil	74;0	34;30
54	Kābul	104;40	34;30
55	Kashmīr	108;0	35;0
56	Hamadān	83;0	35;10
57	Ḥalab	72;10	35;50
58	Mashhad Maqdis	92;30	36;0
59	Bustām	89;30	36;10
60	Balkh	101;0	36;41
61	Tāliqān	85;45	36;10
62	Badakhshān	84;24	37;10
[V] *al-iqlīm panjum* (the fifth climate)			
63	Samarqand	99;16	39;37
64	Bukhārā	97;30	39;50
65	Tubbat	110;0	40;0
66	Burdaᶜa	83;0	40;30
67	Shamākhī	84;30	40;50
68	Khujand	85;35	41;55
69	Khutan	82;0	42;0
70	Farghāna	82;0	42;20
	Inner Circle		
[VI] *al-iqlīm shashum* (the sixth climate)			
71	Kāshghar	106;30	44;0

	Place Names ***asmā’ al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***	
72	Bandaqiya	92;0	44;0	
73	Shalkh	85;30	44;0	
74	Ṭarāz	99;50	44;31	
75	Bīsh Bāligh	112;0	44;50	
76	Qarāqūrūm	115;0	46;0	
77	Khān Bāligh	124;0	46;0	
78	Harqala	67;20	46;30	
[VII] *al-iqlīm haftum* (the seventh climate)				
79	Araq	105;0	48;0	
80	Bulghār	90;0	49;30	
81	Aqchā Kirmān	62;0	50;0	
82	Qirqir	65;15	50;0	
83	Jazā’ir	Rūdjard	68;50	62;0
[VII+] *al-iqlīm khāriz* (beyond the [seventh] climate)[417]				
84	Dhāka Bankālā	130;0	27;0	
85	Patnah	120;45	26;40	
86	Ghāzīpūr	119;40	26;40	
87	Munkīr	121;45	26;40	Mungher
88	Ilāhābād	115;34	26;50	
89	Sūrat	110;50	20;15	

[417] Although the superscript refers to places north of the seventh climate, the six places listed here are from the third climate, placed here as addenda.

BACK

The rim of the two upper quadrants carries altitude scales which are divided in 1° and 5° and labelled as 5—90; 90—5. The upper left quadrant has 60 horizontal and 60 vertical parallels, each fifth dotted; the lines are numbered along the two radii as 5, 10, 15 … 60.

The upper right quadrant has 30 declination arcs for each 6° solar longitude; the names of the signs and the numerical values of their subdivisions (6, 12, 18, 24, 30) are written along the two radii.

In the lower half are engraved shadow squares, on the left for a base of 7 feet and on the right for a base of 12 digits. The vertical and horizontal scales on the left are divided into 7 parts and numbered accordingly. The vertical and horizontal scales on the right are divided into 12 parts and numbered accordingly; these parts are further subdivided into 5 units each. The four scales are accompanied by the following labels:
Vertical scale on the left : *ẓill sullam aqdām maᶜkūs*
Horizontal scale on the left: *ẓill sullam aqdām mustawī*
Horizontal scale on the right: *ẓill sullam aṣābiᶜ wa sittaynī mustawī*
Vertical scale on the right: *ẓill sullam aṣābiᶜ wa sittaynī maᶜkūs*

Inside the shadow squares are engraved two rectangular tables. The table to the left of the vertical diameter is entitled *jadwal faḍl al-dawr* (excess of revolution).

The table on the right carries the heading *jadwal arbāb muthallathāt laylī was nahārī* and displays triplicities in four sub-tables, each devoted to an element: *nārī wa tarābī* (fiery and earthy) and *hawā’ī wa māhī* (airy and watery).

The rim of the lower half carries cotangent scales, on the left in feet and on the right in digits. The next two rows contain the names of the 12 zodiac signs and the names of the 28 lunar mansions. The latter are also numbered serially in the standard Arabic/Persian numerals. The next two rows display the limits of the signs, while the last two rows show the decans and their regents.



Figure A074.4 – Back of the astrolabe (© Museum of the History of Science, Oxford)

ALIDADE

The alidade is well crafted with ornate ends and an ornate centre piece. The right arm carries a sexagesimal scale numbered in 5s from the centre to the tip from 5 to 60. On the lower half of the right arm is a scale of seasonal hours. The left arm carries a declination scale corresponding to the arcs of the signs of the zodiac together with the names of signs arranged in pairs as in the upper right quadrant.

INSCRIPTION

ᶜamal aqall al-ᶜibād ḍiyā’ al-dīn muḥammad ibn qā’im muḥammad ibn mullā ᶜīsā ibn shaykh allāhdād asṭurlābī humāyūnī lāhūrī fī sanah 1069 hijrī gh-s-ṭ

‘The work of the least of the servants [of God], Ḍiyā’ al-Dīn Muḥammad, son of Qā’im Muḥammad, son of Mullā ᶜĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the year 1069 Hijrī, [in Abjad notation] 1000+60+9.’

The year corresponds to AD 1658-59.

PROVENANCE

Gift of Lewis Evans 1924.

BIBLIOGRAPHY

Gunther 1932, no. 77, pp. 208-210, fig. 109.

A075 ASTROLABE BY ḌIYĀ AL-DĪN MUḤAMMAD, 1069 AH (AD 1658-59)

Diameter 145 mm

PLU: ex-London, Sotheby's (auction 27 April 2005, lot 46; auction 9 April 2008, lot 212)



Figure A075.1 – Front of the astrolabe (© Sotheby's)

COMPONENTS

Body with *kursī* (d. 145), shackle and ring, rete for about 50 stars, 4 plates and pin; the alidade and horse are not visible in the photo, nor are they mentioned in the catalogue.

FRONT

The ring is plain; the shackle is of trifoliate shape with tear-drop like bases. The *kursī* displays a very fine fretwork. The profiles are made up of an ogee rising from the limb, which is followed by a lobe and an ogee, all these topped by a trifoliate finial. Inside the frame created by the profiles is a large flower of five petals on a long stalk, with two leaves on each side. All these parts are richly decorated with fine engravings on the surface.

The limb is divided in 1° and 5° and labelled from 5 to 360. Dotted lines mark the divisions of groups of 6°; in the rete also dotted lines mark the divisions into signs and the subdivisions of 6° degrees.

RETE

The two rings of the Tropic of Capricorn and ecliptic are held together by the equinoctial and solstitial bars, both fully represented, the former with counter changes at its two intersections with the ecliptic and the later without any counter changes. The spaces between the two rings and inside the ecliptic ring are filled with an almost symmetrical arrangement of vines, producing circular loops, which are endowed with a profusion of tulip flowers with flared petals (a motif dear to Muqīm). At the tips of these petals and elsewhere are the named pointers to about 50 fixed stars.

The ecliptic circle is divided into the 12 signs of the zodiac and the divisions are labelled with the names of the respective signs. Each sign is divided into units of 6° and these units are numbered as 6, 12,… 30. The sloping edge of the ecliptic circle is marked with the divisions of 2°. There is a handle on the circumferential band, a little below the west point.

PLATES

There are four plates serving the latitudes 22°, 25°, 32°, 34°, 36°, 38°; ecliptic coordinates and multiple horizons. It is strange that there is no plate for the imperial capitals of Agra and Delhi at 27° and 29°. Possibly one plate is missing.

Geographical Gazetteer

There is a gazetteer engraved inside the mater, but the catalogue does not mention the number of localities represented there.

Back

The rim of the two upper quadrant bears altitude scales divided in 1° and 5° and labelled as 5—90; 90—5. The rim on the lower half is engraved with cotangent scales. In the upper left is a trigonometric quadrant with horizontal parallels for each 1° and dotted for each 5°. A solar quadrant in the upper right displays two curves of the sun's meridian altitude at latitudes 27° and 32°. In the lower half are shadow squares and standard astrological tables.

Inscriptions

Below the horizontal diameter is the astrolabe maker's signature, where the year is given in standard Arabic/Persian numerals as well as *Abjad.*

> *ᶜamal aqall al-ᶜibād diyā' al-dīn muḥammad*
> *ibn qā'im muḥammad ibn mullā ᶜīsā*
> *ibn shaykh allāhdād humāyūnī asṭurlābī*
> *lāhūrī fī sanah 1069 hijrī gh-s-ṭ*
>
> 'The work of the least of the servants [of God], Ḍiyā' al-Dīn Muḥammad, son of Qā'im Muḥammad, son of Mullā ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the year 1069 Hijrī, [in *Abjad* 1000+60+9] 1069.'

The year corresponds to AD 1658-59. On the edge of the astrolabe, there is another inscription, probably added by an owner, who is unidentified:

> *ibn muḥammad taqī munajjim muḥammad raḍā munajjim*
>
> 'The son of Muḥammad Taqī, the astronomer, Muḥammad Raḍā, the astronomer.'

Bibliography

London, Sotheby's, auction catalogue of 27.04.2005, lot 46, pp. 66-67; see also auction catalogue of 9 April 2008, lot 212.

A076 ASTROLABE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1070 AH (AD 1659-60)[418]

Diameter 88 mm

Washington DC, National Museum of American History

CCA 87; Répertoire 20



Figure A076.1 – Geographical Gazetteer (from Gibbs & Saliba 1984)

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418 Entry is based on Gibbs & Saliba 1984, pp. 132-134; the geographical gazetteer is added.

Components

Only the mater of this small astrolabe is extant. Body with *kursī* (d. 88), shackle and ring are original. The rete, 5 plates, alidade, pin and horse are later substitutes.

Front

The *kursī* is finely crafted with fretwork. The profiles are made up of a single lobe between two ogees, ending in a trifoliate finial. The surface of the *kursī* is decorated, on both sides, with ornate engravings. On the edges which form the profiles is a continuous chain-like pattern; the fretwork contains intertwined vines with a flower with three petals in the middle.

The limb is graduated in 2° and 6° and labelled separately for each quadrant as 6—90; 6—90; 6—90; 6—90.

Geographical Gazetteer

On the inner side of the mater is engraved a gazetteer of 38 places in two circles. The letters are written upside-down with their tops directed towards the centre of the astrolabe. The zero symbol with loops on both terminals looks like a small pair of scissors.

Table A076-1 Geographical Gazetteer

	Place Name *asmā’ al-buldān*	**L** *al-ṭūl*	**φ** *al-ᶜarḍ*
	Outer Circle		
1	Makka Muᶜaẓẓam	77;10	21;40
2	Madīnat Musharrafa	75;20	25;0
3	Miṣr	63;20	30;20
4	Al-Rūm	77;0	39;40
5	Tabrīz	82;0	38;0
6	Bulghār	90;0	49;30
7	Kūfa	79;30	31;30
8	Baghdād	80;30	33;25

	Place Name ***asmā’ al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
9	Basra	84;0	30;0
10	Shīrāz	88;0	29;36
11	Ardabīl	82;30	38;0
12	Yazd	89;0	32;30
13	Iṣfahān	86;40	32;25
14	Sabzawār	91;30	36;5
15	Ṭūs	94;30	37;0
16	Tūn	92;30	32;30
17	Harāt	94;33	34;30
18	Balkh	101;0	36;41
19	Bukhārā	97;30	39;50
20	Samarqand	99;56	39;37
21	Hurmūz	92;0	25;0
22	Aḥmadābād	108;0	23;15
23	Kābul	104;40	34;30
	Inner Circle		
24	Kashmīr	103;0	35;0
25	Akbarābād	114;0	26;43
26	Shāhjahānābād	113;35	28;39
27	Ajmīr	111;5	24;0
28	Kawāliyār	115;0	26;29
29	Lāhūr	109;20	31;50
30	Qandahār	107;40	33;0
31	Mūltān	107;35	29;40

	Place Name ***asmā’ al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
32	Khanbāyat	109;4	22;20
33	Bījāpūr	105;30	17;20
34	Ilāhābād	105;34	27;50
35	Kalkanda	114;39	18;4
36	Dhakā Bankālā	130;0	27;0
37	Burhānpūr	109;0	20;31
38	Batnah	120;45	26;40

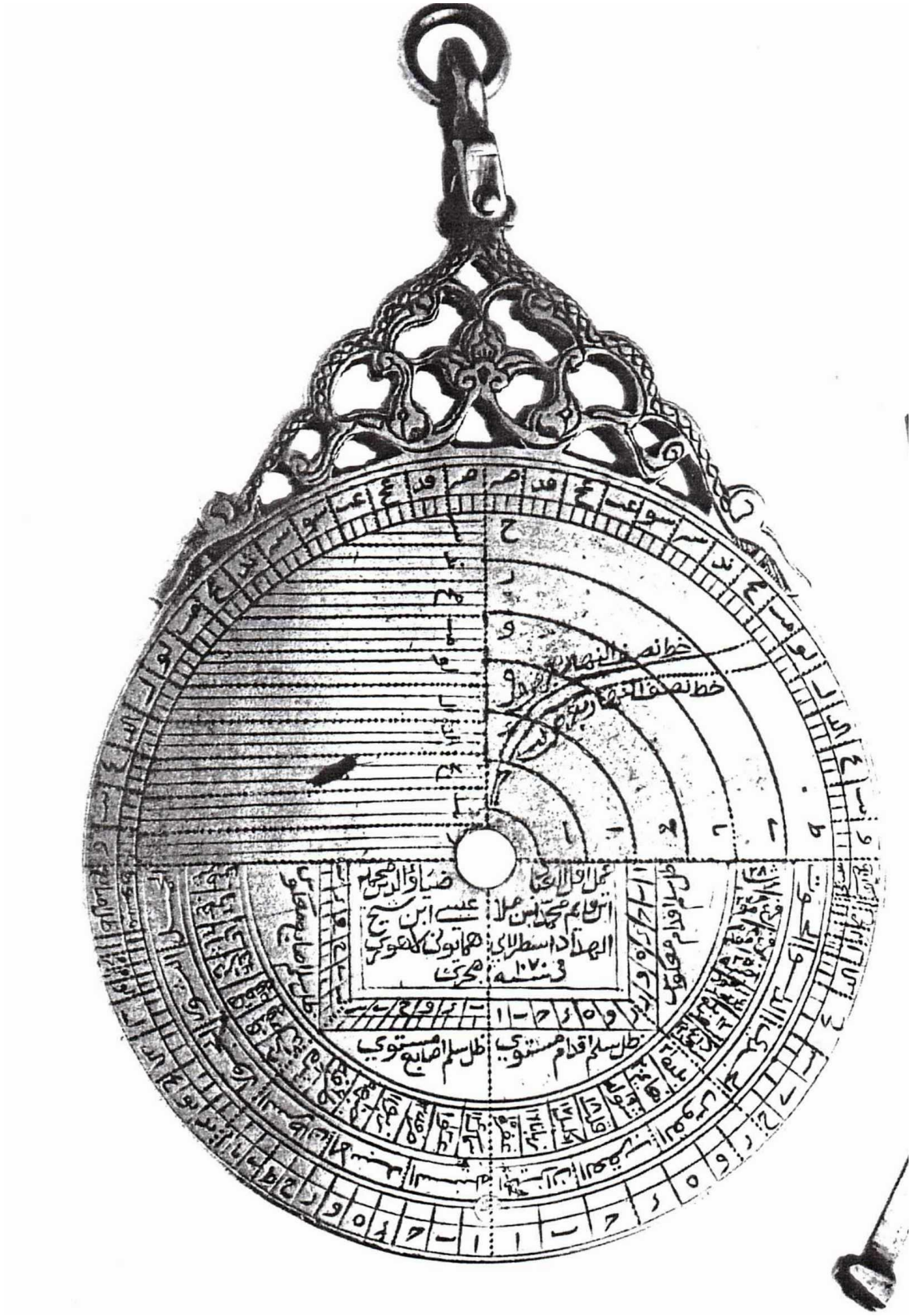


Figure A076.2 – Back of the Astrolabe (from Gibbs & Saliba 1984)

BACK

On the back, the rim of the two upper quadrants carries altitude scales divided in 2° and 6° and labelled as 6—90; 90—6.

The upper left quadrant is engraved with 30 horizontal parallels, i.e., one line for every 2 of 60 parts of the Radius, with every third line dotted. The parallel lines are numbered along the vertical radius as 6, 12, … 60.

The upper right quadrant contains six equally spaced declination arcs, the spaces between them representing a pair zodiac signs. The corresponding signs are marked with their serial numbers (0 to 11) along the two radii. On this grid are plotted two graphs of the solar meridian altitude at the latitudes 27° and 32° with the usual labels.

In the lower half are shadow squares, on the left for a base of 12 and on the right for a base of 7. The related scales are divided and numbered accordingly with the usual labels.

The rim of the lower half carries the cotangent scales, in digits on the left and in feet on the right. In the scale on the left, the unequal divisions are numbered as 1, 2, 3 … 12, 14, 16, 18, 24, 30, 36, 42, 48, 60 followed by the label *ẓill aṣābiʿ*. The same set of numbers are engraved on the right half as well, but followed by the label *ẓill aqdām*.

Inside the cotangent scales are two semi-circular rows showing the correlation between the 12 signs of the zodiac and the 28 lunar mansions; the first scale is filled with the names of the 12 signs of the zodiac while the second is filled with the names of the corresponding lunar mansions.

INSCRIPTION

Within the shadow squares is engraved the astrolabe maker’s signature in four lines:

> *ʿamal aqall al-ʿibād ḍiyā’ al-dīn muḥammad*
> *ibn qā’im muḥammad ibn mullā ʿīsā ibn shaykh*
> *allāhdād asṭurlābī humāyūnī lāhūrī*
> *fī sanah 1070 hijrī*
>
> ‘The work of the least of the servants [of God], Ḍiyā’ al-Dīn Muḥammad, son of Qā’im Muḥammad, son of Mullā ʿĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the 1070 Hijrī.’

The others parts, viz., rete, plates, alidade, pin and wedge are crude modern imitations and in some cases non-functional. The rete has an unusual design and the ecliptic circle is not divided into signs and degree. There are several projections

resembling star pointers, but none of these carry star names. Clearly this rete is non-functional. Likewise the five plates are poor imitations.

Therefore Gibbs & Saliba remark: ‘The obvious difference in quality between the body of the astrolabe and the various separable parts suggests that the latter were not work of Ḍiyā’ al-Dīn. The rete unquestionably non-functional. The numbers identifying altitudes on the plate faces do not correspond to specific divisions. There are several stray arcs among the projected hour lines.’

PROVENANCE

Ex-collection of Samuel Verplank Hoffmann, Edgerton, Mass.

BIBLIOGRAPHY

Gibbs & Saliba 1984, p. 35, fig. 23; pp. 132-134, fig. 86, 87.
Gunther 1932, no. 87, p. 216.

A077⊙ ASTROLABE BY ḌIYĀ AL-DĪN MUḤAMMAD, 1071 AH (AD 1660-61) [419]

Diameter 83 mm

Chicago, Adler Planetarium & Astronomy Museum (#A-81)

CCA 2554; Répertoire 22



Figure A077.1 – Front of the astrolabe. Photograph by Stephen Pitkin, Pitkin Studio.
Image © Adler Planetarium, Chicago, IL.

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[419] Entry based on Pingree 2009, no. 17, pp. 73-77; the star list has been rearranged according to increasing right ascension.

COMPONENTS

Body with *kursī* (d. 83, h. 111, t. 6), shackle and ring, rete for 30 stars, 5 plates, uninscribed alidade, washer, pin and wedge.

FRONT

The ring is plain and the shackle is probably of trifoliate shape. The *kursī* is solid and low with very low, almost flat, lobes in the profiles and with a trifoliate finial. On the front and back are floral decorations in low relief. The limb is divided in 2° and 6°. and labelled from 6 to 90 separately in each quadrant as 6—90; 6—90; 6—90; 6—90.

RETE

The Capricorn and ecliptic rings are held together by complete equinoctial and solstitial bars, the former with two counter changes at the centre and at one of its intersections with the ecliptic in the east, and the latter without any counter changes. Flat handle roughly at the NW point on the ring of the Tropic of Capricorn. The ecliptic circle is divided into the 12 signs of the zodiac and labelled with their names. Each sign is divided into units of 6°, but not numbered. Thorn-like star pointers are joined by vines; 30 of these thorns are engraved with heavily abridged star names.

Table A077-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus*	β Ceti[420]
2	*Fam al-Qayṭus*	γ Ceti
3	*Ṣadr al-Qayṭus*	π Ceti
4	*ᶜAyn al-Thawr*	α Tauri
5	*Yad Jawzā’ al-Yusrā*	γ Orionis
6	*Jawzā’ Yumnā*	κ Orionis
7	*Shiᶜrā Yamānī*	α Canis Majoris

[420] Pingree identifies it as ι Cet, i.e., the northern tip of the tail of Cetus, but what is engraved on this rete is the southern tip, β Ceti.

	Star Name	Identification
8	*Shiᶜrā Shāmī*	α Canis Minoris
9	*Fard al-Shujāᶜ*	α Hydrae
10	*Qalb al-Asad*	α Leonis
11	*Ẓahr Dub*	α Ursae Majoris
12	*Qāᶜidat al-Bāṭiya*	α Crateris
13	*Janāḥ al-Ghurāb*	γ Corvi
14	*Simāk Aᶜzal*	α Virginis
15	*Rāmiḥ*	α Bootis
16	*Kiffa Janūbī*	α Librae
17	*Nayyir Fakkah*	α Coronae Borealis
18	*Al-Ḥayyah*	α Serpentis
19	*Qalb al-ᶜAqrab*	α Scorpii
20	*Rās al-Jāthī*	α Herculi
21	*Rās al-Ḥawwā*	α Ophiuchi
22	*Nasr Wāqiᶜ*	α Lyrae
23	*Nasr Ṭā'ir*	α Aquilae
24	*Dulfīn*	ε Delphini
25	*Dhanab al-Dajājah*	α Cygni
26	*Fam al-Faras*	ε Pegasi
27	*Dhanab al-Jadī*	δ Capricorni
28	*Sāq Sākib al-Mā'*	δ Aquarii
29	*Mankib Faras*	β Pegasi
30	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are five plates with the following specifications:

Table A077-2 Plates

	φ	Longest day
1a	18°	13;9 hours
1b	22°	13;21 hours
2a	24°	13;32 hours
2b	27°	13;43 hours
3a	29°	13;52 hours
3b	32°	14;8 hours
4a	34°	14;20 hours
4b	36°	14;32 hours
5a	Plate of ecliptic coordinates	
5b	Plate of horizons	

On plates 1-4, altitude circles are drawn for every 6°; azimuth arcs are drawn for every 10° below the horizon on all plates except 4b where they are drawn for every 10° above and below the horizon.[421] Plain lines for seasonal hours are traced on all plates. Dotted lines for equal hours are drawn on plates 1 and 2 from both the western and eastern horizons, on 3-4 from the western horizon.

On the plate of ecliptic coordinates, circles of celestial latitude are drawn for every 6° and numbered from the circle of ecliptic to the north and to the south. Arcs of the celestial longitude are drawn for every 10°; every third of these which marks the boundary between two zodiac signs is dotted. The names of zodiac signs are engraved along the circle of ecliptic and the divisions 10° and labelled. At the north point, there is the label *ṣafīḥat mīzān al-ᶜankabūt.*

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421 Pingree states that these are drawn for every 30°, but the photos show otherwise.

On the plate of horizons half-horizons are drawn for the following latitudes:

6	16	26	...	66
8	18	28	…	58
10	20	30	…	60
12	22	32	…	62

Declination scales are marked along the vertical and horizontal diameters with divisions numbered as 6, 12, 18, 24, implying that the obliquity of the ecliptic is treated here as 24.



Figure A077.2 – Geographical Gazetteer
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

GEOGRAPHICAL GAZETTEER

The gazetteer is engraved in two circles with the latitudes, longitudes and names (in this order) of 38 localities. It does not commence at the south point at the top as is usually done, but below at the north point and proceeds from right to left. The writing is upside down, i.e. the tops of the letters are towards the centre.

Table A077-3 Geographical Gazetteer

	Place Name *asmā’ al-buldān*	**L** *al-ṭūl*	**φ** *al-ᶜarḍ*
	Outer Circle		
1	Makka Muᶜaẓẓam	77;10	21;40
2	Madīnat Musharraf	75;20	25;0
3	Miṣr	63;20	30;20
4	Ḥalab	72;10	35;50
5	Tabrīz	82;0	38;0
6	Ardabīl	82;30	38;0
7	Bulghār	90;0	49;30
8	Kūfa	79;30	31;30
9	Madā’in	82;0	33;10
10	Baghdād	80;30	33;25
11	Baṣra	84;0	30;0
12	Shīrāz	88;0	29;36
13	Yazd	88;0	32;30
14	Hamadān	83;0	35;10
15	Iṣfahān	86;40	32;25
16	Sabzwār	91;30	36;5
17	Nīshāpūr	92;30	36;21
18	Balkh	101;0	36;41

	Place Name ***asmā' al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
19	Badakhshān	104;24	37;10
20	Bukhārā	97;30	39;50
21	Samarqand	99;56	39;37
22	Kābul	104;40	34;30
23	Qandahār	107;40	33;0
	Inner Circle		
24	Multān	107;35	29;40
25	Lāhūr	109;20	31;50
26	Shāhjahānābād	113;35	28;39
27	Akbarābād	114;0	26;43
28	Ajmīr	111;5	24;0 !
29	Kwāliyār	115;0	26;29
30	Bījāpūr	105;30	17;20
31	Dawlatābād	111;0	21;40
32	Aḥmadābād	108;40	23;15
33	Kalkanda	115;39	18;10
34	Dhākā Bankālā	130;0	27;0
35	Burhānpūr	109;0	20;31
36	Patna	120;45	27;40
37	Kashmīr	103;0 !	35;0
38	Tubbat	110;0	40;0

BACK

The rim of the upper half carries altitude scales which are divided in 2° and 6°, and labelled as 6—90; 90—6. The rim of the lower half bears the scales of cotangents.

In the upper left quadrant are drawn 30 horizontal parallels, i.e., cosines for every 2 of the 60 parts of the Radius, with each third line dotted. The horizontal lines are numbered in 6s from 6 to 60 along the vertical radius.

In the upper right are drawn five arcs of declination so that spaces in between represent a pair of zodiac signs, which are marked with their serial numbers from 0 to 11 along the two radii. Upon the arcs of declination are plotted two graphs of solar meridian altitude for the latitudes of 27° and 32° with the usual labels.

In the lower half are shadow squares, on the left for 7 feet and on the right for 12 digits with the usual labels. The shadow squares are enclosed inside two semi-circular rows in which are inscribed the names of the 12 zodiac signs and those of the 28 lunar mansions. Inside the shadow squares is the maker’s inscription in three lines (see below).



Figure A077.3 – Back of the astrolabe Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

ALIDADE

The plain and ungraduated alidade is a replacement.

INSCRIPTION

The inscription is problematic. The engraver appears to have first inscribed the second and the third lines and then added the first line as an after-thought, with the result the astrolabe maker’s genealogy stops with ᶜĪsā and does not mention Allāhdād; but his two attributes *asṭurlābī humāyūnī* and *lāhūrī* are added at the top of the inscription. The attribute *lāhūrī* fits every member of the family, but *asṭurlābī humāyūnī* is appropriate only for Allāhdād.

humāyūnī lāhūrī

ᶜamal aqall al-ᶜibād ḍiyā al-dīn muḥammad

ibn qā’im muḥammad ibn mullā ᶜīsā fī sanah 1071 hijrī

‘The work of the least of the servants [of God], Ḍiyā’ al-Dīn Muḥammad, son of Qā’im Muḥammad, son of ᶜĪsā, [son of Allāhdād] of Lahore, [the astrolabe maker to the Emperor] Humāyūn, in the year 1071 Hijrī.’



Figure A077.4 – Signature of the astrolabe maker (detail of Figure A077.3)

PROVENANCE

Ali Kuli Khan, The House of Persian Art, New York, 1941; Adler Purchase 1941.

BIBLIOGRAPHY

Pingree 2009, No. 17, pp. 73-77.

A078⊙ ASTROLABE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1071 AH (AD 1660-61)

Diameter 114 mm

London, Nasser D. Khalili Collection of Islamic Art (#SC111)

CCA 2607; Répertoire 24



Figure A078.1 – Back of the Astrolabe (photo by S. R. Sarma)

Components

Only the mater is extant, with *kursī* (d. 114, h. 133, t. 7), shackle and ring.

Front

The ring has a corrugated edge and the shackle a trifoliate form. As in the previous astrolabe, the *kursī* here also is solid and very low with foliate pattern engraved on both sides. The limb is graduated in 1° and 5° labelled separately for each quadrant as 5—90; 5—90; 5—90; 5—90.



Figure A078.2 – Geographical Gazetteer
(photo by S. R. Sarma)

GEOGRAPHICAL GAZETTEER

The gazetteer provides latitudes, longitudes and place names, in this order, of 54 localities in two circles.[422] It commences from the north point and proceeds clockwise. The shape of the zero symbol here is interesting; at the beginning it is the older form with a single loop; gradually the second loop at the end of the horizontal arm develops; towards the end of the gazetteer it almost reaches the characteristic shape of Ḍiyā’s zero which looks like a small pair of scissors.

Table A078-1 Geographical Gazetteer

	Place Name *asmā’ al-buldān*	**L** *al-ṭūl*	**φ** *al-ᶜarḍ*
	Outer Circle		
1	Makka Muᶜaẓẓam	77;10	21;40
2	Madīnat Musharrafa	75;20	25;0
3	Miṣr	63;20	30;20
4	Al-Rūm	77;0	39;40
5	Tabrīz	82;0	38;0
6	Ardabīl	82;30	38;0
7	Bulghār	90;0	49;30
8	Kūfa	79;30	31;30
9	Baghdād	80;30	33;25
10	Shīrāz	88;0	29;36
11	Yazd	89;0	32;30
12	Qazwīn	85;0	36;55
13	Iṣfahān	86;40	32;25
14	Rayy	86;20	35;0

422 Turner 1985, p. 84, states that the *inhirāf* is also given in the gazetteer, but that is not the case.

	Place Name ***asmā’ al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
15	Sabzawār	91;30	36;5
16	Nīshābūr	92;30	36;21
17	Ṭūs	94;30	37;0
18	Tūn	92;30	32;30
19	Harāt	94;33	34;20
20	Sarakhs	94;30	32;0
21	Marw	97;0	34;40
22	Balkh	101;0	36;41
23	Badakhshān	104;24	37;10
24	Bukhārā	97;30	39;50
25	Samarqand	99;56	39;37
26	Khujand	85;30	41;55
27	Kāshghar	106;30	44;0
28	Hurmūz	92;0	25;0
29	Aḥmadābād	108;40	23;15
30	Ujjayn	102;0	22;30
31	Kābul	104;40	34;30
32	Pānīpatah	113;20	28;52
33	Shāhjahānābād	113;35	28;39
34	Akbarābād	114;0	26;43
35	Ajmīr	111;5	24;0
	Inner Circle		
36	Kawāliyār	115;0	26;29
37	Kashmīr	103;0	35;0

	Place Name ***asmā’ al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
38	Tubbat	110;0	40;0
39	Sarandīp	104;0	10;0
40	Bānāras	117;20	26;52
41	Lāhūr	109;20	31;50
42	Qandahār	107;40	33;0
43	Mūltān	107;35	29;40
44	Nahlawarah ?	102;30	25;0
45	Khanbāyat	109;3	22;20
46	Jidda	76;0	21;0
47	Bījāpūr	105;30	17;20
48	Dawlatābād	111;0	20;30
49	Jawnpūr	119;6	26;36
50	Mansūr Sind	105;0	27;40
51	Burhānpūr	109;0	20;31
52	Patna	120;45	26;40
53	Dhākā Bankāāa	130;0	27;0
54	Kalkanda	114;39	18;4

BACK

The back is engraved almost in the same manner as in the previous two astrolabes (A076, A077). The rim of the upper half bears the altitude scales, divided in 1° and 5° and labelled as 5—90; 90—5. The boundaries of groups of 5° are marked by dotted lines. The rim of the lower half carries cotangent scales.

In the upper left quadrant are drawn 30 horizontal parallels, i.e., one line for 2 of 60 parts of the Radius, with every third line highlighted with dots. Along the vertical radius, these horizontal lines are numbered as 6, 12, …60.

In the upper right quadrant are drawn six dotted declination arcs and the related zodiac signs are marked by their serial numbers (0 to 11) along the two radii. On this grid are plotted two sigmoid graphs of solar meridian altitude for the latitudes 27° and 32° with the usual labels.

In the lower half are drawn the shadow squares, on the left for the base of 12 digits and on the right for the base of 7 feet. The scales on the left are divided into 12 parts (and each part halved) and numbered from 1 to 12; the scales on the right are divided into 7 parts. The scales are accompanied by the usual labels.

In the cotangent scale on the left, the unequal divisions are numbered clockwise from the vertical diameter as 1, 2, 3, …. 8, 10, 12, 15, 18, 21, 24, 30, 42, 48, 60 followed by the label *ẓill-i aṣābiʿ*; on the right the divisions are numbered anti-clockwise 1, 2, 3, … 8, 10, 12, 15, 18, 24, 30, 36, 42, 48, 60, followed by the label *ẓill aqdām.*

Inside this scale are two semi-circular scales which show the correlation between the zodiac signs and lunar mansions; in the outer semicircle are inscribed the names of the 12 zodiac signs and in the inner semicircle the names of the 28 lunar mansions.

INSCRIPTION

Inside the shadow squares is engraved the astrolabe maker’s signature in three lines.

> *ʿamal aqall al-ʿibād ḍiyā’ al-dīn muḥammad ibn qā’im muḥammad*
> *ibn mullā ʿīsā ibn shaykh allāhdād asṭurlābī*
> *humāyūnī lāhūrī fī sanah 1071 hijrī*
>
> ‘The work of the least of the servants [of God], Ḍiyā’ al-Dīn Muḥammad, son of Qā’im Muḥammad, son of Mullā ʿĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn in the year 1071 Hijrī.’

PROVENANCE

Kinloch Collection: Harriet Wynter, London;

The Time Museum, Rockford, Illinois.

BIBLIOGRAPHY

Sotheby’s, London, Catalogue 26 February 1968, lot no. 12.

Wynter & Turner 1975, p. 19, figs. 12, 13.

Turner 1985, no. 5, pp. 84-85, figs. 62-63.

Christie’s, London, 14 April 1988, lot no. 151.

Maddison & Savage-Smith 1997, no. 127, p. 223.

A079⊙ ASTROLABE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1072 AH (AD 1661-62)[423]

Diameter 182 mm

Paris, PC

CCA 3517; Répertoire 25

Only the mater of this astrolabe survives.

COMPONENTS

Body with *kursī* (d. 182, h. 228, t. 8.5) shackle and ring.

FRONT

Shackle trifoliate, *kursī* fine fretwork with designs engraved on the surface; these are clearly visible on the back; in the front they are worn out.

The limb graduated in 1° and 5° and labelled from 5 to 360. There is a lug at the north point to hold the plates in position. There is a slight crack in the limb at 110°.

GEOGRAPHICAL GAZETTEER

The names, longitudes and latitudes of 116 localities in four circles.

BACK

The rim of the upper two quadrants carries altitude scales which are graduated in 1° and 5° and labelled 5—90; 90—5.

Upper left quadrant has 60 horizontal and 60 vertical parallels, each fifth dotted; these are numbered along both the radii.

Upper right quadrant has declination arcs for every 6° of solar longitude; dotted arcs for every 30° at the boundaries of successive signs. Three sigmoid graphs of solar meridian altitude for the latitudes 27°, 29°, 32° with the usual labels.

In the lower half shadow squares, on the left for the base of 12 and on the right for the base of 7. These shadow squares are enclosed in a series of 8 semi-circular rows. Starting from the outside these rows contain

1-2 cotangents and subdivisions

3-4 the names of the zodiac signs and the names of the lunar mansions

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[423] I saw it briefly in 1994; my photos did not turn out well.

5-6 the limits of the signs (*ḥudūd*)

7-8 decans and their regents (*wujūh*).

Inscription

Inside the shadow squares is engraved the astrolabe maker’s signature thus:

ᶜamal aqall al-ᶜibād ḍiyā’ al-dīn muḥammad
ibn qā’im muḥammad ibn mullā ᶜīsā ibn shaykh
allāhdād asṭurlābī humāyūnī
lāhūrī fī sanah 1072 hijrī.

‘The work of the least of the servants [of God], Ḍiyā’ al-Dīn Muḥammad, son of Qā’im Muḥammad, son of Mullā ᶜĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the year 1072 Hijrī.

Provenance

Ex. Coll. Alain Brieux, Le Val Saint-Germain (Essonne)

A080⊙ ASTROLABE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1073 AH (AD 1662-63)

Diameter 106 mm

Cambridge, Mass., PC of Professor Owen Gingerich

CCA 3809; Répertoire 26



Figure A080.1 – Front of the Astrolabe (photo by S. R. Sarma)

COMPONENTS

Body with *kursī* (d. 106), rete for 43 stars, 4 plates, alidade and pin and horse. The original horse is missing; a twisted wire is used as the wedge to hold all the components in position. The original shackle and ring are also missing; these are replaced by a small copper ring which passes through the hole at the top of the *kursī* and a very large copper

ring which passes through the smaller ring. A long leather strap is tied to the larger ring. The whole thing is placed in a leather pouch.

FRONT

The *kursī* is pierced with 11 large symmetrical holes; the profiles are lobed; trifoliate finial. The limb is divided in 1°, 3° and 6°; the boundary lines for groups of 3° and of 6° are dotted. The scale is labelled as 6—90; 6—90; 6—90; 6—90.

RETE

The two circles of the Tropic of Capricorn and ecliptic are held together by a slender equinoctial bar which has a counter change at the centre. The ecliptic circle is divided into 12 signs of the zodiac and labelled with their names. Each sign is subdivided into 5 units and labelled as 6, 12, 18, 24, 30. The sloped edge is calibrated in 3°. There is a handle on the ring of the Tropic of Capricorn, midway between the north and west points.

The 43 star pointers are joined by an almost symmetrical arrangement of vines. Among the star pointers the motif of tulips (as in Muqīm’s astrolabes) with flared petals occurs occasionally, but generally the star pointers look like thorns projecting out of the vines. The following are the names of 43 stars marked on the rete.[424]

Table A080-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus*	β Ceti
2	*Baṭn al-Ḥūt*	β Andromedae
3	*Fam al-Qayṭus*	γ Ceti
4	*Ṣadr al-Qayṭus*	π Ceti
5	*Ghūl*	β Persei
6	*Tālī Masāfat al-Nahr*	γ Eridani

[424] The star names are deciphered and identified in Gingerich 1982a, p. 58. Here they are rearranged according to increasing right ascensions.

	Star Name	Identification
7	*Dabarān*	α Tauri
8	*ᶜAyyūq*	α Aurigae
9	*Rijl Jawzā’ Yusrā*	β Orionis
10	*Yad Jawzā’ [Yusrā]*[425]	γ Orionis
11	*Yad Jawzā’[Yumna]*	α Orionis
12	*Rijl Jawzā’ [Yumnā]*	κ Orionis
13	*Shiᶜrā Yamānī*	α Canis Majoris
14	*Shiᶜrā Shāmī*	α Canis Minoris
15	*Fard Shujāᶜ*	α Hydrae
16	*Rās Asad*	μ Leonis
17	*Qalb al-Asad*	α Leonis
18	*Ẓahr Dub*	α Ursae Majoris
19	*Qāᶜidat al-Bāṭiya*	α Crateris
20	*ᶜAnāq*	ζ Ursae Majoris
21	*Janāḥ al-Ghurāb*	γ Corvi
22	*Simāk Aᶜzal*	α Virginis
23	*Simāk Rāmiḥ*	α Bootis
24	*Kiffa Janūbī*	α Librae
25	*Nayyir Fakkah*	α Coronae Borealis
26	*ᶜUnuq al-Ḥayyah*	α Serpentis
27	*Qalb al-ᶜAqrab*	α Scorpii
28	*Rukbat Ḥawwā*	ζ Ophiuchi

[425] Engraved wrongly as *yad jawzā’*.

	Star Name	Identification
29	*Rās al-Jāthī*	α Herculis
30	*Rās Ḥawwā*	α Ophiuchi
31	*Yad Ḥawwā*	δ Ophiuchi
32	*Nasr Wāqiʿ*	α Lyrae
33	*Minqār al-Dajājah*	β Cygni
34	*Nasr Ṭā’ir*	α Aquilae
35	*Dulfīn*	ε Delphini
36	*Dhanab*	α Cygni
37	*Fam Faras*	ε Pegasi
38	*Dhanab al-Jadī*	δ Capricorni
39	*Sāq Sākib al-Mā’*	α Aquarii
40	*Dhanab al-Qayṭus Sh[amālī]*	ι Ceti
41	*Mankib Faras*	β Pegasi
42	*Surrat [al-Faras]*	α Andromedae
43	*Kaff al-Khaḍīb*	β Cassiopeiae

Plates

There are four plates with the following specifications:

Table A080-2 Plates

	φ	Longest day
1a	22°	13;21 hours
1b	25°	13;25 hours
2a	27°	13;43 hours

	φ	Longest day
2b	29°	13;38 hours
3a	32°	14;8 hours
3b	34°	14;20 hours
4a	18°	13;9 hours
4b	0°+ 72°+ 90°	

On plates 1 to 4a, altitude circles are drawn for every 3° and every fifth line is dotted; azimuth arcs are drawn for every 10° below the horizon and every third line is dotted; and lines for seasonal hours are drawn. Dotted lines for equal hours as counted from the western and eastern horizons are drawn on the plates for 18°, 22° and 25°; dotted lines for equal hours as counted from the western horizon are on the plates for 27°, 29°, 32° and 34°. Plate 4b carries combined projections for the latitudes 0°, 72° and 90°. On all plates *al-maghrib* and *al-mashriq* inscribed at the western and eastern points of the oblique horizon. Strangely there is no plate with the plate of ecliptic coordinates on one side and the plate of horizons on the other side.

Geographical Gazetteer

The gazetteer is engraved in two circles, giving the names, longitudes and latitudes of 50 places. The writing is upside down. Much space is left out between the two circles and inside the inner circle.



Figure A080.2 – Geographical Gazetteer (photo by S. R. Sarma)

Table A080-3

	Place Name ***Asmā’ al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
	Outer Circle		
1	Makka Muᶜaẓẓam	77;10	21;40
2	Madīnat Musharrafa	75;20	25;0
3	Miṣr	63;20	30;20
4	Yaman	77;0	11;30
5	Mawṣil	77;0	37;30
6	Tabrīz	82;0	38;0
7	Ardabīl	82;30	38;0
8	Kūfa	79;30	31;30
9	Madā’īn	72;0	33;10
10	Baghdād	80;30	33;25
11	Baṣra	84;30	30;0
12	Shīrāz	88;0	29;36
13	Yazd	89;0	32;30
14	Hamadān	83;0	35;10
15	Karaj	84;45	34;0
16	Qazwīn	85;0	36;55
17	Iṣfahān	86;40	32;25
18	Qum	85;40	34;45
19	Rayy	86;20	35;0
20	Astarābād	89;30	36;50
21	Bustam	89;30	36;10

	Place Name ***Asmā’ al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
22	Sabzawār	91;30	36;5
23	Nīshābūr	92;30	36;21
24	Ṭūs	94;30	37;0
25	Tūn	92;30	32;30
26	Harāt	94;33	34;30
27	Balkh	101;0	36;41
28	Badakhshān	104;25	37;10
29	Bukhārā	97;30	39;50
30	Samarqand	99;56	39;37
31	Khujand	85;30	41;55
	Inner Circle		
32	Hurmūz	92;0	25;0
33	Ujjayn	102;0	22;30
34	Kābul	104;40	34;30
35	Kashmīr	103;0	35;0
36	Mūltān	107;35	29;40
37	Qandahar	107;40	33;0
38	Lāhūr	109;20	31;50
39	Sarhind	111;33	30;30
40	Shahjahānābād	113;0	28;39
41	Akbarābād	114;0	26;43
42	Ajmīr	111;5	24;00
43	Kawāliyār	115;0	26;29
44	Burhānpūr	109;0	20;31

	Place Name ***Asmā’ al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
45	Dawlatābād	111;0	21;40
46	Bījāpūr	105;30	17;20
47	Ka[l]kanda	117;39	18;4
48	Dhākā Bangal	130;0	27;0
49	Patna	120;45	26;40
50	Bānāras	117;20	26;52

BACK

On the back, the rim of the two upper quadrants bears altitude scales divided in 2° and 6° and labelled as 6—90; 90—6. The boundary lines between groups of 6° are dotted. In the upper left quadrant are drawn 30 horizontal parallels, i.e., cosines of 2 out of 60 parts of the Radius, and every third line is dotted. The spaces between the dotted lines are numbered along the vertical radius as 6, 12, 18, … 60.

In the upper right quadrant six dotted declination arcs divide the quadrant into six zones, one each for a pair of zodiac signs. The related signs are marked with their serial numbers (0 to 11) along the two radii. Upon this grid are plotted two graphs (also in dotted lines) of the solar meridian altitude for the latitudes of 27° and 32° with the labels *khaṭṭ niṣf al-nahār bi-ᶜarḍ 27* and *khaṭṭ niṣf al-nahār bi-ᶜarḍ 32* respectively.



Figure A080.3 – Back of the Astrolabe and the Alidade (photo by S. R. Sarma)

In the lower half are drawn the shadow squares, on the left for a base of 7 feet and on the right for a base of 12 digits. The scales are divided and numbered accordingly, and are accompanied by the following labels:

Vertical scale on the left: *ẓill sullam aqdām maᶜkūs*

Horizontal scale on the left: *ẓill sullam aqdām mustawī*

Horizontal scale of the right: *ẓill sullam aṣābiᶜ mustawī*

Vertical scale on the right: *ẓill sullam aṣābiᶜ maᶜkūs.*

The rim on the lower half carries the cotangent scales. In the scale on the left, the unequal divisions are numbered, from the vertical diameter to the horizontal, as 1, 2, 3,

… 8, 10, 12, 14, 16, 18, 24, 30, 36, 48, 60, followed by *ẓill aqdām.* The divisions in the scale on the right are numbered in the same manner, but followed by *ẓill aṣābiᶜ*.

Inside the shadow squares are two semi-circular scales; the inner one is filled with the names of the zodiac signs and the outer one with the names of the corresponding lunar mansions.

ALIDADE

The alidade carries, on the left hand side, the declination arcs as in the upper right quadrant along with the serial numbers of the zodiac signs; on the right hand side, a sexagesimal scale numbered in 6s as in the upper left quadrant as well as markings for the sundial.

INSCRIPTION

Just below the horizontal diameter is engraved the astrolabe maker’s signature:

> *ᶜamal aqall al-ᶜibād ḍiyā’ al-dīn muḥammad ibn qā’im muḥammad ibn mullā ᶜīsā ibn shaykh allāhdād asṭurlābī humāyūnī lāhūrī*
> *samah 1073*
> ‘The work of the least of the servants [of God], Ḍiyā’ al-Dīn Muḥammad, son of Qā’im Muḥammad, son of Mullā ᶜĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, [in] the year 1073 [Hijri].’

PROVENANCE

Professor Gingerich purchased the astrolabe from an Afghan student in the early 1970’s.

BIBLIOGRAPHY

Gingerich 1992

A081⊙ ASTROLABE BY ḌIYĀ AL-DĪN MUḤAMMAD,1073 AH (AD 1662-63)

Diameter 95 mm

Chicago, Adler Planetarium & Astronomy Museum (#A-78)[426]

CCA 2551[427]; Répertoire 01



Figure A081.1 – Front of the astrolabe. Photograph by Stephen Pitkin, Pitkin Studio.
Image © Adler Planetarium, Chicago, IL.

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426 Entry based on Pingree 2009, No. 18, pp. 78-81; the star list has been rearranged according to increasing right ascension.

427 CCA wrongly attributes it to Muhi al-Din M[uhammad]; the date 1140/1727 is also wrong. But the source (CAP), the accession number (A-78) and diameter (95) are correct.

This astrolabe has many features which are common to A077: solid *kursī* with floral decoration in low relief, the limb labelled in the same style separately for each quadrant, fully represented equinoctial and solstitial bars in the rete, the gazetteer commencing at the north point and so on. Yet the back of this astrolabe is so poorly engraved that it is inconceivable that the master astrolabist Ḍiyā’ al-Dīn engraved it himself. In the upper left quadrant none of the parallel lines are straight, the shadow squares are constructed with crooked lines, the graduations are uneven, the semi-circular scales in the lower half are badly organised, the writing is cluttered and in poor calligraphy! It is difficult to explain the dichotomy. Pingree does not notice it, but the Répertoire does. It does not include this astrolabe in chronological sequence of astrolabes and celestial globe made by Ḍiyā’ al-Dīn, but at the end with the serial number ‘01’ and with the remark ‘Cet astrolabe est très douteux’.

COMPONENTS

Body with *kursī* (d. 95, h. 126, t. 7), shackle and ring, rete for 33 stars, 5 plates, alidade, pin and horse.

FRONT

The ring is large and plain; the shackle is also plain with circular bases. The *kursī* is rather wide and low with lobed profiles and a trifoliate finial. On both sides of the *kursī* a floral design is engraved in very low relief.

The limb is graduated in 2° and 6°. Single degrees are marked with a dot. The scale is numbered in 6s, separately for each quadrant, as 6—90; 6—90; 6—90; 6—90.

RETE

The two rings of Capricorn and ecliptic are joined by complete equinoctial and solstitial bars, the former with two counter changes at its two intersections with the ecliptic ring, and the latter without any counter changes. The handle affixed to the right of the north point is lost, only the hole remains. The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names. Each sign is divided into units of 6°, but not numbered. There are 33 thorn-like star pointers attached to the solstitial bar and to the two rings.

Table A081-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus*	β Ceti
2	*Fam al-Qayṭus*	γ Ceti
3	*Ṣadr [a]l-Qayṭus*	π Ceti
4	*Rās Ghūl*	β Persei
5	*Tālī Masāfat al-Nahr*	γ Eridani
6	*ᶜAyn al-Thawr*	α Tauri
7	*Rijl Jawzā' Yusrā*	β Orionis
8	*Yad Jawzā' Yusrā*	γ Orionis
9	*Yad al-Jawzā' Yumnā*	α Orionis
10	*Rijl Jawzā' Yumnā*	κ Orionis
11	*Shiᶜrā Shāmī*	α Canis Majoris
12	*Mankhar al-Shujāᶜ*	σ Hydrae
13	*Fard al-Shujāᶜ*	α Hydrae
14	*Ẓahr Dub*	α Ursae Majoris
15	*Qā'idat al-Bāṭiya*	α Crateris
16	*Ẓahr*	δ Leonis
17	*Janāḥ al-Ghurāb*	γ Corvi
18	*Simāk Aᶜzal*	α Virginis
19	*Simāk Rāmiḥ*	α Bootis
20	*Nayyir Fakkah*	α Coronae Borealis
21	*ᶜUnuq*	α Serpentis
22	*Qalb al-ᶜAqrab*	α Scorpii
23	*Rās Ḥawwā*	α Ophiuchi
24	*Nasr Wāqiᶜ*	α Lyrae

	Star Name	Identification
25	*Nasr Ṭā’ir*	α Aquilae
26	*Dhanab Dulfīn*	ε Delphini
27	*Dhanab al-Dajājah*	α Cygni
28	*Fam al-Faras*	ε Pegasi
29	*Dhanab al-Jadī*	δ Capricorni
30	*Dhanab al-Qayṭus*	ι Ceti
31	*Sāq Sākib al-Mā’*	δ Aquarii
32	*Mankib al-Faras*	β Pegasi
33	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are five plates with the following specifications:

Table A081-2 Plates

	φ	Longest day
1a	0° + 90°[428]	
1b	22°	13;21 hours
2a	24°	13;32 hours
2b	27°	13;43 hours
3a	29°	13;52 hours
3b	32°	14;8 hours
4a	36°	14;32 hours
4b	40°	14;54 hours

[428] Pingree 2009, p. 81, says 90°, but it is double projection for 0° and 90°.

	φ Longest day
5a	Plate of ecliptic coordinates
5b	Plate of horizons

Plate 1a has the projection of 0° in the upper half and that of 90° in the lower half. In the lower half, below the horizon on the right is inscribed *al-maghrib* and below that *al-ᶜarḍ lah,* 'there is no latitude.' On the left, below the horizon is inscribed *al-mashriq* and below that *al-ᶜarḍ tisᶜūn,* 'the latitude [is] ninety [degrees]'.

On plates 1-4, altitude circles are drawn for every 6° and labelled. Every fifth line (30°) is dotted. On 1b, 2-4, azimuths are drawn for every 10° below the horizon and labelled. Here too every third line (30°) is dotted.[429] On 1b, 2-4, there are plain lines for seasonal hours and dotted lines for equal hours counted from the western and eastern horizons.

On the plate of ecliptic coordinates (5a) are drawn the arcs of celestial longitudes for every 10° and circles of celestial latitudes for every 6°; the latter are numbered from the ecliptic circle to the north up to the zenith and to the south up to the Tropic of Capricorn. The names of the zodiac signs are inscribed along the ecliptic and the units of 10° are numbered as 10, 20, 30 separately for each sign. In the lower half is the label *ṣafīḥat mīzān al-ᶜankabūt*

On the reverse side is engraved the plate of horizons with four sets of half-horizons for the following latitudes:

4	12	20	28	36	44	52	60	68
6	14	22	30	38	46	54	62	70
8	16	24	32	40	48	56	64	72
10	18	26	34	42	50	58	66	74;30

There are declination scales along the vertical and horizontal diameters which are labelled as 6, 12, 18, 24. There is no label with the name of the plate.

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[429] Pingree 2009, p. 78, says 'azimuths on Ia (every 10°) and on IIa (every 45°),' but the photos show otherwise.

GEOGRAPHICAL GAZETTEER

The gazetteer provides the latitudes, longitudes and names (in this order) of 46 localities in two circles without any space in between. The gazetteer commences, not at the south point at the top, but at the north point below and proceeds from right to left, as in A077 of 1660 above. The writing is upside down, i.e., the tops of the letters are towards the centre.

Table A081-3 Geographical Gazetteer

	Place Name	L	φ
	Outer Circle		
1	Makka Muᶜaẓẓam	77;10	21;40
2	Madinat Musharrafa	75;20	25;0
3	Miṣr	63;20	30;20
4	Dimashq	70;0	33;15
5	Ḥalab	72;10	35;50
6	Al-Rūm	77;0	39;40
7	Mawṣil	77;0	34;30
8	Tabrīz	82;0	38;0
9	Ardabīl	82;30	38;0
10	Bulghār	90;0	49;30
11	Kūfa	79;30	31;30
12	Madā’in	72;0	33;10
13	Baghdād	80;30	33;25
14	Baṣra	84;0	30;0
15	Shīrāz	88;0	29;36
16	Yazd	89;0	32;30
17	Iṣfahān	86;40	32;25

	Place Name	L	φ
18	Sabzawār	91;30	36;5
19	Nīshābūr	92;30	36;21
20	Balkh	101;0	36;41
21	Badakhshān	104;24	37;10
22	Bukhārā	97;30	39;50
23	Samarqand	99;56	39;37
24	Ṭūs	94;30	37;0
25	Tūn	92;30	32;30
26	Harāt	94;33	34;30
27	Sarakhs	94;30	32;0
28	Khujand	105;30	41;55
29	Kāshghar	106;30	44;0
30	Hurmūz	92;0	25;0
31	Kashmīr	103;0	35;0
	Inner Circle		
32	Kābul	104;40	34;30
33	Qandahār	107;40	33;0
34	Mūltān	107;35	29;40
35	Lāhūr	109;20	31;50
36	Shāhjahānābād	113;35	28;39
37	Akbarābād	114;0	26;43
38	Ajmīr	111;5	24;0 !
39	Kawāliyār	115;0	26;29
40	Bījāpūr	105;30	17;20

	Place Name	L	φ
41	Dawlatābād	111;0	21;40
42	Aḥmadābād	108;40	23;15
43	Kalkanda	114;39	18;10
44	Dhākā Bankālā	130;0	27;0
45	Burhānpūr	109;0	20;31
46	Patna	120;45	26;40

BACK

Surprisingly the quality of engraving on the back is very poor: none of the horizontal lines in the upper left quadrant is straight, the shadow squares are constructed with crooked lines and the signature is very brief!

The rim of the upper half carries altitude scales which are divided in 2° and 6° and labelled as 6—90; 90—6. The rim of the lower half bears the scale of cotangents.

In the upper left quadrant are drawn 30 horizontal parallels, with every third line dotted (not consistently); these are numbered in 6s, from 6 to 60, from the centre upwards along the vertical radius.

In the upper right are drawn five arcs of declination so that the spaces in between represent a pair of zodiac signs. Upon these arcs of declination are plotted two graphs of solar meridian altitude. At the top of the quadrant is a label inscribed upside down in two lines: *khaṭṭ niṣf al-nahār bānah* (?) *ʿarḍ l.w.y.ḥ* (‘line of the midday [altitude] … (?) latitude 36;18’). The location of the label and its text do not make much sense for here are two lines of midday altitude and not just one for the latitude of 36;18°, if that is the purport of the label.

In the lower half are two small shadow squares, on the left for 7 feet and on the right for 12 digits without any labels. The shadow squares are enclosed by 8 concentric semi-circular scales. Some of the rows are accompanied by a label or title in the lower part of the upper right quadrant.



Figure A081.2 – Back of the astrolabe.
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

1. Cotangent scales. In the scale on the left, the divisions are numbered from the vertical diameter to the horizontal diameter as 3, 6, 7, 9, 12, 15, 18, 24, 30, 36, 42. In the scale on the right the divisions are numbered thus: 3, 6, 9, 12, 15, 18, 24, 30, 36, 42, 48, 40!
2. Subdivisions of the scales in 1.
3. Here the divisions are numbered in the reverse direction, starting from the horizontal diameter. The numbers on the left are: 1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 16, 24, 39 (?). The numbers on the right are 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 16, 21, 24, 30, 36, 48, 72.
4. This row carries the label *al-ḥudūd* and contains the bounds of the limits of the signs.
5. This row carries the label *al-wujūh* and contains the regents of the decans (and not the decans themselves).
6. This row contains the names of the 12 signs with the label *al-burūj.*
7. This row contains the names of the planetary regents of the terms (mentioned in row 4 above). There is a label, but I cannot decipher it.
8. This row contains the names of the 28 lunar mansions, although the label once again undecipherable.

Clearly these scales are badly organised; in other astrolabes, the rows containing the names of the signs and the names of the lunar mansions are placed together; the rows containing the bounds of the terms and the planetary lords of the terms are also placed together. Here they are not. In other astrolabes there are two rows containing the decans and the regents. Here there is only one row with the regents.

INSCRIPTION

ᶜamal ḍiyā’ al-dīn muḥammad sanah 1073 hijrī’

‘The work of Ḍiyā’ al-Dīn Muḥammad, [in] the year 1073 Hijrī.’

PROVENANCE

Sotheby’s London 1938; Perry Webster, London 1938; Adler Purchase 1939.

BIBLIOGRAPHY

Pingree 2009, No. 18, pp. 78-81.

A082⊙ SHIP ASTROLABE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1074 AH (AD 1663-64)

Diameter 223 mm

Patna, Khuda Bakhsh Oriental Public Library

CCA 1117; Répertoire 27



Figure A082.1 – Front of the Astrolabe (photo by S. R. Sarma)

COMPONENTS

Body with *kursī* (d. 223, h. 297, t. 12), shackle and ring, rete (d.202) for about 42 stars, 4 plates (d. 202), alidade (202 x 11) and pin. The horse is missing.

FRONT

The ring is plain and the shackle is trifoliate. Openwork *kursī* with profiles made up of ogees at the base and at the top with two lobes in between and a trifoliate finial. The surface is filled with ornamental engraving in the front and in the back. The limb is graduated in 1° and 5° and labelled from 5 to 360.



Figure A082.2 – Rete of the Astrolabe (photo by S. R. Sarma)

RETE

In the rete, the two rings of Capricorn and ecliptic are held together by the equinoctial bar which has three counter changes at its two intersections with the ecliptic ring and at the centre. Part of the equinoctial bar coincides with the two mutually

intersecting *zawraqī* horizons drawn for the latitudes of 29° and 32°. A part of the solstitial bar is shown so that it functions as the masts for the two *zawraqī* arcs. The star pointers are joined by a floral tracery. Between the two rings, the tracery looks like a flowering bush; its two braches bearing large leaves and flowers cover the entire space in the east and west. A similar flowering bush is incorporated inside the ecliptic circle as well, but its symmetry is marred by the solstitial bar and the longitudinal slits that run parallel to the bar. There is a large handle just below the western segment of the equinoctial bar.

The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names; each sign is subdivided in groups of 6° and numbered from 6 to 30. The edge of the ring is divided in 1°.

Table A082-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus*	β Ceti
2	*Riǰl Musalsala*	γ Andromedae
3	*Fam al-Qayṭus*	γ Ceti
4	*Ṣadr al-Qayṭus*	π Ceti
5	*Rās Ghūl*	β Persei
6	*Mirfaq al-Thurayyā*	α Persei
7	*Kaff al-Jadhmā’*	α Ceti
8	*Tālī Masāfat al-Nahr*	γ Eridani
9	*ᶜAyn al-Thawr*	α Tauri
10	*ᶜAyyūq*	α Aurigae
11	*Riǰl Jawjā’ al-Yusrā*	β Orionis
12	*Yad Jawjā’ al-Yusrā*	γ Orionis
13	*Riǰl Jawjā’ Yumnā*	κ Orionis
14	*Shiᶜrā Yamānī*	α Canis Majoris
15	*Shiᶜrā Shāmī*	α Canis Minoris

	Star Name	Identification
16	*Ṭarfat Safīna*	ρ Puppis
17	*Fard al-Shujā^{c}*	α Hydrae
18	*Qalb al-Asad*	α Leonis
19	*Ẓahr Dubb Akbar*	α Ursae Majoris
20	*Qā’idat al-Bāṭiya*	α Crateris
21	*Ẓahr al-Asad*	δ Leonis
22	*Ṣarfa*	β Leonis
23	*Rās al-Asad*	μ Leonis
24	*Janāḥ al-Ghurāb*	γ Corvi
25	*Simāk al-A^{c}jal*	α Virginis
26	*Simāk Rāmiḥ*	α Bootis
27	*Kiffa J[anūbī]*	α Librae
28	*Nayyir Fakkah*	α Coronae Borealis
29	*Qalb al-^{c}Aqrab*	α Scorpii
30	*Rās al-Jāthī*	α Herculis
31	*Rās al-Ḥawwā*	α Ophiuchi
32	*Rukbat al-Rāmī*	α Sagittarii
33	*Minqār al-Dajājah*	β Cygni
34	*Nasr Ṭā’ir*	α Aquilae
35	*Dhanab al-Dulfīn*	ε Delphini
36	*Dhanab al-Dajājah*	α Cygni
37	*Fam al-Faras*	ε Pegasi
38	*Dhanab al-Jadī*	δ Capricorni
39	*Mankib Sākib al-Mā’*	α Aquarii

	Star Name	Identification
40	*Sāq Sākib al-Mā'*	δ Aquarii
41	*Janāḥ al-faras*	γ Pegasi
42	*Surrat al-Faras*	δ Pegasi



Figure A082.3 – Zawraqī Horizons and their Masts in the Rete (photo by S. R. Sarma)

ZAWRAQĪ HORIZONS

Two mutually intersecting arcs are incorporated at the middle of the rete. These are *zawraqī* horizons.[430] Together with the segments of the solstitial bar, they resemble the outlines of ships (*zawraq*) with their masts. The arc with the convex side to the north is the oblique horizon for latitude 29°. The eastern and western halves of the arc carry the labels *ufq mujassam sharqī bi-ᶜarḍ 29* (eastern solid horizon for latitude 29) and *ufq mujassam gharbī bi-ᶜarḍ 29* (western solid horizon for latitude 29) respectively. The

430 On these horizons, see Frank 1920, pp. 18-21.

mast corresponding to this arc, i.e., the solstitial bar above the central hole, has the inscription *shaẓiya yatiru zawraq fawq al-ᶜard* (pointer spanning the *zawraqī* horizons above the earth).

The other arc, with the convex side to the south is the oblique horizon for latitude 32°. Two halves of this arc carry the labels *ufq mujassam sharqī bi-ᶜarḍ 32* (eastern solid horizon for latitude 32) and *ufq mujassam gharbī bi-ᶜarḍ 32* (western solid horizon for latitude 32). Its mast, i.e., the solstitial bar below the central hole, bears the label *shaẓiya yatiru zawraq tahta al-ᶜard* (pointer spanning the *zawraqī* horizons below the earth).

The equinoctial bar carries the labels *mastarat tarbī’ sharqī* (eastern perpendicular rule) in the east *mastarat tarbī’ gharbī* (western perpendicular rule) in the west.

PLATES

There are four plates serving the following latitudes:

Table A082-2 Plates

	φ	Longest day
1a	25°	13;35 hours
1b	27°	13;43 hours
2a	29°	13;52 hours
2b	32°	14;8 hours
3a	34°	14;20 hours
3b	36°	14;30 hours
4a	Plate of ecliptic coordinates	
4b	Double projection 29° + 32°, to be used with the *zawraqī* horizons	

On plates 1 to 3, altitude circles are drawn for each 1°, every sixth highlighted with dots; azimuth arcs are drawn below the horizon for every 6°; each fifth is highlighted with dots and extended above the horizon. Lines for seasonal hours are drawn on all plates. On plate 1a, dotted lines for equal hours are traced both from the

eastern and western horizons; on the other plates dotted lines for equal hours are drawn from the western horizon. On plate 1a, next to the latitude value of 25° in *Abjad* numbers, the number 25 is also engraved in Devanagari numerals. This may have been added later by a Hindu astronomer who did not read the Arabic-Persian script.

The obverse side of the plate is designed as the plate of ecliptic coordinates. It carries the label *ṣafīḥat mīzān al-ᶜankabūt.* The reverse side of this plate is not prepared as the plate of horizons as is the usual practice, but as a special tablet to the used along with the *zawraqī* horizons.

Plate 4b to be used with the *Zawraqī* Horizons

Like the other plates, this one is also engraved with the vertical and horizontal diameters, and the three concentric circles of the Tropic of Cancer, the celestial equator and the Tropic of Capricorn.

Around the circle of equator, the twelve astrological houses are marked, once outside the equator and once inside the equator, but with a difference. Outside the equator the enumeration commences from the east point and proceeds counterclockwise, but inside the equator the enumeration commences from the west point and proceeds counterclockwise. The two varying sets of the astrological houses are related to the two oblique horizons engraved on this plate. The names of the astrological houses are engraved in elongated letters so that the names occupy the full stretches of the corresponding houses.

In both cases, each house is divided into 5 units of 6° and the numbers in *Abjad* notation are engraved above the names of the astrological houses in Arabic. In Arabic, the first house is named *al-ṭālīᶜ,* 'the ascendant,' and the rest are ordinal numbers.

Two mutually intersecting oblique horizons are drawn across the plate. As in the rete, here also the arc with the convex side to the north is the oblique horizon for the latitude 29° and that with the convex side to the south is the horizon of the latitude 32°. Where the arcs intersect with the equinoctial colure, there are labels at the end of each horizon. Thus at the two ends of the horizon for 29° are engraved *ufq sharqī ᶜarḍ 29* (eastern horizon latitude 29) on the east and *ufq gharbī ᶜarḍ 29* (western horizon latitude 29) on the west. Likewise at the two ends of the horizon for 32° are engraved *ufq sharqī ᶜarḍ 32* on the east and *ufq gharbī ᶜarḍ 32* on the west.

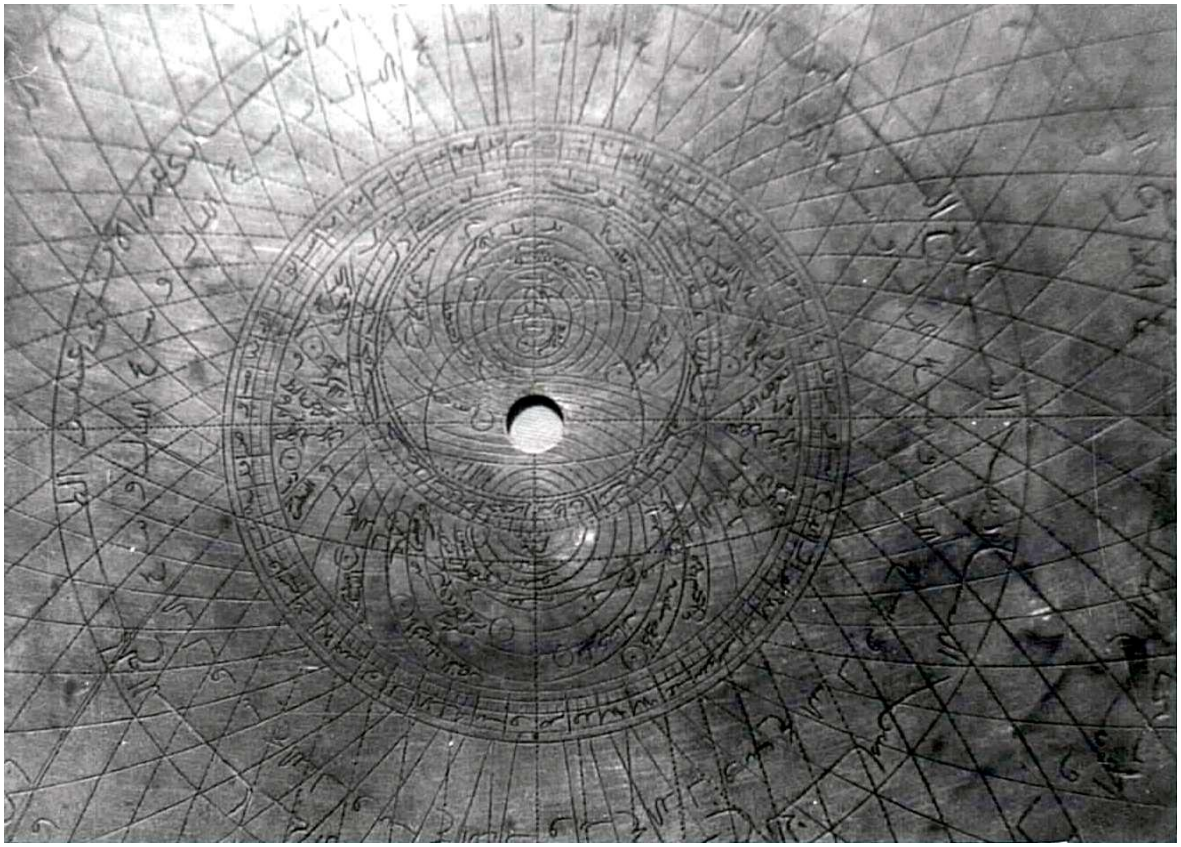


Figure A082.4 – Plate to be used with *zawraqī* horizons, detail (photo by S. R. Sarma)

The rim of the Tropic of Cancer is divided in 360°; each 1° marked and groups of 5° numbered from 5 to 90 counterclockwise, separately for each quadrant. Inside this ring of Cancer a miniature tablet is drawn with smaller versions of the two oblique horizons to match those on the rete, and the corresponding altitude circles. Like the larger horizons drawn across the entire, the oblique horizons in the miniature plate also carry labels on both sides. A circle of ecliptic is drawn; it is divided into the 12 signs and labelled with their names. Several star positons are marked within the Tropic of Cancer with dots enclosed in circles along with their names.

At the bottom of the plate is a long inscription bearing the designation of this special plate: *ṣafīḥat maṭraḥ al-shuʿāʿ kahtrd* (?) *abī rayhān taswīyat al-buyūt khwānand,* (plate for finding the projection of the astrological rays according to (?) Abū Rayhān [al-Bīrūnī] [and] equalization of the astrological houses).

Geographical Gazetteer

On the inner surface of the mater is engraved a geographical gazetteer with the names, longitudes and latitudes of 128 localities, arranged according to climates in four concentric circles. In the fourth circle, after listing three places which lie beyond the

seventh climate, 15 more places are added without any superscript. These are mainly from the Indian subcontinent and should have been included in the third climate.

Table A082-3 Geographical Gazetteer

	Place Name ***asmā’ al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***	
	Outer Circle			
[-I] *az khaṭṭ istiwā’ tā iqlīm awwal* (from the equator up to the first climate)				
1	Sāḥil Baḥr Awqiyānūs	11;0	0;0	
2	Jazīra Qanabala	21;0	3;0	
3	Jamkūt	177;0	5;0	
4	Thala	180;0	5;0	
5	Kūkū	54;10	10;0	
6	ᶜAdan	76;0	11;0	
[I] *al-iqlīm al-awwal* (the first climate)				
7	Jabal	78;0	13;30	
8	Damār	77;15	13;30	
9	Bajja az Barbar	10;0	14;0	
10	Dabīl	74;20	14;10	
11	Ṣanᶜā’ Dar al-Mulk Yaman	77;30	14;30	
12	Janad	75;30	14;30	
13	Sawmnāt	107;0	17;0	Somnath
14	Jaytūn	104;0	17;15	
15	Pijāpūr	105;30	17;20	
16	Burhānpūr	103;0	20;30	
17	Dawlatābād	111;0	20;30	

	Place Name *asmā’ al-buldān*	L *al-ṭūl*	φ *al-ᶜarḍ*
[II] *al-iqlīm dūyam* (the second climate)			
18	Jadda	76;0	21;0
19	Ṭāᶜif	77;30	21;20
20	Makka Muᶜaẓẓam	77;10	21;40
21	Kanbāyat	109;20	22;20
22	Khybar	75;20	24;20
23	Madīnat Musharrafa	75;20	25;0
24	Hurmūz	92;0	25;0
25	Ajmīr	111;5	26;0
26	Kawalyār	114;0	26;29
27	Lahknawtī	114;33	26;30
28	Qannawj	115;50	26;35
29	Jawnpūr	119;6	26;36
30	Akbarābād Dār al-Khilāfat	114;0	26;43
31	Kūpāmāū	116;33	26;45
32	Kara wa Mānikpūr	118;10	26;49
33	Awadh	118;6	27;22
34	Badāwan	119;19	27;22
[III] *al-iqlīm siwum* (the third climate)			
35	Bakr	105;0	27;40
36	Kūlkanda	114;19	18;4
37	Kūl [wa] Jalālī	114;19	28;4

	Place Name ***asmā’ al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
38	Fīrūzābād	106;30	28;10
39	Sulṭānkūt	115;0	28;30
40	Shāhjahānābād Dār al-Mulk Hind	113;35	28;39
41	Baran	114;0	28;43
42	Pānīpatah	113;20	28;20
43	Shīrāz	88;0	29;36
44	Multān	107;35	29;40
45	Hānsī	112;25	29;55
46	Baṣra	84;0	30;0
47	Kirmān	91;30	30;5
	Second Circle		
tatimma al-iqlīm siwum (continuation of the third climate)			
48	Tānīsar	112;33	30;10
49	Iskandariyya	61;54	30;18
50	Miṣr	63;20	30;20
51	Sanām	112;25	30;30
52	Purshawar	105;55	34;0
53	Kūfa	79;30	31;30
54	Bayt al-Maqdis	66;30	31;50
55	Lāhūr Dār al-Saltanat	109;20	31;50
56	Yazd	89;0	32;0
57	Iṣfahān	87;40	32;25

	Place Name ***asmā’ al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
58	Qandahār	107;40	33;0
59	Siyālkūt	109;0	33;0
60	Madā’īn	72;0	33;0
61	Dimashq	70;0	33;15
62	Maymand	101;55	33;20
63	Baghdād	82;0 !	33;25
[IV] *al-iqlīm chahārum* (the fourth climate)			
65	Ṭarābulūs	69;40	34;0
65	ᶜĀna	76;0	34;0
66	Kāshān	86;0	34;0
67	Mawṣil	77;0	34;30
68	Tūn	92;30	34;30
69	Harāt	94;30	34;30
70	Kābul	104;40	34;30
71	Qumm	85;40	34;45
72	Rayy	86;20	35;20
73	Sāwa	85;0	35;0
74	Kashmīr	108;0	35;0
75	Hamadān	83;0	35;10
76	Ḥalab	72;10	35;50
77	Mashhad Maqdis	92;30	36;0
78	Sabzwār	91;30	36;5
79	Bisṭām	89;30	36;10
80	Balkh	101;0	36;41

	Place Name ***asmā’ al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***	
81	Ṭāliqān	85;45	36;10	
82	Qazwīn	85;0	35;55	
	Third Circle			
tatimma al-iqlīm chahārum (continuation of the fourth climate)				
83	Badakhshān	84;24	37;10	
84	Sarakhs	94;30	37;30	
85	Marw	97;0	37;40	
86	Tabrīz	82;0	38;0	
87	Ardabīl	80;0	38;0	
88	Nakhjawān	81;15	38;40	
[V] *al-iqlīm panjum* (the fifth climate)				
89	Samarqand	99;56	39;37	
90	Bukhārā	97;30	39;50	
91	Tubbat	110;0	40;0	
92	Bardᶜa	83;0	40;30	
93	Samākhī	84;30	40;50	
94	Qūnya	66;30	41;0	
95	Khujand	85;35	41;55	
96	Khutan	107;0	42;0	
97	Kāshān	101;35	42;0	correct Kāsān
98	Farghāna	102;0	42;20	
[VI] *al-iqlīm shashum* (the sixth climate)				
99	Kāshghar	106;30	44;0	
100	Bandqīya	92;0	44;0	

	Place Name ***asmā’ al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
101	Shalkh	85;30	44;0
102	Ṭarāz	99;50	44;31
103	Pashīn Bāligh	111;0	44;50
104	Qarāqūrūm	115;0	46;0
105	Khān Bāligh	124;0	46;0
106	Harqala	67;20	46;30
[VII] *al-iqlīm haftum* (the seventh climate)			
107	Araq	105;0	48;0
108	Bulghār	90;0	49;30
109	Aqjā-kirmān	62;0	50;0
	Fourth Circle		
tatimma iqlīm haftum (continuation of the seventh climate)			
110	Qirqir	65;15	50;0
[VII+] *khāriz al-iqlīm haftum* (beyond the seventh climate)			
111	Jazā’ir Rūdjard	68;50	62;0
112	Mari Kirmān	65;45	50;45
113	Ṣūdaq	66;0	51;0
[Addition without any superscript]			
114	Munkīr	121;45	26;40
115	Ilāhābād	115;35	26;50
116	Sūrat	110;50	20;15
117	Bahraich	117;30	28;0
118	Gūrakhpūr	119;10	27;20
119	Mandu	107;13	22;18

	Place Name ***asmā’ al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
120	Sarandīp	104;0	10;0
121	Bānāras	117;20	26;52
122	Daybal	102;30	25;10
123	Dhākā Bankālā	130;0	27;0
124	Sonār Kāmv	131;0	26;0
125	Bharūj	111;5	21;20
126	Sirhind	111;38	30;30
127	Patnah	120;45	26;40
128	Rūhtas	119;45	26;40

BACK

The rim of the upper half carries altitude scales which are divided in 1° and 5° and labelled as 5—90; 90—5.

The upper left quadrant is engraved with 60 horizontal and 60 vertical parallels of which each fifth is highlighted with dots. These are numbered from 5 to 60 along the two radii.

In the upper right is the solar quadrant with 30 arcs of declination; the names of the corresponding zodiac signs are inscribed along the two radii, together with the numerical values of the subdivisions, viz., 6, 12, 18, 24, 30, separately for each sign. Upon this quadrant are also drawn three sigmoid graphs showing the sun’s meridian altitude in all seasons at the three latitudes of 27°, 29° and 32°. Along the graphs are inscribed the legends, *khaṭṭ niṣf al-nahār bi-ᶜarḍ 27; khaṭṭ niṣf al-nahār bi-ᶜarḍ 29; khaṭṭ niṣf al-nahār bi-ᶜarḍ 32.*

In the lower half are engraved the shadow squares, on the left for a base of 12 and on the right for a base of 7. The vertical and horizontal scales on both sides are divided and numbered accordingly and are endowed with the following labels:

Vertical scale on the left: *ẓill sullam aṣābiᶜ maᶜkūs*

Horizontal scale on the left: *ẓill sullam aṣābiʿ mustawī*

Horizontal scale on the right: *ẓill sullam aqdām mustawī*

Vertical scale on the right: *ẓill sullam aqdām maʿkūs.*

Inside the shadow squares are engraved two rectangular tables. On the left is the table entitled *jadwal faḍl al-dawr* (excess of revolution) and on the right is the table of triplicities and their nocturnal and diurnal regents (*arbāb muthallathāth laylī wa nahārī*).



Figure A082.5 – Back of the Astrolabe (photo by S. R. Sarma)

The rim of the lower half is engraved with cotangent tables, on the left in digits and on the right in feet. These are followed by 6 semi-circular rows containing the names of the 12 zodiac signs and the names of the 28 corresponding lunar mansions; the table of the limits of the signs and the table of the decan or faces and their regents.

ALIDADE

The alidade is plain without any graduations and has the pin affixed firmly to it. Clearly it is a late replacement.

INSCRIPTION

Immediately below the horizontal diameter is inscribed the astrolabe maker’s signature.

> *ᶜamal aqall al-ᶜibād ḍiyā’ al-dīn muḥammad ibn qā’im muḥammad ibn mullā ᶜīsā ibn shaykh allāhdād asṭurlābī humāyūnī lāhūrī fī 1074 hijrī.*
>
> ‘The work of the least of the servants [of God], Ḍiyā’ al-Dīn Muḥammad, son of Qā’im Muḥammad, son of Mullā ᶜĪsā, son of Shaykh Allāhdād of Lahore, astrolabe maker to [the Emperor] Humāyūn.’

BIBLIOGRAPHY

Nadvi 1935

Frank 1920

Sarma 1999c

A083 ASTROLABE BY ḌIYĀ AL-DĪN MUḤAMMAD, 1074 AH (AD 1663-64)

Diameter 52 mm

PLU, ex-London, Sotheby's (catalogue 27 April 2005, lot 47, pp. 68-69).



Figure A083.1 – Astrolabe mater with an endless knot and a pouch (© Sotheby's, London)

With a diameter of just 52 mm, this is probably the smallest astrolabe made by Ḍiyā' al-Dīn; his uncle Muḥammad Muqīm made a still smaller astrolabe with a diameter of 45 mm (A050). While all the parts of Muqīm's astrolabe are extant, only the mater survives in the present astrolabe. To the suspensory ring are attached an endless knot and a pouch in red cotton.

The suspensory ring is plain, while the shackle has a trifoliate shape and rather long bases. The *kursī* is quite high and solid. The profiles are made up of a lobe with an ogee below and another above, and topped by a trifoliate finial. On the front of the throne are engraved in a cartouche the words from the Throne Verse of the Qur'ān: '[God's] throne extends over and encompasses the Heavens and Earth.' The back of the throne is decorated with an ornate design.

The limb is divided in 1° and 6° and labelled from 6 to 90 separately for each quadrant thus: 6—90; 6—90; 6—90; 6—90.



Figure A083.2 – Geographical Gazetteer (detail of Fig. 83.1)

GEOGRAPHICAL GAZETTEER

On the inner surface of the mater is engraved a geographical gazetteer with the longitudes and latitudes of 15 places.[431] From the photo in the catalogue, the following place names and longitudes can be deciphered; the latitudes are too faint to read.

Table A083-1 Geographical Gazetteer

	Place name	L
5	Yazd	89;0
6	Iṣfahān	86;40
7	Ṭūs	94;30
8	Balkh	101;0
9		
10	Kābul	104;40
11	Kashmīr	
12	Lāhūr	

BACK

Probably the rim of the upper two quadrants carries an altitude scale which is divided in 1° and 6° as in the front and labelled as 6—90; 90—6.

The upper left quadrant has horizontal parallels. According to the catalogue, the solar quadrant on the right has two graphs showing the midday solar altitude at the latitudes of 28° and 32°. The second is the latitude of Lahore, the first is problematic; for Delhi one would expect a graph at 29° and for Agra 27°.

In the lower half are said to be ‘shadow squares and circumferential scales for determining the shadows for bases 12 (left) and 7 (right).’

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[431] The catalogue states wrongly that there are 17 localities.

INSCRIPTIONS

Inside the shadow squares is the signature of the astrolabe maker:

> *ᶜamal ḍiyā' al-dīn muḥammad ibn qā'im muḥammad ibn mullā ᶜīsā ibn shaykh allāhdād asṭurlābī humāyūnī lāhūrī fī sanah 1074 hijrī.*
>
> 'The work of Ḍiyā' al-Dīn Muḥammad, son of Qā'im Muḥammad, son of Mullā ᶜĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the year 1074 Hijrī.'

The year translates to AD 1663-64. On the edge of the astrolabe is inscribed a prayer asking God to bless 'the fourteen innocents'.

A084⊙ ASTROLABE BY ḌIYĀ’ AL-DĪN MUḤAMMAD, 1074 AH (AD 1663-64)

Diameter 130 mm

Rampur, Rampur Raza Library (#1345 D)

CCA 2511; Répertoire 30



Figure A084.1 – Front of the astrolabe (photo courtesy Rampur Raza Library)

This elegant and handy astrolabe appears to have been actually employed for observation or teaching, which is evident from the signs of wear and tear, especially on the back. Some of the original parts were lost in course of time and were replaced by substitutes. The ring, the bolt and the winged nut are replacements. A sighting tube was added at a later stage to the original alidade. It is now damaged in the middle and is not functional. Otherwise, the astrolabe is in a good state of preservation. Indeed, some of the plates and the inner side of the mater are in mint condition and shine as if these were gilded. [432]

COMPONENTS

Mater with *kursī* (d. 130, h. 168, t. 8), shackle, rete (d. 115) for 42 stars, 5 plates (d. 116), alidade (120 x 20). The ring, pin and bolt are not original, so also the sighting tube.

FRONT

The *kursī* is highly ornate. Several perforations are cut through the surface of the *kursī,* producing a pattern of intertwined vines and tulip-like flowers with flared ends of the petals. The upper surface is further embellished on both sides by finely engraved patterns. The sides of the *kursī* contain four tiers of gradually diminishing lobes. At the top the *kursī* terminates in a trifoliate finial with a hole in the middle. A shackle, also of trifoliate shape, is attached to the *kursī* by means of a pin at this hole. A small ring passes through this shackle.

The limb carries a degree scale divided in 1° and 5° and labelled from 5 to 360.

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[432] This is an abridged and revised version of the description in Sarma 2003, pp. 34-52.



Figure A084.2 – Rete of the Astrolabe (photo courtesy Rampur Raza Library)

RETE

The rete has a higher copper content and is darker in colour than the plates.[433] The Tropic of Capricorn and the ecliptic are held together by the complete equinoctial bar with three counter changes at its two intersections with the ecliptic circle and at the centre. Originally there must have been a handle at the north-west point but it is now missing, leaving just a hole there.

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433 This is a common feature in the Mughal astrolabes, especially in those of small size. High copper content probably makes the plate stronger so that it can be reticulated easily.

The ecliptic is divided into the twelve signs of the zodiac and labelled with their names. Each sign is further subdivided into groups of 6° and marked as 6, 12, …, 30. The outer rim of the ecliptic contains a scale of single degrees. 42 star names can be deciphered on the rete.

Table A084-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab Qayṭus [Janūbī]*	β Ceti
2	*Baṭn Ḥūt*	β Andromedae
3	*Riǰl Musalsala*	γ Andromedae
4	*Fam al-Qayṭus*	γ Ceti
5	*Ṣadr al-Qayṭus*	π Ceti
6	*Rās al-Ghūl*	β Persei
7	*Tālī Masāfat al-Nahr*	ε Eridani
8	*ᶜAyn al-Thawr*	α Tauri
9	*ᶜAyyūq*	α Aurigae
10	*Riǰl al-Jawzā’ Yusrā*	β Orionis
11	*Yad al-Jawzā’ Yumnā*	α Orionis
12	*Riǰl al-Jawxā’ Yumnā*	κ Orionis
13	*Shiᶜrā Yamānī*	α Canis Majoris
14	*Shiᶜrā Shāmī*	α Canis Minoris
15	*Fard al-Shujāᶜ*	α Hydrae
16	*Qalb al-Asad*	α Leonis
17	*Rās al-Asad*	μ Leonis
18	*Dubb al-Akbar*	α Ursae Majoris
19	*Qāᶜidat al-Bāṭiya*	α Crateris
20	*Ẓahr al-Asad*	δ Leonis

	Star Name	Identification
21	*Al-Ṣarfa*	β Leonis
22	*Janāḥ al-Ghurāb*	γ Corvi
23	*Simāk A ᶜzal*	α Virginis
24	*Simāk Rāmiḥ*	α Bootis
25	*Kiffa Janūbī*	α Librae
26	*ᶜUnuq al-Ḥayyah*	α Serpentis
27	*Rukbat al-Ḥawwā*	μ Ophiuchi
28	*Qalb al-ᶜAqrab*	α Scorpii
29	*Rās al-Jāthī*	α Herculis
30	*Rās al-Ḥawwā*	α Ophiuchi
31	*Yad al-Ḥawwā*	δ Ophiuchi
32	*Nasr Wāqiᶜ*	α Lyrae
33	*Minqār al-Dajājah*	β Cygni
34	*Nasr Ṭā’ir*	α Aquilae
35	*Dhanab al-Dulfīn*	ε Delphini
36	*Dhanab al-Dajājah*	α Cygni
37	*Fam al-Faras*	ε Pegasi
38	*Dhanab al-Jadī*	δ Capricorni
39	*Sāq Sākib al-Mā’*	δ Aquarii
40	*Dhanab al-Qayṭus Sh[amālī]*	ι Ceti
41	*Mankib al-Faras*	β Pegasi
42	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are five plates, each with a diameter of 116 mm. Four of these serve eight different latitudes; the fifth plate is engraved with ecliptic co-ordinates on the obverse and with multiple horizons on the reverse.

Table A084-2

	φ	Longest day
1a	18°	13; 9 hours
1b	22°	13;21 hours
2a	25°	13;35 hours
2b	27°	13;43 hours
3a	29°	13;52 hours
3b	32°	14; 8 hours
4a	34°	14;20 hours
4b	36°	14;32 hours
5a	Plate of ecliptic coordinates	
5b	Plate of horizons	

On plates 1-4, equal altitude circles are drawn for each 2° and every fifth circle is highlighted with dots. Azimuth arcs are drawn for each 6° below the horizon and every fifth is highlighted by dots. Lines of seasonal hours are drawn on all plates. In addition, on the plates for 18°, 22°, 25°, lines of equal hours as counted from the western and eastern horizons are drawn, and on the remaining plates, lines of equal hours as counted from the western horizon.

On the plate of ecliptic coordinates, the circles of celestial latitudes are drawn at intervals of 6° inside the ecliptic and are marked from the ecliptic to the zenith as 6, 12, … 90. Outside the ecliptic they are drawn for every three degrees and numbered from from the ecliptic to the Tropic of Capricorn from 3 to 48. The arcs of the celestial longitudes are drawn at intervals of 6°. The ecliptic circles and the circles of longitude

at the beginning of each zodiac sign are shown in dotted lines. There is a label *ṣafīḥat mīzān al-ʿankabūt*.

On the reverse side of the above plate is a of multiple horizons, called *ṣafīḥa āfāqī* and this designation is engraved in the lower right quadrant. In each quadrant, half-horizons for ten different latitudes are drawn and labelled where each horizon begins near the circumference and where it ends near the diameter.

These four sets of latitudes are as follows:

6	12	18	24	30	36	42	48	54	60	66;30
7	13	19	25	31	37	43	49	55	61	
8	14	20	26	32	38	44	50	56	62	
9	15	21	27	33	39	45	51	57	63	

Again, in all the four quadrants, declination scales are engraved along the four radii with the values 6, 12, 18, 23;30, the last being the total or maximum obliquity (*al-mayl al-kullī*).

Geographical Gazetteer

On the inner side of the mater is engraved a geographical gazetteer in three annular rings, providing the names, longitudes and latitudes of 77 localities. The data is engraved upside-down.



Figure A084.3 – Geographical Gazetteer (photo courtesy Rampur Raza Library)

Table A084-3 Geographical Gazetteer

	Place Name ***asmā’ al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
	Outer Circle		
1	Makka Muᶜaẓẓam	77;10	21;40
2	Madīnat Musharrafa	75;20	25;0
3	Mahdiyya Maghrib	42;0	32;30
4	Iskandariyya	61;54	30;18

	Place Name ***asmā’ al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
5	Miṣr	63;20	30;20
6	Ṣanᶜā’ Dār al-Mulk Yaman	77;0	15;30
7	Dimashq	70;0	33;45
8	Ḥalab	72;10	35;50
9	Al-Rūm	77;0	39;40
10	Jarrān al-Jazīra	73;0	36;40
11	Mawṣil	77;0	34;30
12	Amid	73;40	33;0
13	Marāgha	82;0	36;20
14	Tabrīz	82;0	38;0
15	Ardabīl	82;30	38;0
16	Bardaᶜa	83;0	40;30
17	Bāb al-Abwāb	85;0	43;0
18	Bulghār	90;0	49;30
19	Kūfa	79;30	31;30
20	Madā’in	72;0	33;10
21	Baghdād	80;30	33;25
22	Wāsiṭ	81;30	32;20
23	Baṣrah	84;0	30;0
24	Kāzirūn?	87;0	39;35 !
25	Shīrāz	88;0	29;36
26	Iṣṭakhr	88;30	30;0
27	Yazd	89;0	32;30

	Place Name ***asmā’ al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
28	Shahrūd	82;20	32;30
29	Hamadān	83;0	35;10
30	Karkh	84;45	34;0
31	Qazwīn	85;0	36;55
32	Iṣfahān	86;40	32;25
33	Rayy	85;40	34;45
34	Qum	86;20	35;0
35	Hausam az Jīlān	85;10	37;0
	Middle Circle		
36	Sabzawār	91;30	36;5
37	Nīshābūr	92;30	36;21
38	Ṭūs	94;30	37;0
39	Tūn	92;30	32;30
40	Harāt	94;33	34;30
41	Sarkhas	94;30	32;0
42	Marw	97;0	34;40
43	Balkh	101;0	36;41
44	Badakhshān	84;24	37;10
45	Bukhārā	97;30	39;50
46	Samarqand	99;56	39;37
47	Khujand	85;30	41;55
48	Kāshghar	106;30	44;0
49	Hurmūz	92;0	25;0
50	Aḥmadābād	108;40	23;55

	Place Name ***asmā’ al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
51	Ujjayn	112;0	22;30
52	Kābul	104;40	34;30
53	Mewāt	107;10	32;50
54	Badā’ūn	114;59	27;32
55	Hānsī	102;25	29;15
56	Samāna (?)	110;30	28;30
57	Tānīsar	112;43	30;10
58	Pānīpatah	113;20	28;52
59	Sunām	110;25	30;30
60	Akbarābād	114;0	26;43
61	Shāhjahānābād	113;35	28;39
62	Ajmīr	111;5	24;0
	Inner Circle		
63	Bījāpūr	105;30	17;20
64	Burhānpūr	103;0	20;30
65	Dawlatābād	111;0	20;30
66	Bayt al-Maqdis	66;30	31;50
67	Lāhūr	109;20	31;50
68	Multān	107;35	29;40
69	Qandahār	107;40	33;0
70	Kalkanda	114;39	18;10
71	Dhākā Bankālā	130;0	27;0
72	Sarandīb	104;0	10;0
73	Kashmīr	108;0	35;0

	Place Name ***asmā’ al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
74	Kawāliār	115;0	26;29
75	Bānāras	117;20	26;52
76	Sirhind	111;33	30;30
77	Patna	120;45	26;40

BACK

On the back, the rim of the two upper quadrants carries the altitude scales divided in 1° and 5° and labelled as 5—90; 90—5. In the upper left quadrant are drawn 60 horizontal parallels with every fifth highlighted with dots. These are numbered from 5 to 60 along the vertical radius, starting from the centre.

In the upper right quadrant are drawn declination arcs, one for each 10° of solar longitude, with every third arc highlighted with dots. The names of the corresponding zodiac signs, together with their divisions of 10°, 20° and 30°, are engraved along the two radii. Upon these arcs are superimposed three sigmoid curves which show the sun’s meridian altitude throughout the year at the three terrestrial latitudes of 27°, 29° and 32° with the labels *khaṭṭ niṣf al-nahār bi-ᶜarḍ 27, … 29, … 32.*



Figure A084.4 – Back of the Astrolabe (photo courtesy Rampur Raza Library)

In the lower half, below the horizontal diameter, are engraved the shadow squares, on the left for a base of 12 and on the right for a base of 7. The vertical and horizontal

scales are divided and numbered accordingly. The vertical scale on the left is labelled as *ẓill sullam aṣābiᶜ maᶜkūs* (the scale of reverse shadows in digits) and the horizontal scale as *ẓill sullam aṣābi ᶜ mustawī* (the scale of direct shadows in digits). Likewise the vertical scale on the right is labelled as *ẓill sullam aqdām maᶜkūs*, (the scale of the reverse shadows in feet) and the horizontal scale is designated as *ẓilli sullam aqdām mustawī* (the scale of the direct shadows in feet).

Inside the shadow squares is the table designated as *jadwal faḍl al-dawr* (table of excess of revolution) showing the multiples of the difference (in minutes and seconds) between the approximately correct length of the tropical year and 365 days.

The space between these shadow squares and the outer periphery is divided into eight semi-circular rows. The outermost row situated on the rim contains cotangent scales: on the left in digits and on the right in feet. In the scale to the left, there are unequal divisions which are labelled (starting from the centre and proceeding leftwards) as 1, 2, 3, … 12 / 13, 14, 16, 18, 21, 24, 30, 36, 42, 48, 54, 60, followed by the label *zilli aṣābiᶜ mabsūṭ*. The unequal divisions on the right are numbered from the centre to the right, as 1, 2, 3, … 7 / 8, 9, 10, 11, 12, 14, 16, 18, 21, 30, 40, 50, 60, followed by the label *zill aqdām mabsūṭ*. The next semi-circular row displays subdivisions of certain divisions in the previous scale, especially, those in the latter half.

The cotangent scales are followed by two rows carrying the names of the 12 zodiac signs and 28 lunar mansions respectively. The two rows that follow contain a table of the limits (*ḥudūd*) and the last two rows the decans and their regents.

Alidade

The alidade has two ornate ends and an ornate centre-piece. Two sighting plates are attached perpendicularly to the surface of the alidade. These plates contain two holes each. The smaller hole is for sighting in the daytime and the larger one for observing the stars at night. Into the larger hole a sighting tube was inserted at a later time. The metal content in the tube is quite different from that in the alidade, which is evident from the difference in the colour. The tube is slightly broken in the middle and cannot be used any more for observation.

The upper edge of the alidade is bevelled. The right half is divided into 60 divisions and each fifth is numbered. These divisions match exactly with the 60 divisions on the vertical radius of the upper-left quadrant. In the lower half are marked unequal divisions

numbered from the sighting plate towards the centre from 1 to 6 and in the reversed direction from 7 to 12. These are markings to be used when the alidade is employed as a sundial. The shadows thrown by the sighting plate on the length of the alidade are measured in seasonal hours by these units in the forenoon or afternoon as the case may be.

The upper edge of the left half is divided into six parts, which are further subdivided into three parts each. These six main divisions are further extended as arcs upon the surface of the alidade. On these arcs are engraved the names of a pair of zodiac signs one below the other: *al-jawjā’ / al-saraṭan; al-thawr / al-asad* and so on. These arcs match exactly with the arcs on the upper right quadrant and the names of the signs are the same as those engraved in the quadrant.

Inscription

The maker’s signature is engraved on either side of the central hole just below the east-west line. Because the alidade rotated tightly around the hole, certain letters close to the hole are rubbed off and cannot be read now. However, since the inscription is composed in a formula-like style and occurs in the same wording in all the astrolabes and celestial globes crafted by Ḍiyā’ al-Dīn, the missing letters can be inferred. The letters containing the name of the maker and the date are intact. Thus the inscription reads as follows:

> *ᶜamal aqall al-ᶜibād ḍiyā’ al-dīn muḥammad ibn qā’im muḥammad ibn mullā ᶜīsā ibn shaykh allāhdād *** fī sanah 1074 hijrī.*
>
> ‘The work of the least of the servants [of God], Ḍiyā’ al-Dīn Muḥammad, son of Qā’im Muḥammad, son of Mullā ᶜĪsa, son of Shaykh Allāhdād *** in the year 1074 Hijrī.’ The year translates to AD 1663-64.

Bibliography

Dube 1928

Gunther 1932, no. 78a, II, p. 228

Nadvi 1935

Sarma 2003, pp. 34-52.

A085⊙ ASTROLABE BY ḌIYĀ AL-DĪN MUḤAMMAD, 1074 AH (AD 1663-64)

Diameter 113 mm

London, Victoria and Albert Museum (#419-1876) [434]

CCA 1060; Répertoire 31

COMPONENTS

Body with *kursī* (d. 113, h. 147, t. 6.5), shackle, ring and cord, rete for 45 stars, 5 plates, alidade and pin. The horse is missing.

FRONT

A large brown cord, probably modern, is tied to the ring. The shackle, somewhat larger, is of trefoil shape. The *kursī* displays close similarity to that of Ḍiyā' al-Dīn's earlier astrolabe of 1653 (A071) with a pleasing fretwork of intertwining vines and a three-petalled flower in the middle. The profiles are made up of a lobe between two ogees, topped by the trifoliate finial. Ornate engravings on the surface of the front and back. The limb is graduated in 1° and 5° and labelled from 5 to 360.

RETE

The Capricorn and ecliptic rings are held together by the equinoctial bar which has a counter change at the centre. The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names; each sign is divided into groups of 6° and these are numbered from 6 to 30; they are further subdivided to 3°. There is a handle on the outer ring, midway between the north and west points. The star pointers are joined by almost symmetrical floral tracery inside the ecliptic circle and outside of it.

PLATES

There are five plates with the following specifications.

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[434] Victoria and Albert Museum wrote to me to say that they do not permit publication of private photography of their objects. Therefore, this entry is regretfully without my photos.

Table A085-1 Plates

	φ	Longest day
1a	22°	13;22 hours
1b	25°	13;25 hours
2a	27°	13;43 hours
2b	29°	13;52 hours
3a	32°	14;8 hours
3b	34°	14;20 hours
4a	36°	14;32 hours
4b	40°	14;52 hours
5a	Plate of ecliptic coordinates	
5b	Plate of horizons	

Plate 1 is heavier than the rest of the plates. Plate 5 does not fit well into the recess; it appears to be a late replacement. Altitude circles for every 3°, each fifth is dotted; azimuth arcs for every 10° below the horizon; lines of seasonal hours and lines of equal hours.

GEOGRAPHICAL GAZETTEER

The geographical gazetteer is inscribed in two circles in zigzag fashion with the names, longitudes and latitudes of 58 localities.

BACK

The rim of the two upper quadrants carries altitude scales graduated in 1° and 5° and labelled as 5—90; 90—5.

In the upper left quadrant are drawn 30 horizontal lines, with each third dotted. These are numbered along the vertical radius as 6, 12, … 60.

In the upper right quadrant are drawn 18 equally spaced declination arcs. The names of the corresponding signs and degrees of the decans are written along the two

radii. On this grid are plotted two graphs of solar meridian altitude for the latitudes of 27° and 32° with the usual labels.

In the lower half are drawn two shadow squares, on the left for a base of 12 and on the right for a base of 7. The shadow squares are enclosed in eight concentric semi-circular scales containing the cotangent scales, the names of the 12 zodiac signs and the 28 corresponding lunar mansions, limits of the signs, decans and their regents.

Alidade

The alidade has ornate ends and an ornate centre-piece. The right arm is engraved with a sexagesimal scale in the upper register and with a scale of seasonal hours in the lower register, while the arm on the left carries a zodiac scale with the names of signs engraved in pairs in each division of the scale.

Inscription

The astrolabe maker's signature is inscribed inside the shadow squares:

ᶜamal aqall al-ᶜibād ḍiyā' al-dīn
muḥammad ibn qā'im muḥammad ibn mullā ᶜīsā ibn
shaykh allāhdād asṭurlābī humāyūnī
lāhūrī fī sanah 1074 hijrī.

'The work of the least of the servants [of God], Ḍiyā' al-Dīn Muḥammad, son of Qā'im Muḥammad, son of Mullā ᶜĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the year 1074 Hijrī.'

The Hijrī year corresponds to AD 1663-64.

Bibliography

Nadvi 1935.

A086 ASTROLABE BY ḌIYĀ’ AL-DĪN MUḤAMMAD, 1074 AH (AD 1663-64)

Diameter 101mm

Mosul, al-Basha Mosque

Répertoire 32 lists this astrolabe with the following particulars. It is not known whether this astrolabe exists still in Mosul. No images are available.

BACK

A sine graph in the upper left quadrant and, in the upper right quadrant, declination arcs with the curves showing the midday altitude of the sun at the latitudes 27° and 32°.

INSCRIPTION

ᶜamal ḍiyā’ al-dīn muḥammad ibn qā’im muḥammad ibn mullā ᶜīsā ibn shaykh allāhdād asṭurlābī humāyūnī lāhūrī fī sanah 1074 hijrī

‘The work of Ḍiyā’ al-Dīn Muḥammad, son of Qā’im Muḥammad, son of Mullā ᶜĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the year 1074 Hijrī.’

A087 ASTROLABE BY ḌIYĀ AL-DĪN MUḤAMMAD, 1074 AH (AD 1663-64)

Diameter ?

PLU, ex. Aligarh, Maulana Abu Bakar

CCA 1116; Répertiore 33

In his pioneering survey of the Lahore family of astrolabe makers, Nadvi 1935, p. 629, states that an astrolabe by Ḍiyā' al-Dīn Muḥammad was

'with Maulâna Abu Bakar of Jaunpur (Chairman of Theology, Muslim University, Aligarh). It is comparatively smaller and bears the following legend:-

ᶜamal aqall al-ᶜibād ḍiyā' al-dīn muḥammad ibn qā'im muḥammad ibn mullā ᶜīsā ibn shaykh allāhdād asṭurlābī humāyūnī lahūrī fī sanah 1074 h

(The work of the humblest creature Zîa'u'd-dîn Muḥammad, son of Qâim Muḥammad, son of Mullâ 'Isâ, son of Sheykh Allâh-Dâd, Astrolâbî , Humâyûnî, Lahôrî, dated 1074 A.H.)'

During my long stay at Aligarh Muslim University, I could not locate any descendants of Maulana Abu Bakar, nor find any trace of the astrolabe. Nadvi says that the astrolabe was 'comparatively smaller'. The smallest astrolabe made by Ḍiyā al-Dīn measured 52 mm in diameter and it was made in the same year ah 1074. It came up for auction at Sotheby's on 27 April 2005 (A083). It is difficult to say whether it is the same astrolabe which was in the collection of Maulana Abu Bakar in 1935 at Aligarh.

A088 ASTROLABE BY ḌIYĀ’ AL-DĪN MUḤAMMAD, 1077 AH (AD 1666-67)

Diameter 190 mm

Srinagar, Sir Pratap Singh Museum



Figure A088.1 – Front of the astrolabe (photo by Nazir Ahmad Doshab)

Components

Body with *kursī* (d. 190), shackle and ring, rete for 51 stars, 10 plates, alidade, pin, washer; wedge appears to be missing.

Front

The ring is plain; the shackle has a trifoliate shape and trifoliate bases. The *kursī* is worked *à jour* with the motif of a three-petalled flower at the centre. Its surface is embellished by engravings. As in other astrolabes by him, the profiles of the *kursī* are made up of ogees at the base and at the top with a lobe in between. Here the ogees and the lobe contain still smaller lobes. The finial is trifoliate.

The circular scale on the limb is divided in 0;30°, 1° and 6° and numbered from 6° to 360°.

Rete

The rete consists of the incomplete ring of the Tropic of Capricorn and the full ring of the ecliptic, both held together by equinoctial bar which is counterchanged at the two intersections with the ecliptic. The space between the two rings and inside the ecliptic ring is filled with asymmetric floral tracery, with stylized tulips with flared petals. The ecliptic ring is broader than that of the Tropic of Capricorn; it is divided into the 12 signs and labelled with their names. Each sign is further subdivided into 6° and numbered as 6, 12, 18, 24, 30. The sloped edge of the ecliptic ring is graduated in single degrees. There are 51 named star pointers which are listed below.



Figure A088.2 – Rete of the Astrolabe (photo by Nazir Ahmad Doshab)

Table A088-1 Stars on the Rete

	Star Names	Identification
1	*Dhanab al-Qayṭus J[anūbī]*	β Ceti
2	*[Rijl al-] Musalsala*	γ Andromedae
3	*Fam al-Qayṭus*	γ Ceti
4	*Ṣadr al-Qayṭus*	π Ceti
5	*[Rās al-]Ghūl*	β Persei
6	*Mirfaq al-Thurayyā*	α Persei

	Star Names	Identification
7	*Kaff al-Jadhmā’*	α Ceti
8	*Tālī Masāfat al-Nahr*	γ Eridani
9	*ᶜAyn al-Thawr*	α Tauri
10	*ᶜAyyūq*	α Aurigae
11	*Rijl Jawzā’ Yusrā*	β Orionis
12	*Yad Jawzā’ Yusrā*	γ Orionis
13	*Yad Jawzā’ Yumnā*	α Orionis
14	*Rijl Jawzā’ Yumnā*	κ Orionis
15	*Shiᶜrā Yamānī*	α Canis Majoris
16	*Shiᶜrā Shamī*	α Canis Minoris
17	*Ṭarafat Safīna*	ρ Puppis
18	?	
19	*Mankhar al-Shujāᶜ*	σ Hydrae
20	*Fard al-Shujāᶜ*	α Hydrae
21	*Qalb al-Asad*	α Leonis
22	*Qāᶜidat al-Bāṭiya*	α Crateris
23	*Ẓahr al-Asad*	δ Leonis
24	?	
25	*Anwar al-Farqadayn*	β Ursae Minoris
26	*Al-ᶜAnāq*	ζ Ursae Majoris
27	*Janāḥ al-Ghurāb*	γ Corvi
28	*Simāk Aᶜzal*	α Virginis
29	*Simāk Rāmiḥ*	α Bootis
30	*Nayyir Fakkah*	α Coronae Borealis

	Star Names	Identification
31	*ᶜUnuq al-Ḥayyah*	α Serpentis
32	*[Qalb] al-ᶜAqrab*	α Scorpii
33	?	
34	*Rās al-Jāthī*	α Herculis
35	*Rās al-Ḥawwā*	α Ophiuchi
36	*ᶜAyn al-Tinnīn*	γ Draconis
37	*Yad al-Ḥawwā al-Yumnā al-Muqaddam*	δ Ophiuchi
38	*Nasr Wāqīᶜ*	α Lyrae
39	*Minqār al-Dajājah*	β Cygni
40	*Nasr Ṭā’ir*	α Aquilae
41	*Dhanab al-Dulfīn*	ε Delphini
42	*Dhanab al-Dajājah*	α Cygni
43	*Fam al-Faras*	ε Pegasi
44	*Dhanab al-Jadī*	δ Capricorni
45	*[Rukbat?]Dhāt al-Kursī*	δ Cassiopeiae
46	*Sāq Sākib al-Mā’ J[anūbī]*	δ Aquarii
47	*Dhanab al-Qayṭus Sh[amālī]*	ι Ceti
48	*Mankib al-Faras*	β Pegasi
49	*Surrat al-Faras*	δ Pegasi
50	*Janāḥ al-Faras*	γ Pegasi
51	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are ten plates, perhaps the largest number in the Lahore astrolabes, serving the latitudes 11° to 45° at 2° intervals and the ecliptic coordinates and multiple horizons. There is no double projection, nor a plate calibrated for the latitude of Lahore at 32°.

Table A088-2 Plates

	φ	Longest day
1a	11°	12;40 hours
1b	13°	12;48 hours
2a	15°	13;0 hours
2b	17°	13;6 hours
3a	19°	13;12 hours
3b	21°	13;18 hours
4a	23°	13;25 hours
4b	25°	13;35 hours
5a	27°	13;43 hours
5b	29°	13;52 hours
6a	31°	14;2 hours
6b	33°	14;12 hours
7a	35°	14;23 hours
7b	37°	14;34 hours
8a	39°	14;45 hours
8b	41°	15;0 hours
9a	43°	15;14 hours
9b	45°	15;28 hours
10a	Plate of ecliptic coordinates	
10b	Plate of horizons	

φ	Longest day

The latitude plates (i.e., nos 1 to 9) are almost uniformly calibrated, except in the case of hour lines. On all plates, the south-north and east-west lines, the circles of equator and of the tropics, and the arc of the oblique horizon are drawn. There is a small square-shaped incision at the bottom of the meridian line, to keep the plate firmly inside the mater.

Above the oblique horizon altitude circles are drawn for each single degree; every sixth is highlighted with dots. The altitude circles are numbered on both sides. Azimuth arcs are drawn for every 6°, below the horizon and numbered; these numbers are in a straight line, below the horizon and a little above the lowermost point of the Tropic of Cancer. Every fifth line (i.e., 30°) is dotted and extended above the horizon.

Lines for unequal hours are drawn and numbered from 1 to 12, starting at the western horizon. On plate nos. 1 to 4, lines of equal hours counted from the western and eastern horizons (dotted) are drawn. These are numbered from 1 to 6, from the eastern horizon up to the meridian and again from 1 to 6, from the western horizon up to the meridian. On the other hand, on plates 5 to 9, equal hour lines are drawn from the western horizon and these are numbered from 1 to 12 from the western horizon.

On the plate of ecliptic coordinates are drawn the equator, the two tropics and the ecliptic. The ecliptic is marked with the names of the twelve zodiac signs. The arcs radiating from the centre are the lines of the celestial longitudes at intervals of 6°; these are numbered from 6 to 30, separately for each zodiac sign, along the ecliptic circle. The circles of celestial latitudes are drawn for each 1° and every sixth circle is dotted. Since the ecliptic circle is also the horizon at this terrestrial latitude of 66;30°, these circles of celestial latitudes are counted from the ecliptic both northwards up to the zenith and southwards up to the Tropic of Capricorn. In the present plate, the numbers of these lines are engraved six times: twice from the zenith towards the bottom of the plate (counting northwards from the ecliptic up to the zenith from 1 to 90 and southwards from the ecliptic up to the Tropic of Capricorn from 1 to 47), twice from the top of the plate where the equator touches the Tropic of Capricorn up to the zenith from 1 to 90, once in the east from the ecliptic from 1 to 24 eastwards and once in the

west from the ecliptic from 1 to 24 wastwards. A little above the north point is the *ṣafīhah mīzān al-ᶜankabūt.*



Figure A088.3 – Plate of ecliptic coordinates (photo by Nazir Ahmad Doshab)

The reverse side of plate 10 is fashioned as the plate of horizons with four sets of half-horizons for each degree of latitude from 1° to 90°. These half- horizons are distributed in the four quadrants thus:

1	5	9	…	85	89	90
2	6	10	…	86		90
3	7	11	…	87		90
4	8	12	…	88		90

The horizons are numbered at both ends. The scales of declination are marked along each of the radii between the equator and each of the tropics. These are divided

into 30 units and numbered as 6, 12, 18, 24, 30; the numbers starting from the equator and reaching to the tropics. Under each scale is the inscription *taqsīm mayl kullī shamālī* or *janūbī,* ‘division of the maximum declination north’ or ‘south’.

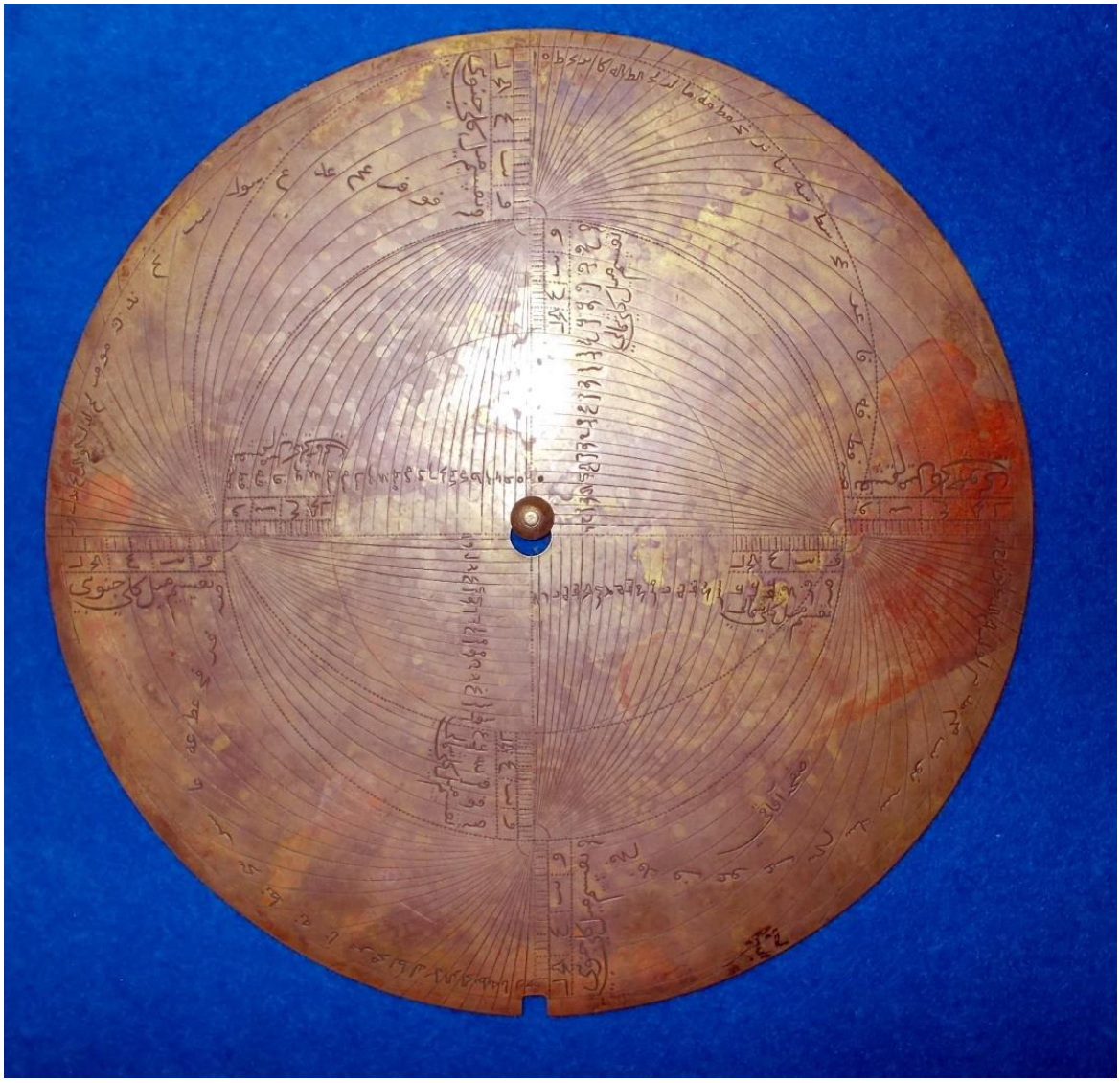


Figure A088.4 – Plate of horizons (photo by Nazir Ahmad Doshab)

On this small plate, these 90 arcs for each degree are very cleverly distributed in a pleasing symmetric manner so that they do not look cluttered. It requires a great skill on the part of the engraver to draw these 90 arcs here.

Geographical Gazetteer

On the inner side of the mater, the geographic gazetteer is engraved in four annular circles, carrying the names, longitudes and latitudes of 124 localities arranged according

to climates.[435] The circles are separated by double lines and a circle containing the names of relevant climates. The writing is upside-down, i.e., the tops of the letters are towards the centre of the plate.



Figure A088.5 – Geographical Gazetteer (photo by Nazir Ahmad Doshab)

Table A088-3 Geographical Gazetteer

	Place Name	L	φ
	First Circle		

435 This gazetteer is exactly the same as the gazetteer in the astrolabe made 30 years earlier by Muqīm (A024). At the end of the present gazetteer, Ḍiyā’ al-Dīn adds four names.

	Place Name	L	φ
[-I] *az khaṭṭ istiwā’ tā iqlīm awwal* (from the equator up to the first climate)			
1	Sāḥil Bahr Awqiyānūs	11;0	0;0
2	Jazīra Qanbala	21;0	3;0
3	Jamkūt	177;0	5;0
4	Thala	180;0	5;0
5	Kūkū	54;10	10;0
6	ᶜAdan	76;0	11;0
[I] *al-iqlīm al-awwal* (the first climate)			
7	Jabal	75;0	13;30
8	Dammār	77;15	13;30
9	Bajja az Barbar	10;0	14;0
10	Dabīl	74;20	14;10
11	Ṣanᶜā’ dar al-Mulk Yaman	77;30	14;30
12	Janad	75;30	14;30
13	Sawmnāt	107;0	17;0
14	Zatūn	114;0	17;15
15	Pijāpūr	105;30	17;20
16	Burhānpūr	103;0	20;30
17	Dawlatābād	111;0	20;30
[II] *al-iqlīm dūyum* (the second climate)			
18	Jadda	76;0	21;0
19	Ṭāᶜif	77;30	21;20
20	Makka Muᶜaẓẓam	77;10	21;40

	Place Name	L	φ
21	Kanbāyat	109;20	22;20
22	Khaybar	75;20	24;20
23	Madīnat Musharrafa	75;20	25;0
24	Hurmūz	92;0	25;0
25	Ajmīr	111;5	26;0
26	Kawaliyar	114;0	26;29
27	Lahknawtī	114;33	26;30
28	Qannawj	115;50	26;35
29	Jawnpūr	119;6	26;36
30	Akbarābād	114;0	26;43
31	Kūpāmāū	116;33	26;45
32	Kara wa Mānikpūr	118;10	26;49
33	Awadh	118;6	27;22
34	Badāwan	119;19	27;22
[III] *al-iqlīm siwum* (the third climate)			
35	Bakar	105;0	27;40
36	Kūlkanda	114;19	18;4
37	Kūl [wa] Jalālī	114;19	28;4
38	Fīrūzābād	106;30	28;10
39	Sulṭānkūt	115;0	28;30
40	Shāhjahānābād	113;35	28;39
41	Baran	114;0	28;43
42	Pānīpatah	113;20	28;20
43	Shīrāz	88;0	29;36

	Place Name	L	φ
44	Multān	107;35	29;40
45	Hānsī	112;25	29;55
46	Baṣra	84;0	30;0
47	Kirmān	91;30	30;5
	Second Circle		
[IV] *tatimma al-iqlīm siwum* (continuation of the third climate)			
48	Tānīsar	112;33	30;10
49	Iskandariyya	61;54	30;18
50	Miṣr	63;20	30;20
51	Sunām	112;25	30;30
52	Parshūr	105;55	31;0[436]
53	Kūfa	79;30	31;30
54	Bayt al-Maqdis	66;30	31;50
55	Lāhūr	109;20	31;50
56	Yazd	89;0	32;0
57	Iṣfahān	87;40	32;25
58	Farmal	104;55	32;55
59	Qandahār	107;40	33;0
60	Siyālkūt	109;0	33;0
61	Madā’īn	72;0	33;0
62	Dimashq	70;0	33;15
63	Maymand	101;55	33;20

[436] Engraved wrongly as 7;0.

	Place Name	L	φ
64	Baghdād	82;0	33;25
[IV] *al-iqlīm chahārum* (the fourth climate)			
65	Ṭarābulus	69;40	34;0
66	ᶜĀna	76;0	34;0
67	Kāshān	86;0	34;0
68	Mawṣil	77;0	34;30
69	Tūn	92;30	34;30
70	Harāt	94;30	34;30
71	Kābul	104;40	34;30
72	Qumm	85;40	34;45
73	Rayy	86;20	35;20
74	Sāwa	85;0	35;0
75	Kashmīr	108;0	35;0
76	Hamadān	83;0	35;10
77	Ḥalab	72;10	35;50
78	Mashhad Maqdis	92;30	36;0
79	Suharwa[r]d	83;20	36;0
80	Sabzawār	91;30	36;5
81	Basṭām	89;30	36;10
82	Balkh	101;0	36;41
83	Ṭāliqān	85;45	36;10
84	Abhar	84;36	36;45
85	Astarābād	89;35	36;50
86	Qazwīn	85;0	35;55

	Place Name	L	φ
	Third Circle		
[IV] *tatimma al-iqlīm chahārum* (continuation of the fourth climate)			
87	Badakhshān	84;24	37;10
88	Marāgha	82;0	37;20
89	Sarakhs	94;30	37;30
90	Marw	97;0	37;40
91	Tabrīz	82;0	38;0
92	Ardabīl	80;0	38;0
93	Nawshahr	78;20	38;10
94	Nakhjawān	81;15	38;40
[V] *al-iqlīm panjum* (the fifth climate)			
95	Bākūya	84;36	39;30
96	Samarqand	99;56	39;37
97	Bukhārā	97;30	39;50
98	Tubbat	110;0	40;0
99	Bardᶜa	83;0	40;30
100	Samākhī	84;30	40;50
101	Qūniya	66;30	41;0
102	Khujand	105;35	41;55
103	Khutan	107;0	42;0
104	Kāshān[437]	101;35	42;0
105	Farghāna	102;0	42;20

[437] This and the no. 67 earlier are both spelt as ‘Kāshān’. The present one ought to be Kasān, see Kennedy 1987a, pp. 174-75.

	Place Name	L	φ
[VI] *al-iqlīm shashum* (the sixth climate)			
106	Kāshghar	106;30	44;0
107	Bandqīya	92;0	44;0
108	Shalkh	85;30	44;0
109	Ṭarāz	99;50	44;31
110	Pashīn Bāligh	111;0	44;50
111	Qarāqūrūm	115;0	46;0
112	Khān Bāligh	124;0	46;0
113	Harqala	67;20	46;30
	Fourth Circle		
[VII] *al-iqlīm haftum* (the seventh climate)			
114	Araq	105;0	48;0
115	Bulghār	90;0	49;30
116	Aqjā Kirmān	62;0	50;0
117	Qirqir	65;30	50;0
[VII+] *khāriz al-iqlīm haftum* (beyond the seventh climate)			
118	Jazā’ir Rūdjard	68;50	62;0
119	Mārī Kirmān	65;45	50;45
120	Ṣūdaq	66;0	51;0
121	Patnah[438]	120;45	26;40
122	Dhākā Bankālā	130;0	27;0

[438] The last four place names do not occur in Muqīm’s gazetteer mentioned earlier. They should have come in the third climate. Ḍiyā’ al-Dīn adds these here as a kind of post-script. But Kūl (123) has already been mentioned under no. 37 as Kūl [wa] Jalālī.

	Place Name	L	φ
123	Kūl	114;19	28;6
124	Bahrāij	117;30	28;0

BACK

The rim of the two upper quadrants carries altitude scales divided in 1° and 5° and labelled as 5—90; 90—5.

The upper left quadrant bears a sine-cosine graph with 60 horizontal and 60 vertical parallels which are numbered along the two radii from 5 to 60.

The upper right quadrant is divided by 30 quarter circles into as many segments, one each for 6° of solar longitude. The names of the corresponding zodiac signs and the numerical values of their subdivisions (6, 12, 18, 24, 30) are engraved along the two radii of the quadrant. Thus along the vertical radius are engraved, from the centre up to the periphery, the names *al-saraṭān, al-asad, al-sunbula, al-mīzān, al-ᶜaqrab, al-qaws,* i. e. from summer solstice to winter solstice. Likewise along the horizontal radius are engraved, from the periphery up to the centre, the names *al-jadī, al-dalw, al-ḥūt, al-ḥamal, al-thawr, al-jawjā’,* i. e., from winter solstice to summer solstice.

Upon this grid are plotted three sigmoid curves of the meridian altitude of the sun throughout the year at the latitudes 27°, 29° and 32°, which are the latitudes of the three imperial cities of Agra, Delhi and Lahore, with the labels *khaṭṭ niṣf al-nahār bi-ᶜarḍ 27, … 29, … 32.*

In the lower half of the back, immediately below the horizontal diameter, are drawn the shadow squares, on the left for the shadows thrown by gnomon of 12 digits and on the right for the shadows cast by gnomon of 7 feet. The vertical and horizontal scales are divided accordingly into 12 units on the left and into 7 units on the right and numbered.



Figure A088.6 – Back of the Astrolabe (photo by Nazir Ahmad Doshab)

These scales are accompanied by the following labels. Vertical scale on the left: *ẓill sullam aṣabi*^{c} *ma*^{c}*kūs* (the scale of the reverse shadows in digits); horizontal scale on

the left: *ẓill sullam aṣabi*^{c} *mustawī* (the scale of the direct shadows in digits) ;horizontal scale on the right: *ẓill sullam aqdām mustawī* (the scale of the direct shadows in feet), and vertical scale on the right: *ẓill sullam aqdām ma*^{c}*kūs* (the scale of the reverse shadows in feet).

Inside the shadow squares are engraved two rectangular tables. The table to the left of the vertical diameter is entitled *jadwal faḍl al-dawr* (excess of revolution). Here the serial numbers in columns 1 and 3 are given in the standard Arabic/Persian numerals while the numerical values of the differences in minutes and seconds are in *Abjad* numerals.

The table on the right carries the heading *jadwal arbāb muthallathāt laylī wa nahārī* and displays triplicities in four sub-tables, each devoted to an element: *nārī wa tarābī* (fiery and earthy) and *hawā’ī wa māhī* (airy and watery).

The rim of the lower half bears the scales of cotangents, on the left in digits and on the right in feet. The unequal divisions in the scale on the left are numbered clockwise from the vertical diameter to the horizontal diameter as 1, 2, 3 … 10, 12, 14, 16, 18, 20, 22, 24, 27, 30, 36, 42, 48, 54, 60 followed by the label *ẓill aṣābi*^{c} *mabsūṭ*. Those in the scale on the right are numbered anti-clockwise from the vertical diameter as 1, 2, 3 … 12, 14, 16, 18, 21, 24, 30, 36, 42, 48, 54, 60, followed by the label *ẓill aqdām mabsūṭ*. In a parallel band inside, these divisions in the scales are subdivided into smaller units.

Then follow six concentric semi-circular rows. The first two are engraved with the names of the 12 zodiac signs and the names of the corresponding 28 lunar mansions respectively. The following two rows contain a table of limits (*ḥudūd*) while the last two rows show the decans and their lords.

ALIDADE



Figure A088.7 – Detail of Fig. 88.1 showing the Alidade

The alidade is straight without any counter change. It has pointed ornate ends and a matching ornate centre piece. In the right half, the upper edge is divided into 60 parts

and numbered as 5, 10, 15…55, 60, from the centre to the right end, to match the divisions on the upper left quadrant.

The left half of the alidade is designed to match the solar quadrant on the upper right of the back of the astrolabe. It carries 6 arcs, each representing a pair of signs. The names of these signs are engraved in two rows. In the lower row, starting from the centre and proceeding to the end are the six names from *al-Saraṭān* (Cancer) to *al-Qaws* (Sagittarius) and in the upper row, starting from the end and proceeding up to the centre, are the six names from *al-Jady* (Capricorn) to *al-Jawzā'* (Gemini).

Moreover, on the right hand side, below the sexagesimal scale, there is another scale with unequal divisions. These are numbered in *Abjad* from the sighting plate onwards from 1 to 6 and in the reverse order from 7 to 11. These are the markings to be used when the alidade is employed as a sundial. The shadow thrown by the sighting plate on the right across the length of the alidade is measured with these numerals to determine the seasonal hours in the forenoon or afternoon as the case may be.

Inscription

In the narrow space between the rectangular tables and the horizontal diameter is the maker's signature, engraved in two lines:

> *ᶜamal aqall al-ᶜibād ḍiyā' al-dīn muḥammad ibn qā'im muḥammad ibn mullā ᶜīsā ibn shaykh allāhdād asṭurlābī humāyūnī lāhūrī fī sanah 1077 hijrī gh-ᶜa-z.*
>
> 'The work of the least of the servants [of God], Ḍiyā al-Dīn Muḥammad, son of Qā'im Muḥammad, son of Mullā ᶜĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the year 1077 of Hijra, [in *Abjad*] 1000 + 70 + 7.'

Provenance

The astrolabe was on loan to the Central Asian Museum of the University of Kashmir from 1980 to 2015 February. The authorities of Central Asian Museum, in particular Mr Nazir Ahmad Doshab, kindly provided the measurements and a full set of excellent photos of the astrolabe.

A089 ASTROLABE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1077 AH (AD 1666-67)

Diameter ?

PLU

Répertoire 34

The Répertoire mentions the National Museum, Karachi, as the place of deposit of this astrolabe, and provides the following information about the astrolabe. But I have been informed by the museum that this astrolabe does not exist there. It is not known from where the Répertoire gathered the details about this astrolabe.

Only the mater is extant, diameter is not mentioned.

On the back, the upper left quadrant has a graph of sines and cosines; upper right quadrant is divided in 30 parts by the declination arcs, with the names of zodiac signs, three sigmoid curves displaying the midday altitude of the sun at the latitudes of 27°, 29° and 32°.

INSCRIPTION

ᶜamal aqall al-ᶜibād ḍiyā' al-dīn muḥammad ibn qā'im muḥammad ibn mullā ᶜīsā ibn shaykh
allāhdād asṭurlābī humāyūnī lāhūrī fī sanah 1077 hijrī
gh-ᶜa-z

'The work of the least of the servants [of God], Ḍiyā' al-Dīn Muḥammad, son of Qā'im Muḥammad, son of Mullā ᶜĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the year 1077 Hijrī, [the same in Abjad notation] 1000+70+7.'

A090⊙ NORTH-SOUTH ASTROLABE BY DIYĀ' AL-DĪN MUḤAMMAD 1085 AH (AD 1674-75)

Diameter 163 mm

Jaipur, Jai Singh's Observatory

CCA 2703; Répertoire 36



Figure A090.1 – Obverse side of the astrolabe (photo by S. R. Sarma)

In this north-south astrolabe (*asṭurlāb shamālī wa janūbī*), the obverse side of the single plate is engraved as a latitude plate for 33° N and on it is superimposed a northern projection of the ecliptic circle together with the positions of 46 stars, while the reverse side is designed for latitude 35° N on which a southern projection of the ecliptic circle is drawn and the positions of the same 46 stars, but with southern orientation, are marked. The choice of these latitudes is rather intriguing. There is a minimal rete consisting of just the ecliptic ring and an alidade with a sighting tube.

COMPONENTS

Plate with *kursī* (d. 163, h. 186), shackle and ring, rete, ruler, alidade with a sighting tube, pin and nut. The pin and nut are modern replacements

Obverse Side with the Northern Projection of the Ecliptic

The plain *kursī,* faintly lobed, terminates in a trefoil, to which a small shackle is attached. A small ring passes through the shackle. A small rectangular copper plaque is attached to the ring by means of an iron chain. This plaque was added in Jaipur during the reign of Sawai Madho Singh in the mid-eighteenth century. On this plaque is engraved in Devanagari script *yaṃtrarāja do ṭo patra ek ko,* which translates roughly to ‘astrolabe, two latitude plates in one.’

The rim of the plate is graduated into groups of 6° and labelled separately for each quadrant with *Abjad* numerals as 6, 12, … 84, 90, in clockwise direction. In the upper right quadrant, however, groups of 6° are numbered, in addition to the *Abjad* numerals, also in common Arabic/Persian numerals from 6 to 90, but proceeding in the reverse direction from the west point up to the south point, for measuring the angles of altitude. These groups of 6° are further subdivided into single degrees of arc, where each third line is highlighted by dotted lines. Vertical and horizontal diameters are also represented by dotted lines.

Inside the circular scale are drawn the Tropic of Capricorn, the equator and the Tropic of Cancer, one inside the other, each as a pair of concentric circles. The oblique horizon is shown with a dotted line. Above the western end of the oblique horizon is written *al-maghrib* and above the eastern end *al-mashriq.* Above the oblique horizon are traced a series of altitude circles, drawn for every 6°. They are numbered in *Abjad* numerals on both sides of the meridian. Each third altitude circle is highlighted with

dots. There are no azimuth arcs. Below the oblique horizon are engraved the latitude for which the plate is calibrated and the maximum length of the daylight at this latitude: *al-ᶜarḍ 33 sāᶜāt*--. The value of the maximum duration is difficult to decipher. In the lower half are the lines of seasonal hours, counted from the western horizon in *Abjad* numerals.

Below the oblique horizon and almost parallel to it are a pair of arcs, one plain and the dotted. The plain arc is about 18° from the horizon and the dotted one is roughly at 24° from the horizon. These appear to be the arcs of the *ṣubḥ-i sādiq* (the true dawn) and of the *ṣubḥ-i kāẕib* (false dawn) respectively. In the rete there is a reference to the *ṣubḥ-i sādiq.*

Upon all these circles is superimposed the ecliptic circle, touching the south point of the Tropic of Cancer and the north point of the Tropic of Capricorn. It is divided into the 12 zodiac signs and labelled with the names of the signs, starting from the vernal equinox at the east point and proceeding anti-clockwise. Each sign is further subdivided into groups of 6° and numbered in common Arabic/Persian numerals in the anti-clockwise direction.

Finally, the entire surface of the plate is marked with 46 star positions with dots enclosed in small circles and labelled with the names of the stars. These names are listed below in the order of increasing right ascension, starting from the vernal equinox at the east point.

Table A090-1 Stars on the Obverse Side of the Plate

	Star Name	Identification
1	*Dhanab al-Qayṭus Sh[amālī]*	ι Ceti
2	*Dhanab al-Qayṭus J[anūbī]*	β Ceti
3	*Rijl Musalsala*	γ Andromedae
4	*Fam al-Qayṭus*	γ Ceti
5	*Ṣadr al-Qayṭus*	π Ceti
6	*Rās al-Ghūl*	β Persei
7	*Kaff al-Jadhmā'*	α Ceti

	Star Name	Identification
8	*Tālī Masāfat al-Nahr*	γ Eridani
9	*ᶜAyn al-Thawr*	α Tauri
10	*ᶜAyyūq*	α Aurigae
11	*Rijl al-Jawzā’ al-Yusrā*	β Orionis
12	*Yad al-Jawzā’ al-Yusrā*	γ Orionis
13	*Yad al-Jawzā’ al-Yumnā*	α Orionis
14	*Yad al-Jawzā’ al-Yumnā*	κ Orionis
15	*Shiᶜrā Yamānī*	α Canis Majoris
16	*Ṭarfat al-Safīna*	ρ Puppis
17	*Shiᶜrā Shāmī*	α Canis Minoris
18	*Nathra Saḥābī*	ε Cancri
19	*Fard al-Shujāᶜ*	α Hydrae
20	*Qalb al-Asad*	α Leonis
21	*Rās al-Asad*	μ Leonis
22	*Ẓahr Dubb Akbar*	α Ursae Majoris
23	*Qāᶜidat al-Bāṭiya*	α Crateris
24	*Ṣarfa*	β Leonis
25	*Anwar al-Farqadayn*	β Ursae Minoris
26	*ᶜAnāq*	ζ Ursae Majoris
27	*Janāḥ al-Ghurāb*	γ Corvi
28	*Simāk Aᶜzal*	α Virginis
29	*Simāk Rāmiḥ*	α Bootis
30	*Kiffa J[anūbī]*	α Librae
31	*Kiffa Sh[amālī]*	β Librae

	Star Name	Identification
32	*Nayyir Fakkah*	α Coronae Borealis
33	*ᶜUnuq al-Ḥayyah*	α Serpentis
34	*Qalb al-ᶜAqrab*	α Scorpii
35	*Rukbat al-Ḥawwā Yusrā*	ζ Ophiuchi
36	*Rās al-Ḥawwā*	α Ophiuchi
37	*ᶜAyn Tinnīn*	γ Draconis
38	*Yad al-Ḥawwā*	δ Ophiuchi
39	*Nasr Wāqiᶜ*	α Lyrae
40	*Dhanab al-Dajājah*	α Cygni
41	*Fam al-Faras*	ε Pegasi
42	*Dhanab al-Jadī*	δ Capricorni
43	*Sāq Sākib al-Mā’*	δ Aquarii
44	*Mankib al-Faras*	β Pegasi
45	*Kaff al-Khaḍīb*	β Cassiopeiae
46	*Surrat al-Faras*	δ Pegasi



Figure A090.2 – Reverse side of the astrolabe with the sighting tube (photo by S. R. Sarma)

Reverse Side with the Southern Projection of the Ecliptic

The rim of the plate is graduated into groups of 6° and numbered continuously from 6 to 360 in *Abjad* numerals in clockwise direction. In the upper right quadrant, the

groups of 6° are numbered also with the standard Arabic numerals from 6 to 90 from the west point up to the south point, as is done on the obverse side. Also as on the obverse side, groups of 6° are further subdivided into single degrees of arc, where each third line is highlighted by dotted lines. Vertical and horizontal diameters are also represented by dotted lines.

Since this side carries southern projections, the two tropics change places. Therefore here the Tropic of Cancer, the equator and the Tropic of Capricorn are drawn one inside the other. The oblique horizon is shown with a dotted line. Above the western end of the oblique horizon is written *al-maghrib* and above the eastern end *al-mashriq.* Above the oblique horizon are a series of altitude circles, drawn for every 6°. They are numbered in *Abjad* numerals on both sides of the meridian. Each third altitude circle is highlighted as a dotted line. There are no azimuth arcs. Below the oblique horizon are engraved two labels on either side of the meridian. That on the right reads *al-ᶜarḍ 35* (latitude 35°) and that on the left *sāᶜāt 14;25* ([maximum duration of the daylight] 14;25 hours). There are also lines for seasonal hours, counted from the western horizon in *Abjad* numerals.

As on the obverse side, here also two twilight arcs, one plain and the other dotted, are drawn below the oblique horizon at 18° and 24° from it.

In the lower half is drawn the ecliptic circle so that it touches the north point of the Tropic of Cancer and the south point of the Tropic of Capricorn. It is divided into the 12 zodiac signs and labelled with the names of the signs, starting from the west point and proceeding anticlockwise. Each sign is further subdivided into groups of 6° and numbered in standard Arabic numerals in the anti-clock direction. Finally the entire surface of the plate is marked with the same set of 46 star positions as on the obverse sides, but with their positions changed by about 180° due to the southern orientation.

RETE

The rete which can be used on either side is reduced to the bare minimum of the ecliptic ring, which has a diameter of 100 mm. Inside the ring are a north-south and an east-west bar which intersect at the centre of the astrolabe. Near the intersection, a small ring is attached to the two bars for the pin to pass through. The ecliptic ring is divided into the 12 signs of the zodiac and engraved with their names, starting from the vernal equinox at the east point and proceeding anticlockwise. Each sign is further subdivided

into groups of 6°. These are labelled separately for each sign as 6, 12, 18, 24, 30 in *Abjad* notation in anti-clock direction. On the upper part of the north-south bar, there is a handle, trifoliate in outline, to facilitate the rotation of the rete. At the south point, there projects a small pointed Capricorn index (*al-mūrī*). Above this rete rotates a ruler with a pointed terminal, but otherwise plain.

The north-south bar is divided in groups 6 units and these are marked unevenly from the south point up to the centre. The first two units are not numbered, those from the third are numbered as 6, 6, 12, 18, … 90. On the eastern half of the east-west bar *ayn waqt subaḥ-i sādiq numā* (this is the indicator of the time of the true dawn).[439] It is presumed that this rete would be used in combination with the two arcs engraved below the horizon on both sides of the plate.

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[439] I am grateful to Mr Mubashir Al-Huq Abbasi for this translation and explanation: *ṣubḥ-i sādiq* means the true morning, the time between sun rise and when sun is 18° below the horizon, as against the *ṣubḥ-i kāẕib,* 'the first or false dawn'.

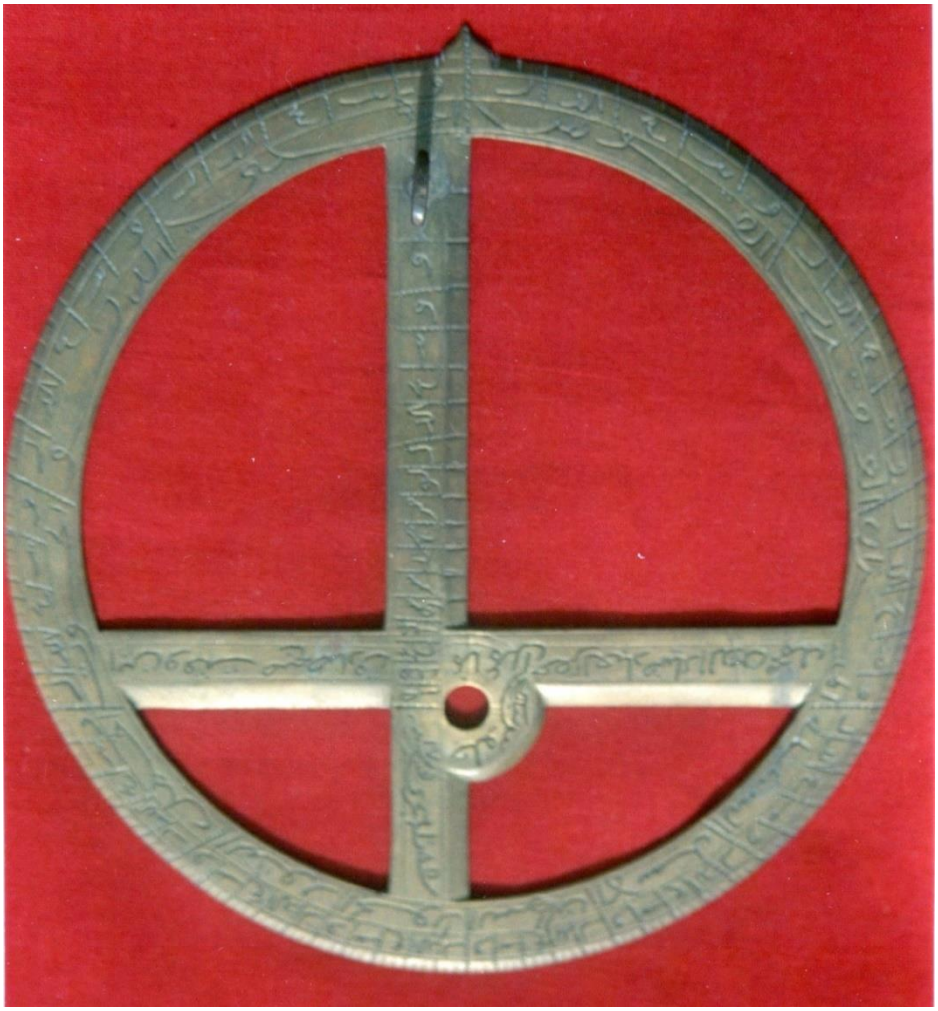


Figure A090.3 – The minimal rete (photo by S. R. Sarma)

Signature of the Astrolabe Maker

The signature is engraved on the left half of the east-west bar and continued on the upper half of the north-south bar and concluded on the central ring:

> *ʿamal aḥqar al-ʿibād ḍiyā’ al-dīn muḥammad sanah 1085 hijrī wa sanah 18 julūs mubārak.*
>
> ‘The work of the most wretched servant [of God], Ḍiyā’ al-Dīn Muḥammad, [in] the year 1084 Hijrī and the year 18 of the blessed reign [of the Emperor Aurangzeb].’



Figure A090.4 – Signature of the astrolabe maker (detail of Figure A090.3)

ALIDADE AND SIGHTING TUBE

On the back of the astrolabe is attached a straight-bar alidade (length 150 mm) with a centre-piece through which the pin passes. Diyā al-Dīn’s subtle art of ornamentation can be seen in the fact that the tapering ends of the alidade are fashioned to match the profiles of the centre-piece and the profiles of the *kursī*. A sighting tube is attached to this alidade with supports at either end. This is one of the few instances where a sighting tube is attached to the alidade in the Lahore astrolabes. On the right hand side of the alidade, the sloped rim between the centre and the support for the sighting tube is divided into 21 units and numbered in 7s as 7, 14, 21 from the support up to the centre. The significance of this numbering is not understood.

The components are held together by a broad-headed bolt and a winged nut which are not original.

PROVENANCE

The astrolabe appears to have been acquired by Sawai Jai Singh in the first quarter of the eighteenth century, along with a number of other important astrolabes of the Lahore family such as the zoomorphic astrolabe attributable to Muqīm (A051) and Ḍiyā’ al-Dīn’s A072 and A091. Most probably during the time of his son Sawai Madho Singh in the mid-eighteenth century, copper plaques with the description or functions of the instruments were attached.

BIBLIOGRAPHY

Turner 1985, p. 78 and figure 58.

A091⊙ ZARQĀLĪ UNIVERSAL ASTROLABE BY ḌIYĀ' AL-DĪN MUḤAMMAD MADE FOR NAWĀB IFTIKHĀR KHĀN, 1091 AH (AD 1680-1681)

Diameter 555 mm

Jaipur, Jai Singh's Observatory

CCA 80; Répertoire 39



Figure A091.1 – Front of the astrolabe (photo by S. R. Sarma)

This monumental *zarqālī* universal astrolabe represents the culmination of Diyā' al-Dīn's craft. The inscription on the back records that it was produced at the behest of a high Mughal dignitary Nawāb Iftikhār Khān. It is a very large instrument, made of a single sheet of brass, and measures 555 mm in diameter and 643 in height. It is the last dated extant piece fashioned by Ḍiyā' al-Dīn.

Within half a century of its manufacture, it was acquired by Sawai Jai Singh of Jaipur (1688-1742). Realizing of the importance of this universal astrolabe, he caused the composition of a Sanskrit manual entitled *Sarvadeśīya-jarakālī-yantra* on the construction and use of this instrument. At his orders a Sanskrit / Rajasthani name in Devanagari script was engraved at the back of the crown of the astrolabe thus: *yantra jarakālī sarvadeśī* (*Zarqālī* universal instrument) (see Figure A091.8). The first letters of the Sanskrit names of the zodiacal signs were engraved at appropriate places on both sides of the ecliptic. At several star positions Sanskrit names were added next to the original Arabic names; some new star positions were also marked and their Sanskrit names were inscribed. A detailed account of Jai Singh's engagement with this astrolabe will be given in the last part of this entry.

In modern times, A. ff. Garrett was the first to notice this instrument at the beginning of the twentieth century when he renovated the Jaipur Observatory at the instance of the Maharaja of Jaipur; his remarks will be reproduced at the end of this description. Then, in 1918, G. R. Kaye devoted an exclusive chapter to this astrolabe in his celebrated work *The Astronomical Observatories of Jai Singh*.[440]

Components

Main plate with *kursī* (d. 555, h. 643), shackle and ring, cross-bars, alidade with a sighting tube and pin. The wedge is missing; the ensemble is held together by a wire.[441]

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[440] Kaye 1918, Chapter IV, pp. 27-30, 118, figs. 21-22. See also Gunther 1932, no. 80, pp. 212-213; Savage-Smith 1985, p. 45; Sarma 1996b.

[441] Kaye 1918, p. 27 mentions a rough value of the diameter as 'two feet'; others repeat it.

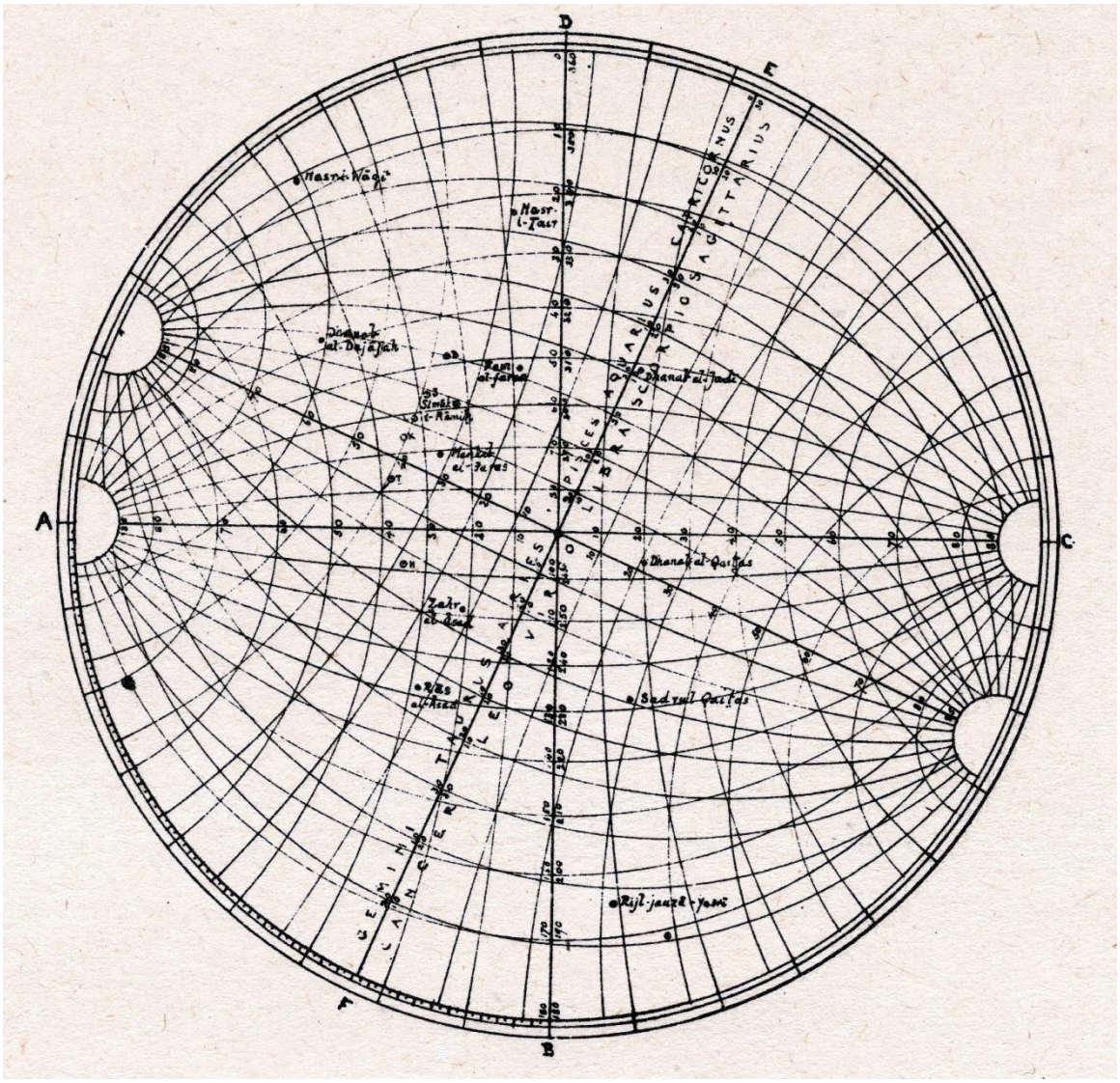


Figure A091.2 – Front of the astrolabe (diagram from Kaye 1918, fig. 21)

FRONT

The *kursī* and the plate are formed from a single sheet of brass. The profiles of the *kursī*, as in many other astrolabes by Ḍiyā’ al-Dīn, consist of a pair of ogees at the base and at the top, interspersed with a lobe in the middle. The finial is trifoliate, to which is attached a small shackle with ornate bases. The shackle and the ring that passes through it have diamond cross-sections. The *kursī* is solid and bears simple ornamentation. On both sides decorative lines run parallel to the profiles, and a pair of tulip-like flowers adorns the surface.

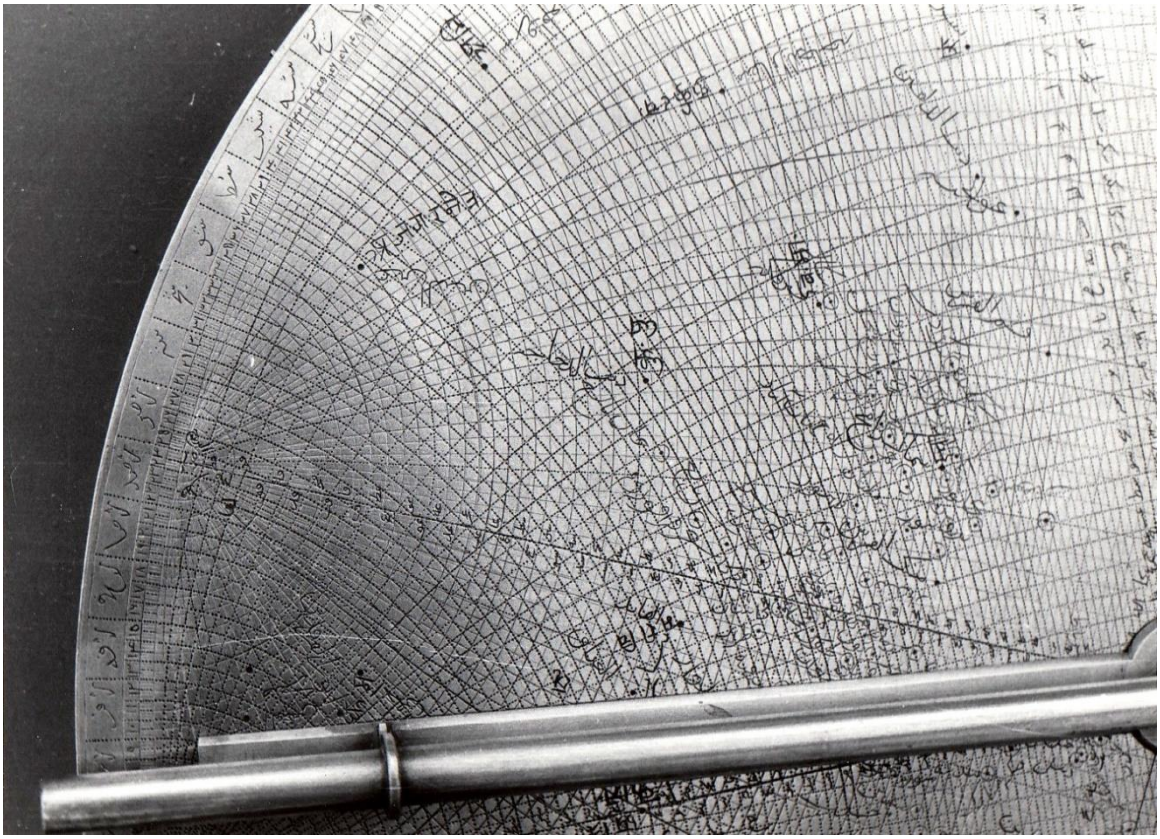


Figure A091.3 – Front of the astrolabe, detail of the upper left quadrant (photo by S. R. Sarma)

The *Zarqālī* projection, with the vernal / autumnal equinox as the centre and the solstitial colure as the plane of horizontal projection, is engraved on the obverse side of the instrument.[442] Here the outer rim is graduated for every three degrees and numbered in *Abjad* notation in a clockwise direction, starting at the top. It appears that the east point is placed at top on this astrolabe — instead of the south point as in common astrolabes — so that it is north on the left and south on the right.[443]

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442 Kaye 1918, p. 27, states that the 'characteristic part of the instrument is engraved on the reverse.' Because Jai Singh caused the Sanskrit name of the instrument engraved on the back of the *kursī,* Kaye appears to consider this side to be the front and the other side which carries the *Zarqālī* projection as the 'reverse'. But there cannot be any doubt that the side where the Sanskrit name of the instrument was inscribed is the back of the astrolabe, for here are the altitude scales, shadow scales, the trigonometric quadrant and the various astrological tables. These are elements which are always on the back of the astrolabe.

443 The Sanskrit text states this explicitly: *yantre sanmukhe kṛte sva-dakṣiṇa-vibhāge dakṣiṇā dig jñeyā, vāma-bhāge saumyā dig jñeyā,* 'when you hold the instrument in front of you, on your right is the southern direction and on your left the northern direction.' See Appendix B4.

The next concentric ring is graduated for every degree and numbered in common Arabic/Persian numerals, separately for each quadrant from 1 to 90, also in a clockwise direction, starting at the top. Next there are divisions for every one-sixth of a degree.

Inside these degree scales are drawn two sets of coordinates, the equatorial and the ecliptical. The vertical diameter of the plate (extending from the east point at the top to the west point at the bottom) is the celestial equator. It is graduated for every three degrees and numbered, on the northern side from 1 to 180 running from the top to the bottom, and on the southern side from 181 to 360 in the reverse direction. Circles parallel to the equator are the circles of declination; these are drawn for every degree and numbered, from the centre to the poles, along the line which is perpendicular to the equator. Circles perpendicular to the equator and converging at its two poles are the circles of right ascension; these are drawn for every three degrees and numbered along the line of equator.

The ecliptic is also drawn as a straight line which passes through the centre of the plate and is inclined to the equator at an angle equal to the obliquity of 23;30°. It is marked with the zodiacal signs from Capricorn to Gemini in the north and from Cancer to Sagittarius in the south so that Aries and Pisces lie at the centre. Each sign is divided for every three degrees. Circles parallel to the ecliptic are the circles of latitude; these are drawn for every degree and numbered, from the centre to the poles, along the line which is perpendicular to the ecliptic. Circles which are perpendicular to the ecliptic and which pass through its two poles are the circles of longitude. These are drawn for every three degrees and numbered along the ecliptic.

Dotted lines are used for the equatorial system and simple lines for the ecliptic system so that these two can be clearly distinguished.

Against these two sets of coordinates, several star positions are marked with dots enclosed in circles and labelled. In some cases, Sanskrit names are added next to the Arabic names at the behest of Sawai Jai Singh. He also caused some more star positions marked with their Sanskrit names. At places, the plate is so cluttered with these names that it is difficult to decipher all the star names. Kaye recorded 14 names along with their equatorial and ecliptic coordinates and compared these values with those given by

Flamsteed.[444] Some more star names are added in the following table, but a complete list needs to be prepared.

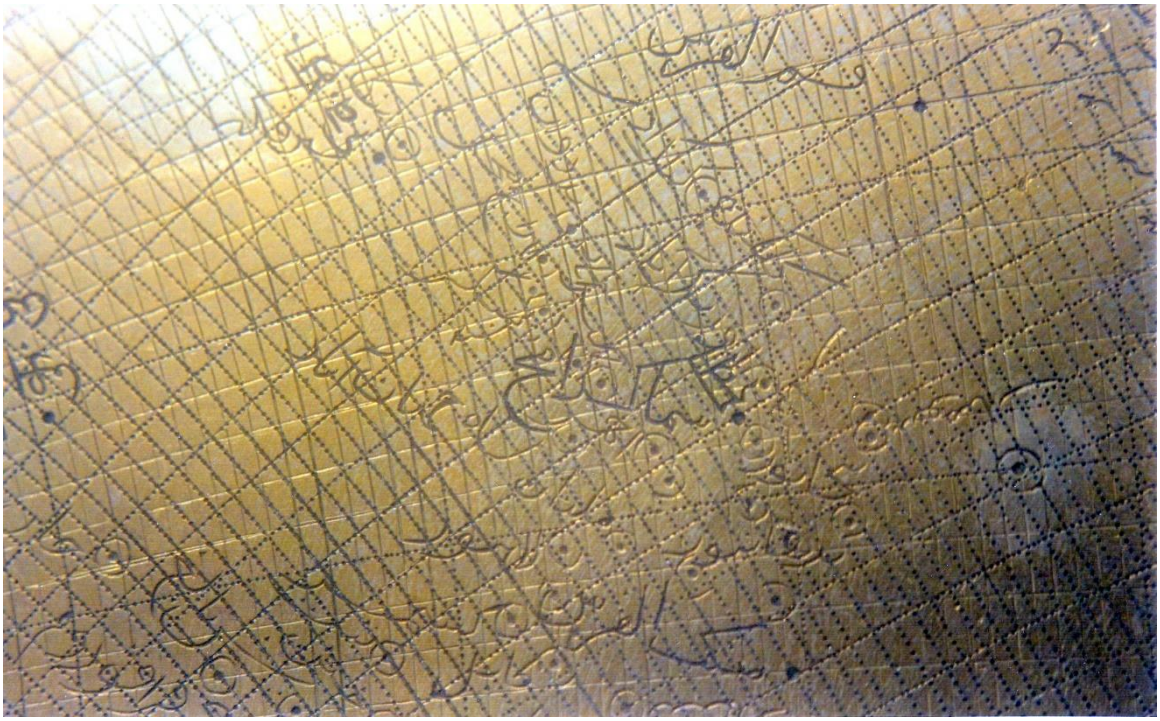


Figure A091.4 – Clutter of star pointers (photo by S. R. Sarma)

Table A091-1 Stars on the Rete

	Star Name	Identification	Sanskrit Name
1	*Dhanab al-Qayṭus*	β Ceti	
2	*Fam al-Qayṭus*	γ Ceti	
3	*Ṣadr al-Qayṭus*	π Ceti	
4	*Rās al-Ghūl*	β Persei	
5	*Mirfaq al-Thurayyā*	α Persei	
6	*ᶜAyn al-Thawr*	α Tauri	
7	*ᶜAyyūq*	α Aurigae	*Bra[hma-hṛdaya]*
8	*Riǰl al-Jawzā' al-Yusrā*	β Orionis	

444 Kaye 1918, p. 118.

	Star Name	Identification	Sanskrit Name
9	*Yad al-Jawzā’ al-Yusrā*	γ Orionis	*Mithuna-vāma-hasta*
10	*Yad al-Jawzā’ al-Yumnā*	α Orionis	*Mithu[na-dakṣaṇa-hasta]*
11	*Shiᶜrā Yamānī*	α Canis Majoris	*Lubaṃ [! Lubdhaka]*
12	*Rās al Taw’am al-Muqaddam*	α Geminorum	
13	*Ras al Taw’am al-Mu’akkhar*	β Geminorum	*Punarvasu*
14	*Al-Qā’id*	β Ursae Majoris	*Pulaha*
15	*Rās al-Asad*	μ Leonis	*Siṃha-mastaka*
16	*Fard al-Shujāᶜ*	α Hydrae	
17	*Ẓahr al-Asad*	δ Leonis	
18	*Al-ᶜAnāq*	ζ Ursae Majoris	
19	?	η Ursae Majoris	*Marīci*
20	*Simāk Rāmiḥ*	α Bootis	*Svā[ti]*
21	*Rukbat al-Ḥawwā Yusrā*	β Orionis	*Sarpadhara kā vāgoṃḍā*[445]
22	*ᶜAyn al-Tinnīn*	γ Draconis	*Ajagara-netra*
23	*Nasr Wāqiᶜ*	α Lyrae	*Abhi[jit]*
24	*Minqār al-Dajājah*	β Cygni	*Kurkuṭa-caṃ[cu]*
25	*Dhanab al-Dulfīn*	ε Delphini	
26	*Dhanab al-Dajājah*	α Cygni	*Ku[kkuṭa]-pu[ccha]*
27	*Fam al-Faras*	ε Pegasi	

[445] The Arabic name means ‘the left knee of the serpent charmer’. The Sanskrit/Hindi rendering has *vāgoṃḍā* for ‘knee’ which makes no sense.

	Star Name	Identification	Sanskrit Name
28	*Dhanab al-Jadī*	δ Capricorni	
29	*Mankib al-Faras*	β Pegasi	

GEOGRAPHICAL GAZETTEER

This celestial map is also made to serve geographical purposes. Treating the celestial equator and the polar axis as the zero latitude and zero longitude respectively, a number of town names were inscribed at appropriate distances. These include Ḥalab, Ṭūs, Kābul, Shāhjahānābād, Lāhūr, Khān Bāligh, Bīs Bāligh, Multān and Kashmīr. Kaye shows that longitudes were reckoned from Baghdad.[446]

Climates

A little inside the rim of the north-western quadrant, the seven climates of antiquity are marked in their Persian form: *iqlīm awwal, iqlīm dūyam, iqlīm siwum, iqlīm chahārum, iqlīm panjum, iqlīm shashum, iqlīm haftum.* There are some labels before and after the seven climates, but these could not be deciphered.

BACK

On the back there are many scales and tables arranged in some twenty-six annular rings on the rim. Reading from the outer circumference to the centre, the annuli contain the following scales and tables.

1. The rim of the two upper quadrants carries altitude scales, labelled in *Abjad* for every 3°, starting from the two ends of the horizontal diameter and reaching the upper end of the vertical diameter. The rim of the two lower quadrants carries shadow scales or cotangent scales, on the left for a gnomon of 12 digits followed by the label *ẓill aṣābiʿ mabsūṭ* (umbra recta in digits) and on the right for a gnomon of 7 feet followed by the label *ẓill aqdām mabsūṭ* (umbra recta in feet).
2. Annulus graduated for 1° and labelled in common Arabic/Persian numerals.

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446 Kaye 1918, p. 29.



Figure A091.5 – Back of the astrolabe (photo by S. R. Sarma)

3. Each degree in the above row divided into 30′ and then into 10′.

4. Names of the twelve signs of the zodiac, starting from the south point and proceeding clockwise.

5. Each sign divided in 3° and numbered in Abjad as 3, 6, 9, … 30.

6. Each sign divided in 1° and numbered from 1 to 30 in common Arabic/Persian numerals.

7. Each degree in the above row divided into 30′ and then into 10′.

8. Names of the 28 lunar mansions

9-19. Astrological tables, neatly separated from each other by a narrow blank annulus.
9-10. Duodenaries: 12 planets are assigned to each sign (the full table is reproduced in Kaye 1918, p. 125).
11-12. Novenaries: 9 planets are allotted to each sign (see Kaye 1918, p. 124, for the full table).
13-14. Limits or Terms of the signs. The five planets domiciled in each sign, their individual and cumulative strengths are given.
15-16. Septenaries: Each sign is given 7 planets (the full table is reproduced in Kaye 1918, p. 124).
17-18. Decans and their regents.
19. Looks like decans, but is different. Aries is assigned Mars, Sun and Jupiter.
20. Shadow scales once again, on the left for a gnomon of 12 digits and on the right for a gnomon of 7 feet; each unit divided in 10.
21-23. Calendar scale, concentric, separated from the scales above by a broad blank annulus.
21. Civil days of the months
22. Groups of 5 days, numbered in *Abjad* separately for each month.
23. Names of the Rūmī (Syrian-Macedonian) months: *Kānūn al-Thānī* (January), *Shubāṭ* (February), *Ādhār* (March), *Nīsān* (April), *Ayyār* (May), *Ḥuzayrān* (June), *Tammūz* (July), *Āb* (August), *Aylūl* (September), *Tishrīn al-Awwal* (October), *Tishrīn al-Thānī* (November), *Kānūn al-Awwal* (December). Here the first point of Aries is placed at 10 *Ādhār* (March). According to Kaye, it is the correct value for the year 1680 when the instrument was made.
24. Long signature of the astrolabe maker (see below), separated from the rest by a blank ring on either side.
25. Groups of 5° labelled in *Abjad*, starting from the east point, proceeding clockwise, 5, 10, … 90; 5, 10, … 90; 180, 175 … 95; 90, 85 … 5.
26. Single degrees.

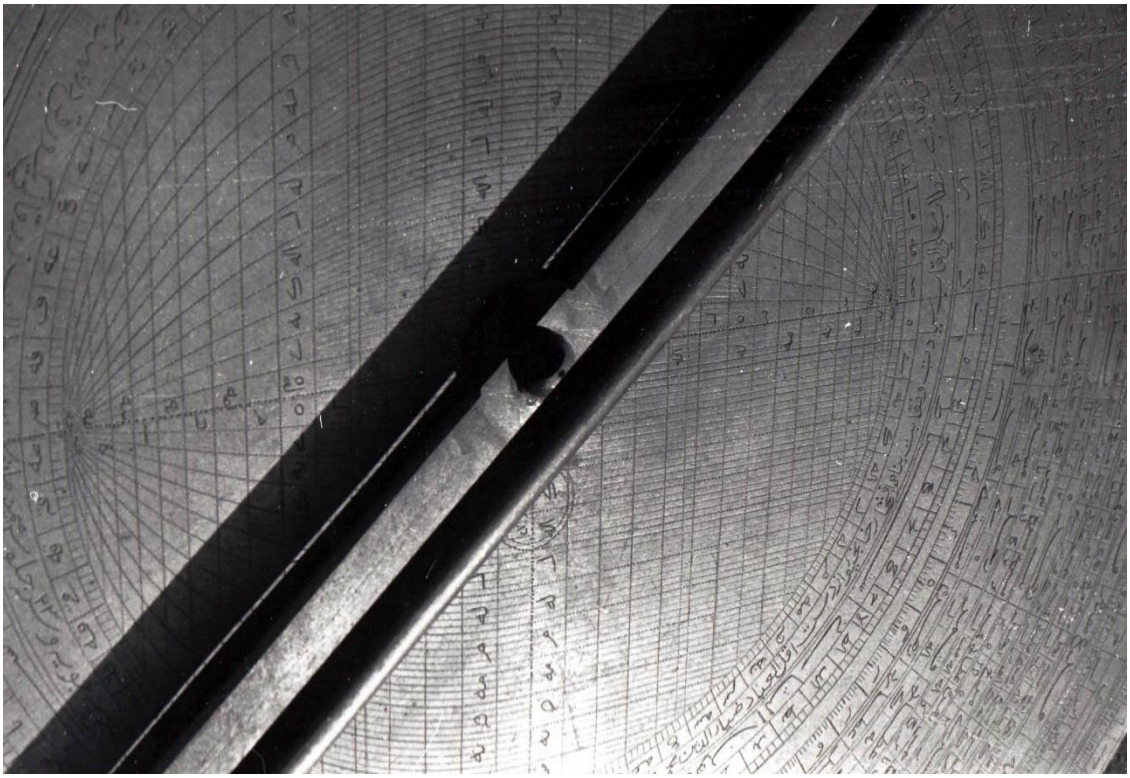


Figure A091.6 – Central part of the back (photo courtesy A. J. Turner)

The circle inside these annular rings is divided into four quadrants by the vertical and horizontal diameters. On the lower right is engraved a trigonometric quadrant. The vertical axis is divided into 60 parts and numbered in 5s in *Abjad* from the centre up to the arc. From each point of division horizontal lines are drawn up to the arc; every fifth of these lines is dotted. The horizontal axis is also divided into 60 parts and numbered in 5s (as 5, 15, 25 …) and from every fifth point dotted vertical lines are drawn up to the arc.

The other three quadrants contain orthogonal projections of the great circles inclined to the meridian. The upper radius is divided into 60 equal parts and through each point of division, circles are drawn so that they pass through the two points at the extremities of the horizontal diameter of the circle inside the annual rings. Every fifth of these circles is highlighted with dots. To reduce the clutter, in some parts only the fifth circles are shown. These circles are also numbered in 5s in all the three quadrants.

The Circle of the Moon

The ‘Circle of the Moon’ is considered to be a special invention of al-Zarqalluh for graphically obtaining the earth-moon distance and then for determining the lunar parallax. He prescribes that the ‘centre is to coincide with the thirteenth division below

the centre of the *ṣafīḥa* and its radius is to be equal to six of these divisions. A concentric circle, with a smaller radius, is also inscribed and the ring between the two circles is divided into twenty-four equal parts.'[447] On my first visit to Jaipur, I missed this lunar circle. Therefore, I wrote in my earlier study of this astrolabe that there was no circle engraved nor was it mentioned in the Sanskrit manual on the *Zarqālī* astrolabe.[448] There is indeed a circle. But it is placed slightly differently, with its centre on the 24th parallel. There is a smaller concentric circle inside, but the ring is not divided into 24 parts.

ALIDADE/ CROSS-BARS

Originally the instrument must have been equipped with an alidade at the back for taking the altitudes, and a regula with a sliding transversal cursor in the front for reading the coordinates of any point in either the equatorial system or in the ecliptic system. These were missing in 1902 when the instrument was first noticed by Garrett.[449] Subsequently, sometime before 1918, cross-bars consisting of four arms at right angles and an alidade with a sighting tube were added to the instrument; neither is graduated.[450] The cross-bars could not have functioned in the same manner as the regula with sliding cursor. At a later point, the cross-bars were wrongly mounted on the back and the alidade on the front and the whole ensemble was tightly fixed with a wire. Therefore, in my photos, the alidade with sighting tube appears in the front and the cross-bars on the back.

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447 Puig 1989, pp. 295-296.

448 Sarma 1996b, p. 726.

449 Thus Garrett & Guleri 1902, p. 60, write: 'There is a round hole in the centre of the disk which probably indicates the former existence of some kind of sighting bar for taking altitudes, but if so, this has now been lost'.

450 Kaye 1918, p. 27, speaks of the cross-bar but not of the alidade with the sighting tube. But the latter also must have existed then, for both are of the same workmanship.

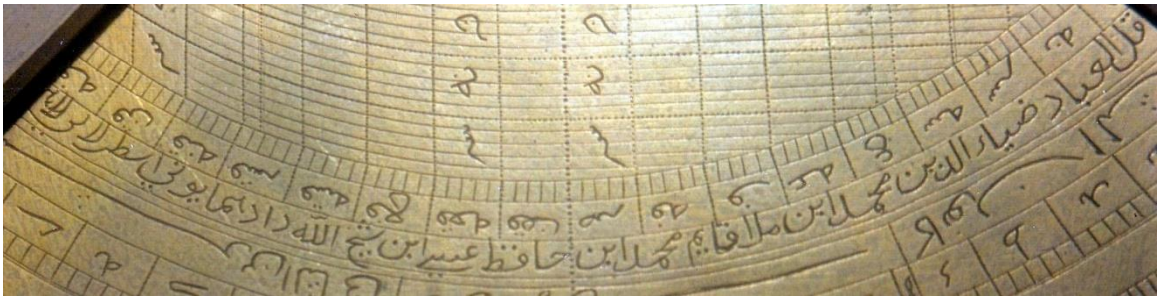


Figure A091.7 – Ḍiyā’ al-Dīn’s name in the inscription (photo by S. R. Sarma)

INSCRIPTION

A long inscription is engraved along the entire circumference of the astrolabe in the twenty-fourth annulus on the back. The Persian text is reproduced in the Répertoire thus:

این اسطرلاب زرقالی یك ورقی در عهد حضرت محی الدین
محمد اورنك زیب بهادر عالم گیر بادشاه غازی ساخته شد در
بلده دار الخلافة حضرت شاه جهان آباد بفرمایش نواب مستطاب
معلی القاب سیادت و نقابت پناه نواب افتخار خانجیور از دست
اقل العباد ضیاء الدین محمد ابن ملا قایم محمد ابن حافظ عسی
(کذا) ابن شیخ الله داد همایونی اسطرلابی لاهوری فی سنة
۱۰۹۱ هجریة نبویة و سنة ۲۳ جلوس میمنت مانوس

ayn ***asṭurlāb zarqālī*** *yak-waraqī dar ahad ḥaḍrat* ***muhyī al-din muḥammad awrangjayb*** *bahādar ᶜālamgīr bādshāh ghāzī sākhteh shud dar bilād dār al-khilāfat ḥaḍrat shāh-jahān-ābād bi-farmāyish nawāb musaṭṭāb muᶜalī alqāb siyādat wa naqābat panāh* ***nawāb iftikhār khān****-jī’ū az dast aqall al-ᶜibād* ***ḍiyā al-dīn muḥammad*** *ibn mullā qā’im muḥammad ibn ḥāfiz ᶜīsā (kazhā) ibn shaykh allāhdād humāyānī asṭurlābī lahūrī fī sanah 1091 hijariyah nabūyah wa sanah 23 julūs maymant mānūs.*

‘This *zarqālī* astrolabe with a single plate (*yak-waraqī*)
in the reign (*dar ahad*) of His Majesty (*ḥaḍrat*) Muhyī al-Din Muḥammad Awrangjayb Bahādur ᶜĀlamgīr Bādshāh Ghāzī
was constructed (*sākhteh shud*) in the city, the seat of the Caliphate (*dār al-khilāfat*), the exalted (*ḥaḍrat*) Shāhjahānābad,

on the order of this excellent Nawāb, an illustrious and publicly esteemed sovereign and learned scholar (*bi-farmāyish nawāb musaṭṭāb muᶜalī alqāb siyādat wa naqābat panāh*), **Nawāb Iftikhār Khān**-Jī'ū[451]

with [his own] hand (*az dast*) [by] of the least of the servants [of God] (*aqall al-ᶜibād*), **Ḍiyā' al-Dīn Muḥammad**, son of Mullā Qā'im Muḥammad, son of Ḥāfiz ᶜĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn (*asṭurlābī Humāyūnī*)

in the year 1091 of the Hijra of the Prophet and in the 23rd year of enthronement of His Dignified Prosperity (*maymant mānūs*).'[452]

Nawab Iftikhār Khān, the dedicatee of the astrolabe, was a high dignitary at the Mughal court.[453] It is interesting that the inscription expressly mentions that the astrolabe was made in Shāhjahānābad, i.e., Delhi. Since Ḍiyā' al-Dīn and other members of his family were from Lahore, it is assumed that they had a workshop at Lahore where their astrolabes and globes were manufactured. However, there are absolutely no records to provide any information on this workshop, about the number of persons employed there or about the equipment used there. As mentioned already, all our information stems only from the extant instruments. Therefore, it is difficult to say

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451 In his mail of 11 March 2016, Professor Irfan Habib explains that 'Khān Jī'ū was a proper expression in 17th-century Indo-Persian; it is attested in the *Zakhīratu'l Khawānīn* which was completed in1651. *Jī'ū* corresponds to old Hindi *Jīv* and present *jī* (as in Gandhiji).'

452 This translation is based on the French rendering in the Répertoire. Mubashir Ul-Haq Abbasi and Dr Owen Cornwall helped in drafting the English version.

453 Cf. Beale 1894, p. 175: '**Iftikhar Khan,** title of Sulṭān Husain, the eldest son Mir 'Abdūl Hādī, entitled Asālat Khān Mīr Bakhshī, who died at Balkh in the 20th year of the emperor Shāh Jahān A.D. 1647, A.H. 1057. In the first year of 'Alamgir, Sulṭān Husain was honoured with the title of Iftikhār Khān. Sometime before his death he was appointed Fauzdār of Jaunpūr, where he died in A.D. 1681, A.H. 1092.'
Professor Irfan Habib has kindly sent this note on Iftikhār Khān on 19 March 2016: 'This chap was Governor of Ajmer when the Rathor rebellion broke out in 1678. There are many references to him in the unpublished *Waqa'i* (Official Reports) from Ajmer at the time (unique copy in Asafiya Library, Hyderabad, and transcript at Aligarh). The Ma'asiru'l Umarā's entry on him is mainly derived from Sāqī Musta'idd Khān's *Ma'āṣ-i 'Ālamgīrī*. The latter work tells us that in A.H. 1090/22 RY/ AD 1679, on removal from the governorship of Ajmer (Bib. Ind. ed. pp. 173-74), Iftikhār Khān was asked to accompany Aurangzeb's son Akbar to Lahore (p. 175). When the astrolabe was made in AH 1091/23 RY/AD 1680, he was apparently holding the post of *Faujdār* of Jaunpur. He died, while at Jaunpur in AH 1092/24 RY/AD 1681 (p. 209).'

whether Ḍiyā al-Dīn fabricated just this one astrolabe in Delhi or whether the entire workshop of the family was moved to Delhi about 1680.[454]

PROVENANCE

As mentioned above, Sawai Jai Singh acquired this astrolabe in the first quarter of the eighteenth century, together with other Lahore astrolabes like Ḍiyā’ al-Dīn’s beautiful astrolabe of 1656 (A072) and the splendid zoomorphic astrolabe which can be attributed to Muḥammad Muqīm (A051). First of all, he caused Sanskrit names of stars added next to the Arabic names so that the Hindu astronomers at his court could make use of this astrolabe. He also caused the Sanskrit name of the instrument engraved at the back of the *kursī*.



Figure A091.8 – Sanskrit name on the back of the *kursī* (photo by S. R. Sarma)

It appears that both Jai Singh and his son Madho Singh wished to set up a kind of private museum of astronomical instruments. For this purpose, copper plaques were added to many portable instruments mentioning the name and functions of the instruments.

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454 In the latter case, the astrolabes by his cousins Ḥāmid and Jamāl al-Dīn which bear dates after 1680 (such as A113, A114, A115, 0, A123, A124) may also have been made in Delhi.

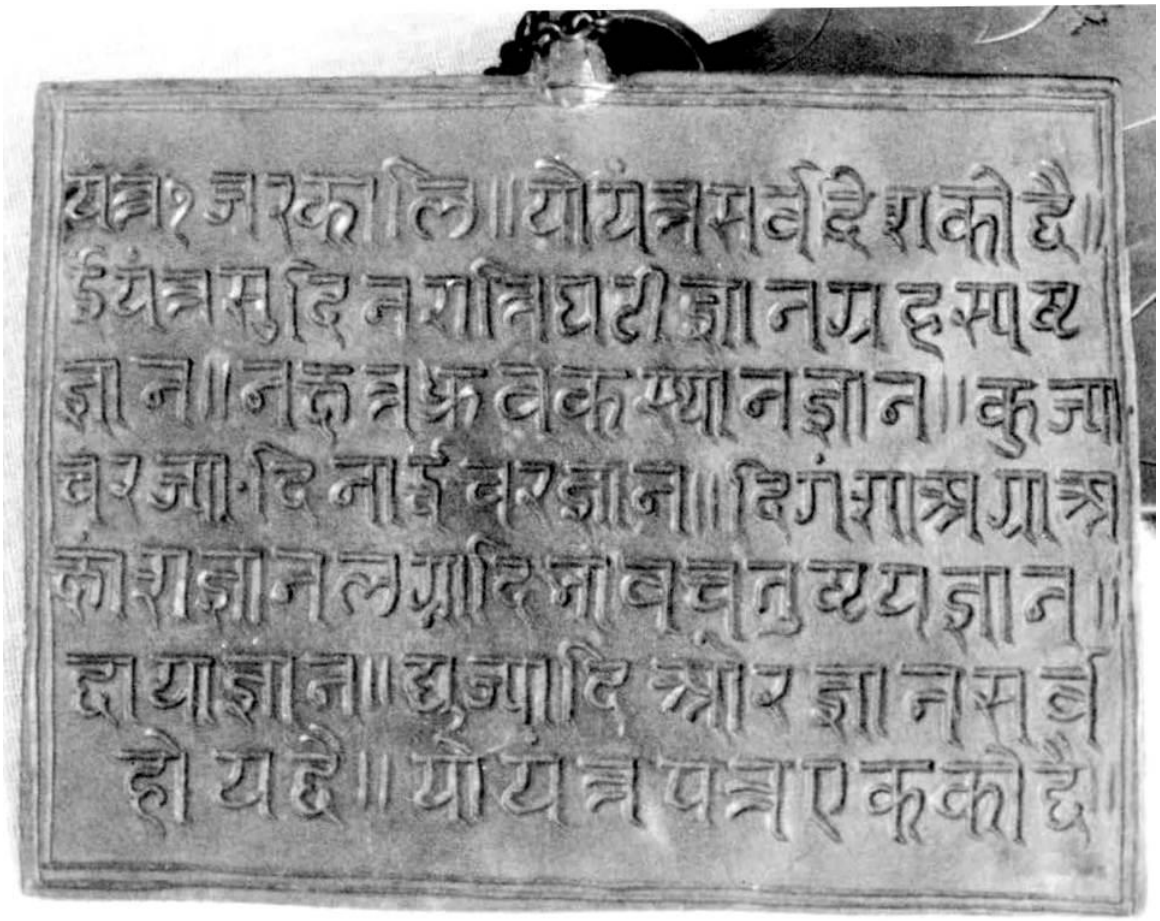


Figure A091.9 – The copper plaque (photo by S. R. Sarma)

The most impressive of such plaques is the one attached to the *Zarqālī* astrolabe on which the functions of this universal instrument were enumerated in Rajasthani dialect. The copper plaque, measuring 150 X 110 mm, reads as follows:

> One instrument [called] *Zarqālī.* This instrument is for all latitudes. This instrument provides the knowledge of [time in] *ghaṭīs* in the day and at night; knowledge of the true [longitudes of the] planets (*graha spaṣṭa jñāna*); knowledge of the polar longitudes of the fixed stars (*nakṣatra dhruvaka*); knowledge of the earth-sine (*ku-jyā*); sine of the ascensional difference (*cara-jyā*); half duration of daylight (*dinārdha*); ascensional difference (*cara*); knowledge of the azimuth (*digaṃśa*), amplitude (*agrā*) and terrestrial latitude (*akṣāṃśa*); knowledge of the four points on the ecliptic beginning with the ascendant (*lagna*); knowledge of the gnomon shadow (*chāyā*); knowledge of the day sine (*dyu-jyā*), and all other kinds of knowledge. This instrument consists of a single plate.

More important still is that Jai Singh caused the composition of a Sanskrit manual entitled *Sarvadeśīya-jarakālī-yantra* on the construction and use of this instrument. There are forty sections in this work. The first section explains the construction of the front side of the astrolabe, while the second lays down how to prepare the reverse side. These two sections are designated jointly as *paraibhāṣa*, ‘definition.’ The remaining part is called *gaṇita-prakāra*, ‘method of computations’ and deals with the solving of various problems, such as finding the true longitude of the sun from the declination by three different methods; the converse of the problem, viz. finding the declination when the solar longitude is known, also by three different methods; finding the current ascendant and from it determining the same for any location or for another year, and so on.[455]

In modern times, Lieutt. A. ff. Garrett of the Royal Engineers was the first to notice this instrument at the beginning of the twentieth century when he renovated the Jaipur Observatory at the instance of the Maharaja of Jaipur. In *The Jaipur Observatory and its Builder* which he wrote with Chandradhar Guleri, he states:

> There is also another […] instrument consisting of a brass disc about two feet in diameter on which is engraved a stereographic projection of the celestial sphere on the plane of the solstitial colure. Parallels of declination and latitude are drawn for every degree, and meridians and corresponding great circles through the pole of the ecliptic for every three degrees. The places of a number of stars are indicated by dots with the names written alongside. There is a graduated circle round the circumference divided into spaces of 10′, and the graduations are remarkably accurate for hand work. There is a round hole in the centre of the disc which probably indicates the former existence of some kind of sighting bar for taking altitudes, but if so, this has now been lost. This instrument was probably used as a star atlas, and also for the ready conversion of latitude and longitude into declination and right ascension and *vice versa*. Both sets of co-ordinates being engraved on

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455 Cf. Sarma 1996b, Appendix.

> the disc, one could be converted into the other by mere inspection, with an error of possibly a quarter of a degree.[456]

For his assistant who was barely nineteen at that time, Garrett is all praise in his preface:

> I have to express my thanks to Pundit Chandradhar Guleri, gold medallist of the Maharaja's College, Jaipur, for the great pains he has taken and the ability he has shown in translating Jai Singh's old astronomical works from Sanskrit into English. He has also helped in supervising the repairs to the observatory, and adjusting and testing the instruments.[457]

Chandradhar Sharma Guleri (1882-1922) graduated from Allahabad University, became the head of the department of Sanskrit in Mayo Collegea at Ajmer and was appointed in 1922 to the Manindra Chandra Nandi Chair in Ancient Indian History at Banaras Hindu University. But he is more renowned as one of the founders of the modern Hindi literature. In a book entitled *Śrī Candradhar Śarmā Gulerī: Vyaktitva aur Kṛtitva,* New Delhi 1983, by Pīyūsh Guleri, there is a rare photo showing Garrett and Guleri with the *Zarqālī* astrolabe, which is reproduced below.

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456 Garrett & Guleri 1902, p. 60.

457 Garrett & Guleri 1902, pp. 50-60, contains translations of extracts from Jai Singh's Sanskrit work on the astrolabe with the title *Yantrarāja-kārikā.* These translations must have been made by Guleri.



Figure A091.10 – Garrett and Guleri with the *Zarqālī* astrolabe

Guleri is on the right in the upper row, holding the *Zarqālī* astrolabe in front of him; Garrett must be the person sitting next to him in the middle of the row. The man in front of Garrett is holding a small-scale brass model of the *Cakra-yantra.*

BIBLIOGRAPHY

Garrett & Guleri 1902.

Kaye 1918, pp. 27-30.

Sarma 1996b.

A092⊙ ASTROLABE BY ḌIYĀ' AL-DĪN MUḤAMMAD, NOT DATED

Diameter 282

London, Nasser D. Khalili Collection of Islamic Art of Islamic Art (#SC 283)

CCA 3651; Répertoire 40



Figure A092.1 – Back of the astrolabe (photo by S. R. Sarma)

Of this astrolabe, there survives only the mater with an exquisitely crafted *kursī*. The limb, the inner surface of the mater and the back are almost completely engraved with appropriate numbers, tables and labels. On the back, the rim on the lower half is not engraved with the cotangent scales. In the upper right quadrant, no sigmoid curves for the midday altitude of the sun were drawn. Moreover, the central hole through which the pin passes and the hole at the top of the *kursī* through which the shackle passes are very small and not large enough for their designated function. Inside the limb on the front, no peg has been attached to keep the latitude plates in position.

The mater is heavily damaged: there are large dents at the back and cracks around the central hole. The front side is worn off and covered with patina and grime. Probably the astrolabe maker first prepared the mater and engraved it almost completely on both sides; but before he could insert the peg on the front and enlarge the holes, there happened an accident in which the mater received the dents and cracks and therefore it was abandoned at this point. In such a case, a prudent metal worker would recycle the damaged piece and not leave it in the damaged condition. It is difficult to ascertain what actually happened.

It is however obvious that this astrolabe was planned on a very ambitious scale. Had it been completed according to plan, this would have become the most magnificent astrolabe fashioned by Ḍiyā’ al-Dīn. Even the heavily damaged mater still looks splendid with its throne. It is one of the few Lahore astrolabe where the *Abjad* numbers on the limb and on the back, and also several other labels on the back are carved in relief against a finely hatched background as is done in the Safavid astrolabes of Iran.

Components

Mater with *kursī* (d. 282, h. 379, t. 15).

Front

The *kursī* is very intricately carved, creating a bouquet of five large flowers and several long leaves, all framed inside the two profiles which are topped by a trifoliate finial. There is much decorative engraving on the surface on both sides.

The limb is divided in 5° and 1° and labelled in 5s from 5 to 360 in *Abjad* numbers which stand out in relief against a hatched background. But these *Abjad* numbers are much worn out and cannot be deciphered easily.



Figure A092.2 – Geographical Gazetteer, detail showing the upper right hand corner (upside down) where the gazetteer commences (photo by S. R. Sarma)

GEOGRAPHICAL GAZETTEER

The gazetteer of 93 localities is engraved in three concentric circles with the tops of the letters pointing towards the centre of the astrolabe. The localities are arranged according to the climates, as in A074 and A088. In all the three astrolabes, at the end of the gazetteer where the localities beyond the seventh climate are to be listed, a few Indian localities are also added as if the astrolabe maker is making amends for forgetting to inscribe them at the correct place!

Nevertheless, the style in which the place names, their longitudes and latitudes are presented is very impressive. Each item of this data is placed inside a small cartouche. Between every two cartouches in a row are engraved tiny flowers with four petals. The rows are arranged so that the cartouches do not rest one upon the other vertically, but in a staggered fashion. The headings mentioning the climates are engraved in elongated letters; these are hardly distinguishable from the decorative designs.

Table A092-1 Geographical Gazetteer

	Locality ***asmā’al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***	
	Outer Circle			
[-I] *az khaṭṭ istiwā’ tā iqlīm awwal* (from the equator to the first climate)				
01	Ṣāhil Baḥr Awqiyānūs	11;0	0;0	
02	Jazīra Qanbala	21;0	3;0	Madagascar
03	ᶜAdan	76;0	11;0	
[I] *al-iqlīm al-awwal* (the first climate)				
04	Jubil	75;0	13;30	K Jubla
05	Bajja	10;0	14;0	
06	Dabīl	74;20	14;10	
07	Ṣanᶜā’ Dār al-Mulk Yaman	77;30	14;30	
08	Janad	75;30	14;30	in Yemen
09	Sawmnāt	107;0	17;0	Somnath
10	Zaytūn	154;0	17;15	
11	Pījāpūr	105;0	17;20	
12	Burhānpūr	103;0	20;30	
13	Dawlatābād	111;0	20;30	
[II] *al-iqlīm dūyam* (the second climate)				
14	Jadda	76;0	21;0	
15	Tā’if	77;30	21;20	
16	Makka Muᶜaẓẓam	77;10	21;40	
17	Madīnat Musharrafa	75;20	25;0	

	Locality ***asmā’al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
18	Kanbāyat	109;20	22;20
19	Khaybar	75;20	24;20
20	Hurmūz	92;0	25;0
21	Haḍrat Ajmīr	101;5	26;0
22	Kawāliyār	114;43	26;30
23	Lahknawtī	114;43	26;30
24	Qannawj	115;50	26;35
25	Jawnpūr	119;6	26;36
26	Akbarābād Dār al-Khilāfat	114;0	26;43
27	Kara wa Mānikpūr	118;10	26;49
28	Badāwan	119;19	27;32
[III] *al-iqlīm siwum* (the third climate)			
29	Kūlkanda	114;19	18;3
30	Kūl [wa] Jalālī	114;19	28;4
31	Fīrūzābād	106;30	28;10
32	Shāhjahānābād	113;35	28;39
33	Baran	114;--	28;43
34	Pānīpat	113;20	28;20
35	Shīrāz	88;0	29;36
36	Multān	107;35	29;40
37	Hānsī	112;25	29;45
38	Baṣra	84;0	30;0
39	Kirmān	91;30	30;5

	Locality ***asmā’al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
	Middle Circle		
[III] *tatimma al-iqlīm siwum* (continuation of the third climate)			
40	Tānīsar	112;33	30;10
41	Iskandariyya	61;54	30;18
42	Miṣr	63;20	30;20
43	Kūfa	79;30	31;30
44	Bayt al-Maqdis Dār al-Saṭna (?)	66;30	31;50
45	Lāhūr	109;20	31;50
46	Yazd	89;0	32;0
47	Iṣfahān	87;40	32;25
48	Qandahār	107;40	33;0
49	Madā’in	72;0	33;0
50	Dimashq	70;0	33;15
51	Maymand	81;55	33;20
52	Baghdād	82;0	33;25
[IV] *al-iqlīm chahāram* (the fourth climate)			
53	Mawṣil	77;0	34;30
54	Tūn	92;30	34;30
55	Harāt	94;30	34;30
56	Kābul	104;40	34;30
57	Rayy	86;20	35;20
58	Kashmīr	108;0	35;0
59	Hamadān	83;0	35;10

	Locality ***asmā’al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***
60	Ḥalab	72;10	35;50
61	Mashhad Maqdis	92;30	36;0
62	Sabzawār	91;30	36;5
63	Balkh	101;0	36;41
64	Ṭāliqān	85;45	36;10
65	Qazwīn	85;0	35;55
66	Badakhshān	104;24	37;10
67	Sarakhs	94;30	37;30
68	Tabrīz	82;0	38;0
69	Ardabīl	80;0	38;0
70	Nakhjawān	81;15	38;40
	Inner Circle		
[V] *al-iqlīm panjum* (the fifth climate)			
71	Samarqand	99;16	39;37
72	Bukhārā	97;30	39;50
73	Tubbat	110;0	40;0
74	Bardaᶜa	83;0	40;30
75	Shamākhī	84;30	40;50
76	Khujand	85;35	41;15
77	Khutan	87;0	42;0
78	Kāshān	81;35	42;0
[VI] *al-iqlīm shashum* (the sixth climate)			
79	Kāshghar	106;30	44;0

	Locality ***asmā’al-buldān***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***	
80	Shalkh	84;30	44;0	
81	Pīsh Bāligh	81;0	44;50	
82	Qarāqūrūm	105;0	46;0	
83	Khān Bāligh	124;0	46;0	
84	Harla	67;20	46;30	correct Harqala
[VII] *al-iqlīm haftum* (the seventh climate)				
85	Araq	85;0	48;0	
86	Bulghār	90;0	49;30	
87	Aqchā Kirmān	62;0	50;0	
88	Qirqir	65;30	50;0	
[VII+] *al-iqlīm khāriz* (beyond the [seventh] climate)				
89	Jazā’ir Rūdjard	68;50	62;0	K Hebrides
90	Dhākā Bankālā[458]	130;0	27;0	
91	Ilāhābād	115;34	26;50	
92	Sūrat	110;50	20;15	
93	Patnah	120;45	29;40	

BACK

On the back, the rim of the two upper quadrants carries altitude scales which are divided in 5°, 1° and 0;20°and labelled in 5s as 5—90; 90—5. In addition, in the rim of the upper left quadrant, the groups of 5° are counted also in the reverse direction (i.e.,

458 This and the next three are not situated beyond the seventh climate, but in the third. They are inserted here as addenda; the same is done in A074, A082, A088, A096 also.

from the south point to the east) in common Arabic/Persian numerals which are engraved just above the *Abjad* numerals. The upper left quadrant contains a sine-cosine graph with 60 horizontal and 60 vertical parallels. These are counted along both the vertical and horizontal radii, from the centre to the arc, in groups of 5. As the rim of this quadrant constitutes the arc of the sine quadrant, it is convenient to have the divisions of the arc numbered in both directions.

The upper right quadrant is divided by 30 declination arcs, one for each decan or 10° of the solar longitude. The names of the corresponding zodiac signs are engraved in embossed letters along the two radii; the numerical values of the decans are engraved above the names of the zodiac signs. However, graphs of solar meridian altitudes at different latitudes are not plotted on this quadrant, as is done in other Lahore astrolabes.



Figure A092.3 – Back of the Astrolabe; the lower half (photo by S. R. Sarma)

In the lower half, just below the horizontal diameter, are engraved the shadow squares, on the left for a gnomon of 12 digits and 60 parts and on the right for a gnomon of 7 feet. The vertical and horizontal scales on both sides are divided appropriately and endowed with the following labels. The letters of these four labels are also embossed in relief.

Vertical scale on the left: *ẓill sullam aṣābiʿ wa sittaynī maʿkūs*

Horizontal scale on the left: *ẓill sullam aṣābiʿ wa sittaynī mustawī*

Horizontal scale on the right: *ẓill sullam ᶜaqdām mustawī*

Vertical scale of the right: *ẓill sullam ᶜaqdām maᶜkūs*

Table of Rising Times of the Signs at Latitudes from 20° to 40°

Inside the shadow squares, there is a table with its title engraved in relief: *zadwal sāᶜāt ṭulūᶜ burūj bi-ᶜarḍ baᶜḍī az bilād mulk al-Hind* (table of the times of rising of signs in the latitudes of some of the localities belonging to the country of India).[459]

Table A092-2 Rising Times of the Signs

Signs → **Latitudes**	**Aries Pisces** (h;m)	**Taurus Aquarius** (h;m)	**Gemini Capricorn** (h;m)	**Cancer Sagittarius** (h;m)	**Leo Scorpio** (h;m)	**Virgo Libra** (h;m)
20°	1;34	1;46	2;3	2;14	2;14	2;9
21°	1;34	1;45	2;3	2;15	2;14	2;10
22°	1;33	1;44	2;3	2;10	2;16	2;10
23°	1;32	1;44	2;2	2;10	2;16	2;9
24°	1;31	1;43	2;2	2;16	2;16	2;12
25°	1;30	1;42	2;2	2;16	2;17	2;13
26°	1;29	1;41	2;1	2;16	2;18	2;14
27°	1;28	1;40	2;1	2;17	2;19	2;15
28°	1;27	1;39	2;0	2;17	2;20	2;16
29°	1;26	1;38	2;0	2;17	2;21	2;18
30°	1;25	1;38	2;0	2;18	2;22	2;19
31°	1;25	1;37	1;39	2;18	2;23	2;20
32°	1;22	1;36	1;18	2;19	2;24	2;21
33°	1;21	1;35	1;18	2;19	2;25	2;22
34°	1;20	1;34	1;18	2;20	2;26	2;23

459 Cf. A072 where the table stops at 39°.

Signs → **Latitudes**	**Aries** **Pisces** (h;m)	**Taurus** **Aquarius** (h;m)	**Gemini** **Capricorn** (h;m)	**Cancer** **Sagittarius** (h;m)	**Leo** **Scorpio** (h;m)	**Virgo** **Libra** (h;m)
35°	1;19	1;33	1;18	2;20	2;27	2;24
36°	1;18	1;32	1;17	2;20	2;28	2;26
37°	1;16	1;31	1;17	2;21	2;29	2;27
38°	1;16	1;29	1;17	2;21	2;30	2;28
39°	1;14	1;28	1;16	2;22	2;31	2;30
40°	1;13	1;27	1;16	2;22	2;32	2;31

Between the table and the horizontal diameter is the astrolabe maker's signature which is reproduced below.



Figure A092.4 – Astrological Tables, detail of Figure A036.3, showing the signs *al-Ḥamal* (Aries) and *al-Thawr* (Taurus) (row 1), the lunar mansions *Ṣaratān*, *Buṭayn*, *Thurayya*, *Debaran* and *Haq'ah* (row 2), planetary regents of the limits (row 3), their quantities of influence (row 4), regents of decans (row 5), the decans (row 6), names of planets with unidentified function (row 7) and decans (row 8).

The rim of the lower half is blank; no cotangent scale engraved here. But between the rim and the shadow squares there are 8 semi-circular rows containing the following data. The rows 1 and 2 as counted from the outside carry the names of the 12 zodiac signs and the names of 28 lunar mansions in relief.

Table of the Limits of the Signs

Thereafter, the rows 3 and 4, together with the row 1 containing the names of signs, constitute the table of the limits of the signs (*ḥudūd*). In row 3 are the names of the five planetary regents of each sign; these names are engraved here in full and not with the final consonants of their Arabic names as is usually done on astrolabes. In row 4, there are two registers; the upper register in *Abjad* shows the quantity of influence exercised by the regent. The lower register in standard Arabic/Persian numerals shows the cumulative influence, i.e., the quantity of this influence of a particular regent plus the preceding quantities in this sign.

Because of the constraints of space, in the table below the signs are arranged in a vertical column. In the three rows related to each sign, the first row carries the names of the five planets, the second the individual limit assigned to each planet and the third the cumulative values in bold numerals.

Table A092-3

Aries	Jupiter	Venus	Mercury	Mars	Saturn
	6	6	8	5	5
	6	**12**	**20**	**25**	**30**
Taurus	Venus	Mercury	Saturn	Jupiter	Mars
	8	6	5	8	3
	8	**14**	**19**	**27**	**30**
Gemini	Mercury	Jupiter	Venus	Mars	Saturn
	6	6	5	7	6
	6	**12**	**17**	**24**	**30**
Cancer	Mars	Venus	Mercury	Jupiter	Saturn
	7	6	6	7	4
	7	**13**	**19**	**26**	**30**
Leo	Jupiter	Venus	Saturn	Mercury	Mars
	6	5	7	6	6
	6	**11**	**18**	**24**	**30**
Virgo	Mercury	Venus	Jupiter	Mars	Saturn
	7	10	4	7	2
	7	**17**	**21**	**28**	**30**

Libra	Saturn	Mercury	Jupiter	Venus	Mars
	6	8	7	7	2
	6	**14**	**21**	**28**	**30**
Scorpio	Mars	Venus	Mercury	Jupiter	Saturn
	7	4	8	5	6
	7	**11**	**19**	**24**	**30**
Sagittarius	Jupiter	Venus	Mercury	Saturn	Mars
	12	5	4	5	4
	12	**17**	**21**	**26**	**30**
Capricorn	Mercury	Jupiter	Venus	Saturn	Mars
	7	7	8	4	4
	7	**14**	**22**	**26**	**30**
Aquarius	Mercury	Venus	Jupiter	Mars	Saturn
	7	6	7	5	5
	7	**13**	**20**	**25**	**30**
Pisces	Venus	Jupiter	Mercury	Mars	Saturn
	12	4	3	9	2
	12	**16**	**19**	**28**	**30**

Table of Decans and their Regents

The next four rows are devoted to decans or faces. Rows 6 and 8 carry the numerical values of decans (10, 20, 30) while rows 5 and 7 are engraved with the names of the regents of the decans in relief against a hatched background. Here the astrolabe suffered much damage and it is difficult to read the names of the planetary regents. With great effort the names of the planets could be read in row 5 and establish that rows 5 and 6 constitute a table of decans (*wujūh*) as we know from other astrolabes.

Table A092-4 Decans and their Regents

Signs	**10°**	**20°**	**30°**
Aries	Mars	Sun	Venus
Taurus	Mercury	Moon	Saturn
Gemini	Jupiter	Mars	Sun
Cancer	Venus	Mercury	Moon
Leo	Saturn	Jupiter	Mars
Virgo	Sun	Venus	Mercury
Libra	Moon	Saturn	Jupiter

Scorpio	Mars	Sun	Venus
Sagittarius	Mercury	Moon	Saturn
Capricorn	Jupiter	Mars	Sun
Aquarius	Venus	Mercury	Moon
Pisces	Saturn	Jupiter	Mars

Row 7 also appears to contain the names of planets, but in a sequence different from that in row 5. Here the names of the planets are hardly legible. With difficulty, the data related to the first four signs are deciphered as shown in the following table.

Table A092-5

	10°	**20°**	**30°**
Aries	Mars	Sun	Jupiter
Taurus	Venus	Mercury	Saturn
Gemini	Mercury	Venus	Saturn
Cancer	Moon	Mars	Jupiter

This table is clearly different from the table of *wujūḥ;* it is also different from the variant called *ardjān.*[460] Its nature remains unknown.

INSCRIPTION

> *ᶜamal aqall al-ᶜibād ḍiyā’ al-dīn muḥammad ibn qā’im muḥammad ibn mullā ᶜīsā ibn shaykh allāhdād asṭurlābī humāyūnī lāhūrī.*
>
> ‘The work of the least of the servants [of God], Ḍiyā’ al-Dīn Muḥammad, son of Qā’im Muḥammad, son of Mullā ᶜĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn.’

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460 On *ardjān,* see Khareghat 1950, pp. 19-20.

PROVENANCE

Formerly of the collection of Mrs. L. Marjory Hopkins; collection of Nicholas Landau, Paris.

BIBLIOGRAPHY

Sotheby’s, London, Catalogue, 7 May 1956, lot 114.

Maddison & Savage-Smith 1997, part I, no. 130, p. 226, 227.

A093⊙ ASTROLABE ATTRIBUTABLE TO ḌIYĀ’ AL-DĪN MUḤAMMAD

Between 1648 and 1658

Diameter 526 mm

London, Nasser D. Khalili Collection of Islamic Art (#SCI 53)



Figure A093.1 – Front of the astrolabe. The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 53. Photo courtesy of the Khalili Family Trust © Nour Foundation

This large Indo-Persian astrolabe was thoroughly reworked with Sanskrit labels in 1701 at the instance of Nayanānanda of Delhi. In this process the inscription containing the name of the maker and the date of its manufacture was erased. But internal evidence shows that the astrolabe was made by Ḍiyā’ al-Dīn Muḥammad. The unusual image engraved in low relief at the back of the *kursī* indicates it was created for no less an exalted personage than the Emperor Shāh Jahān (r. 1628-1658) himself. Moreover, Delhi is referred to as Shāhjahānābād in the geographical gazetteer. Therefore, the astrolabe must have been produced sometime after 1648 when Delhi was renamed Shāhjahānābād and during the reign of Shāh Jahān, i.e., before 1658.

This entry describes the astrolabe as it was made originally by Ḍiyā’ al-Dīn. The Sanskrit additions will be discussed E005. These two entries must be read together.[461]

Components

Body with *kursī* (d. 526, h. 602, t. 14), ring, shackle, rete for 53 stars, 6 plates. Alidade, pin and horse are missing.

Front

The suspension apparatus of the astrolabe consists of a heavy ring and a heavy shackle, both with an octagonal cross section. The terminals of the shackle are simple and circular. Through these two terminals and the tip of the *kursī* passes a pin, attaching the shackle thus to the *kursī* and to the main body of the astrolabe. The *kursī* is rather small for the enormous size of the astrolabe. It is solid and filled with designs in the front and on the back inside a heavy rim that runs along the lobed profiles. In the front there is a simple floral design.

On the back of the *kursī* is engraved an image in low relief of a finely drawn falcon swooping down and tearing into a bird, while smaller birds, one each on either side, are scuttling away from the fearsome falcon. This is an unusual image; such an image does not occur in any of the Lahore astrolabes. It alludes to an event in the career of the Shāh Jahān. Around 1634 he sent a letter to the Sulṭān of Bijapur, Muḥammad ᶜĀdil Shāh, ordering him to see that *khuṭba* be read in Shāh Jahān’s name in the Bijapur territory;

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461 The original engravings and the Sanskrit additions are discussed together in Sarma 2017.

otherwise he would pounce on the Sulṭān and tear him to pieces just as a falcon tears into a hoopoe.[462] Thus this unusual image, by referring to Shāh Jahān’s efforts to subjugate the minor kingdom of the Deccan, clearly establishes that this large and lavishly decorated astrolabe with many special features, which will be described below, was made for the Emperor Shāh Jahān himself.



Figure A093.2 – Falcon attacking Hoopoes on the Back of the *Kursī*.
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 53.
Photo courtesy of the Khalili Family Trust © Nour Foundation

RETE

The rete, measuring 151 mm in diameter, is the most ornate part of the astrolabe. It is thicker in the middle and tapers towards the rim; the thickness at the centre is about 3 mm and that at the rim is 1.5 mm. It consists of a Capricorn ring and a much wider ecliptic ring. These two are held together by the equinoctial bar which has counter changes at its two intersections with the ecliptic ring. The vertical solstitial bar is shown partially. The space between the two rings and inside the ecliptic ring is filled with floral tracery of a creeper with abundant leaves and flowers. The creeper rises from the Capricorn ring at its north point, branches off to the right and left and fills the whole space between the two rings; another branch enters the ecliptic ring, fills the space inside and culminates in a large empty circle with small protuberances issuing from its outer

462 Fischel 2012, pp. 253-54: see also Sarma 2017.

circumference. On the stem of the creeper, a little above the north point, is a large knob with which to rotate the rete around the centre.



Figure A093.3 – Rete of the astrolabe (photo by S. R. Sarma)

The ecliptic ring carries four circular scales: (i) the innermost scale is divided into 28 lunar mansions and their names are written in outline against a hatched background; (ii) the next scale is divided into the 12 zodiac signs and their names are embossed in low relief; (iii) in the third scale, groups of 3° are labelled in *Abjad* notation, separately for each sign as 3, 6, 9 … 30; and (iv) the outermost scale on the rim of the ecliptic circle is divided into single degrees. The boundary lines between the lunar mansions, those between the zodiac signs, the divisions of 3°, and divisions of 1° are marked by inlaid silver wire.



Figure A093.4 – Ecliptic ring on the rete (detail showng the signs Capricorn, Aquarius and Pisces)
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 53
Photo courtesy of the Khalili Family Trust © Nour Foundation

The pointed tips of the leaves and other projections on them constitute 53 star pointers; 29 of these are inside the ecliptic, i.e., to the north of the ecliptic circle, and 24 outside the ecliptic, i.e. to the south of the ecliptic between the ecliptic and the Tropic of Capricorn. The star names are inlaid with silver on the leaves of the tracery.

Table A093-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus Janūbī*	β Ceti
2	*Baṭn al-Ḥūt*	β Andromedae
3	*Fam al-Qayṭus*	γ Ceti
4	*Ṣadr al-Qayṭus*	π Ceti
5	*Kaff al-Jadhmāʾ*	α Ceti
6	*Rās al-Ghūl*	β Persei
7	*Mirfaq al-Thurayyā*	α Persei
8	*Tālī Masāfat al-Nahr*	γ Eridani
9	*ᶜAyn al-Thawr*	α Tauri
10	*ᶜAyyūq*	α Aurigae
11	*Rijl al-Jawzāʾ Yusrā*	β Orionis
12	*Yad al-Jawzāʾ Yusrā*	γ Orionis
13	*Yad al-Jawzāʾ Yumnā*	α Orionis
14	*Rijl Jawzāʾ [Yumnā]*	κ Orionis
15	*Shiᶜrā Yamānī*	α Canis Majoris
16	*Shiᶜrā Shāmī*	α Canis Minoris
17	*Ṭarfat Safīna*	ρ Puppis
18	*Nathra Saḥābī*	ε Cancri
19	*Fard Shujāᶜ*	α Hydrae
20	*Rās al-Asad*	μ Leonis
21	*Qalb al-Asad*	α Leonis
22	*Ẓahr Dubb Akbar*	α Ursae Majoris
23	*Qāʾidat al-Bāṭiya*	α Crateris
24	*Ẓahr al-Asad*	δ Leonis

	Star Name	Identification
25	*Al-Ṣarfa*	β Leonis
26	*Al-ᶜAnāq*	ζ Ursae Majoris
27	*Janāḥ al-Ghurāb*	γ Corvi
28	*Simāk al-Aᶜzal*	α Virginis
29	*Simāk Rāmiḥ*	α Bootis
30	*Kiffa J[anūbī]*	α Librae
31	*Kiffa Shamālī*	β Janūbī
32	*Nayyir Fakkā*	α Coronae Borealis
33	*ᶜUnuq al-Ḥayyah*	α Serpentis
34	*Qalb al-ᶜAqrab*	α Scorpii
35	*Rukbat al-Ḥawwā al-Yusrā*	ζ Ophiuchi
36	*Rās al-Jāthī*	α Herculis
37	*Rās al-Ḥawwā*	α Ophiuchi
38	*ᶜAyn al-Tinnīn*	γ Draconis
39	*Yad al-Ḥawwā al-Yumnā al-Muqaddam*	δ Ophiuchi
40	*Nasr Wāqiᶜ*	α Lyrae
41	*Minqār al-Dajājah*	β Cygni
42	*Nasr Ṭā’ir*	α Aquilae
43	*Dhanab al-Dulfīn*	ε Delphini
44	*Dhanab al-Dajājah*	α Cygni
45	*Fam al-Faras*	ε Pegasi
46	*Dhanab al-Jadī*	δ Capricorni
47	*Mankib Sākib al-Mā’*	α Aquarii
48	*Sāq Sākib al-Mā’ J[anūbī]*	δ Aquarii

	Star Name	Identification
49	*Dhanab al-Qayṭus Sh[amālī]*	ι Ceti
50	*Mankib al-Faras*	β Pegasi
51	*Surrat al-Faras*	δ Pegasi = α Andomedae
52	*Janāḥ al-Faras*	γ Pegasi
53	*Dhāt al-Kursī*	β Cassipeiae

ZAWRAQĪ HORIZONS ON THE RETE

In this rete are incorporated two small *zawraqī* horizons which intersect each other on the equinoctial bar. The arc with the convex side to the north is the oblique horizon for latitude 29° (Delhi). The western and eastern halves of the arc carry the labels *ufq mujassam gharbī bi-ᶜarḍ 29,* ‘western solid horizon for latitude 29’ and *ufq mujassam sharqī bi-ᶜarḍ 29,* ‘eastern solid horizon for latitude 29’ respectively. The mast corresponding to this arc, i.e., the solstitial bar above the central hole, has the inscription *shaẓiya yatiru zawraq fawq al-ᶜard,* ‘pointer spanning the *zawraqī* horizons above the latitude’.



Figure A093.5 – The Oblique Horizons for the Latitudes of 29° and 32° on the Rete
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 53
Photo courtesy of the Khalili Family Trust © Nour Foundation

The second arc, with the convex side to the south is the oblique horizon for latitude 32° (Lahore). Two halves of this arc carry the labels *ufq mujassam gharbī bi-ᶜarḍ 32,* ‘western solid horizon for latitude 32’ and *ufq mujassam sharqī bi-ᶜarḍ 32,* ‘eastern solid horizon for latitude 32’. Its mast, i.e., the solstitial bar below the central hole, bears the label *shaẓiya yatiru zawraq taḥt al-ᶜard,* ‘pointer spanning the *zawraqī* horizons below the latitude’.

The equinoctial bar carries the label *mastarat tarbī’ gharbī,* ‘western perpendicular rule’ in the west and the label *mastarat tarbī’ sharqī,* ‘eastern perpendicular rule’ in the east.

All these inscriptions on the two arcs and on the solstitial and equinoctial bars are inlaid in silver. These *zawraqī* horizons have to be used with a special plate which will be described in the following section.

Plates

There are six plates in this astrolabe. The first five plates serve different latitudes between 0° and 45°. The obverse side of the sixth plate is engraved with the ecliptic coordinates and the reverse side with the plate of horizons. The plates have a uniform

diameter of 501 mm, but with varying thickness. There is a notch at the north point in all the plates into which the peg affixed at the same place on the mater fits in and holds the plates in position.

Table A093-2 Plates

	φ	Longest Day
1a	*zawraqī plate* for 29° +32°	
1b	18°	13;9 hours
2a	0°	12 hours
2b	3°	12;11 hours
3a	27°	13;43 hours
3b	29°	13;52 hours
4a	37°	14;31 hours
4b	39	14;45 hours
5a	42°	14;0 hours! It should read 15;0
5b	45°	15;22 hours
6a	66;30° Plate of ecliptic coordinates	
6b	Plate of horizons	

The plate faces 1a, 2a, 6a and 6b contain special projections which will be described below. The rest of the plates are fashioned in the same style with altitude circles drawn for each 1° and azimuth circles for every 15° above the horizon and for every 3° below the horizon. Each sixth altitude circle is highlighted by a dotted line. The altitude circles are numbered serially from 1 to 90, from the horizon up to the zenith, both in the eastern and western halves, the series of numbers in these two parts forming a symmetrical pattern. The azimuth circles are also numbered in a symmetric form.

In the lower half, lines for equal and unequal hours are drawn between the tropics of Cancer and Capricorn and numbered.

Plate 6a for latitude 66;30°

The obverse side of the sixth plate contains a stereographic projection relative to the latitude of 66;30°, which is a complement of the total obliquity of 23;30°. Here the local horizon coincides with the ecliptic circle. The ecliptic circle is divided into the 12 signs of zodiac and labelled with their names. Arcs of longitude, which radiate from the zenith, are drawn for every 3° and are numbered separatey for each sign.

Concentric circles of celestial latitudes are drawn for each 1°. Every sixth circle is highlighted with dots. The circles are numbered from the ecliptic up to the North Pole as 1, 2, 3, 4, 5, 6; thereafter only in even numbers 8, 10, 12, … 90. Outside the ecliptic, in the lower half, each circle is numbered serially from the ecliptic onwards from 1 to 48.

The label *ṣafīḥat mīzān al-ᶜankabūt* is engraved in the lower half of the plate.

Plate 6b with the plate of horizons

On the reverse side of the sixth plate are drawn half horizons for every single degree of latitude from 2 to 90, in the following four separate sets:

2 6 10 … 82 86 90;
3 7 11 … 83 87 90;
4 8 12 … 84 88 90;
5 9 13 … 85 89 90.

In all the four quadrants, declination scales are engraved along the radii, once outside the equator, i.e., to the south of the equator, and once inside, i.e., to the north of the equator.

These scales carry the values 3, 6, 9, 12, 15, 18, 21 and 23;30, the last being the value of maximum obliquity. Each scale is accompanied by a label in florid calligraphy, those to the south of the equator reading *taqsīm mayl kullī janūbī* (divisions of the obliquity, i.e. declination scale, south) and those to the north *taqsīm mayl kullī shamālī* (divisions of the obliquity, i.e. declination scale, north).

The designation of the plate *ṣafīḥa āfāqī* is engraved in the lower right quadrant.

Plate 2a for Latitude 0°

Plate 2a carries projections for latitude 0°. Combined projections for latitudes 0° + 90° or for 0° + 72° + 90° occur in some astrolabes, but this is the only case where

projections are made exclusively for latitude 0°. As in the other latitude plates, here also latitude circles are drawn for each 1°and numbered on the right and on the left; with every sixth line highlighted with dots. Azimuth arcs are drawn for every 6°; above the horizon they are drawn all over, but below the horizon only inside the circle of equator and labelled.



Figure A093.6 – Plate 2a for Latitude 0°
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 53
Photo courtesy of the Khalili Family Trust © Nour Foundation

In the lower half, a series of 30 *ghaṭīs* lines are drawn and numbered from the western horizon, from 1 to 30. Because two and half *ghaṭīs* make one hour, certain *ghaṭī* units (i.e., 3, 8, 13, 18, 23, 28) are divided into two parts to synchronize with the equal hours, because 2 ½ gh = 1h; 5 gh = 2 h, 7 ½ gh = 3 h; 10 gh = 4 h; 12 ½ = 5 h, and so on. Thus from these lines time can be measured in both the *ghaṭīs* and hours. The

numbers of the *ghaṭīs* are engraved below the circle of the equator and those for the hours above the equator.

However, the astrolabe maker erred in drawing the *ghaṭī* lines here as unequal units, for the *ghaṭīs* are always equal and never unequal. In the other Lahore astrolabes, lines are drawn correctly for equal *ghaṭīs.*

At the middle of the plate, the specifications of the plate are given as *sāᶜāt 12;0* and *al-ᶜarḍ 0;35.* The plate is clearly calibrated for the latitude 0°, i.e., the terrestrial equator; but it is not clear why the latitude is mentioned here as ‘0;35’. Moreover, in 0;35 the zero symbol is unlike the symbol engraved throughout this astrolabe, e.g. in 12;0 just across the line of the meridian. It is written not to the right of ‘35’ but just above it, in a smaller size, as if in an afterthought.

Plate 1a

This plate is specially designed for use in conjunction with the two *zawraqī* horizons inserted in the rete for the latitudes 29° and 32°. Like the other plates, this one is also engraved with the vertical and horizontal diameters, and the three concentric circles of the Tropic of Cancer, the celestial equator and the Tropic of Capricorn.

Around the circle of equator, the twelve astrological houses are marked, once outside the equator and once inside the equator, but with a difference. Outside the equator the enumeration commences from the east point and proceeds counterclockwise, but inside the equator the enumeration commences from the west point and proceeds counterclockwise. The two varying sets of the astrological houses are related to the two oblique horizons engraved on this plate. The names of the astrological houses are engraved in elongated letters so that the names occupy the full stretches of the corresponding houses.

In both cases, each house is divided into 5 units of 6° and the numbers in *Abjad* notation are engraved above the names of the astrological houses in Arabic. In Arabic, the first house is named *al-ṭālīᶜ,* ‘the ascendant,’ and the rest are ordinal numbers.



Figure A093.7 – Plate 1a to be used with the *Zawraqī* Horizons
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 53
Photo courtesy of the Khalili Family Trust © Nour Foundation

Two mutually intersecting oblique horizons are drawn across the plate. As in the rete, here also the arc with the convex side to the north is the oblique horizon for the latitude 29° and that with the convex side to the south is the horizon of the latitude 32°. Where the arcs intersect with the equinoctial colure, there are labels at the end of each horizon. Thus at the two ends of the horizon for 29° are engraved *ufq sharqī ʿarḍ 29* on the east, meaning "eastern horizon latitude 29" and *ufq gharbī ʿarḍ 29* on the west, meaning "western horizon latitude 29". Likewise at the two ends of the horizon for 32° are engraved *ufq sharqī ʿarḍ 32* on the east and *ufq gharbī ʿarḍ 32* on the west.

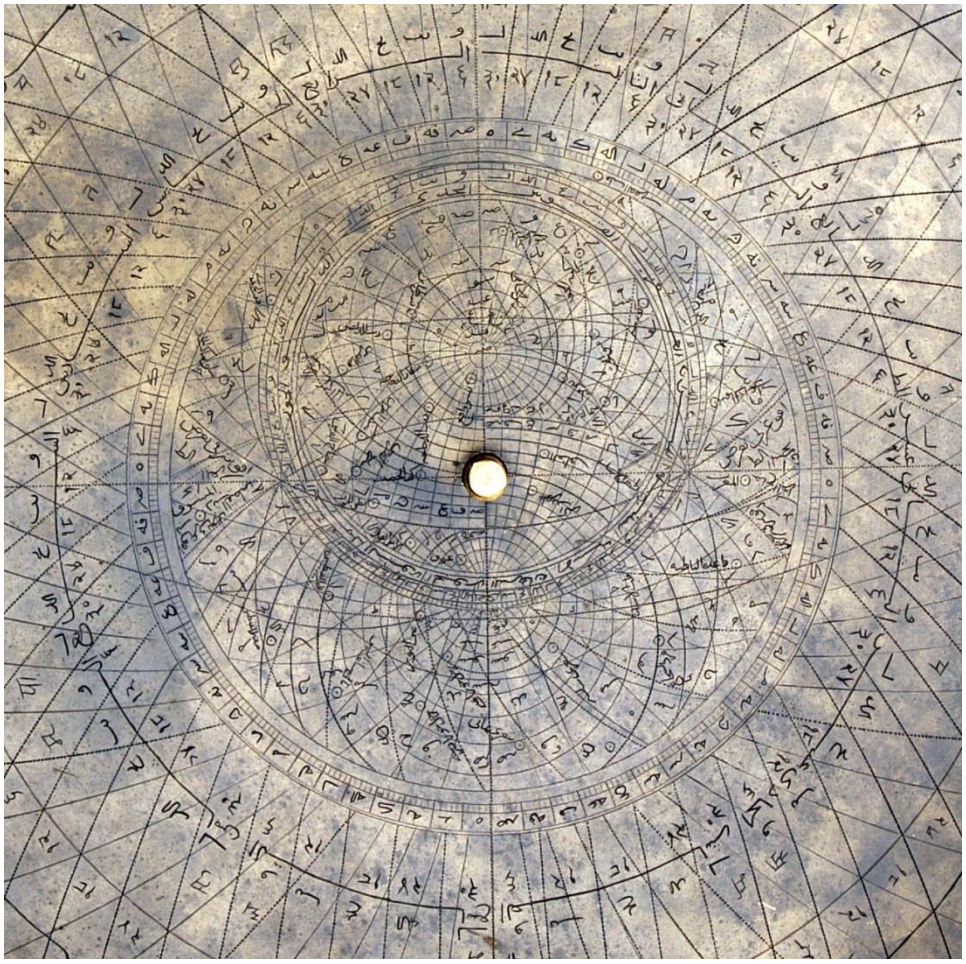


Figure A093.8 – Plate 1a (detail showing the astrological houses and the miniature tablet inside the Tropic of Cancer)
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 53
Photo courtesy of the Khalili Family Trust © Nour Foundation

The rim of the Tropic of Cancer is divided in 360°; each 1° marked and groups of 5° numbered from 5 to 90 counterclockwise, separately for each quadrant. Inside this ring of Cancer a miniature tablet is drawn with smaller versions of the two oblique horizons to match those on the rete, and the corresponding altitude circles. Like the larger horizons drawn across the whole the plate, the oblique horizons in the miniature plate also carry labels on both sides. The ecliptic ring is drawn on this miniatature tablet; it is divided into the 12 signs and labelled with their names. Each sign is divided into groups of 6° and numbered. Some 35 star positons are marked within the Tropic of Cancer with dots enclosed in circles along with their names.



Figure A093.9 – The Designation of Plate 1a
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 53
Photo courtesy of the Khalili Family Trust © Nour Foundation

At the bottom of the plate is a long inscription bearing the designation of this special plate: *ṣafīḥa maṭraḥ al-shuᶜāᶜ keh nazd abī rayhān taswīyat al-buyūt khwānand,* “plate for finding the projection of the astrological rays according to (?) Abū Rayhān [al-Bīrūnī] [and] equalization of the astrological houses”.

Geographical Gazetteer

On the inner face of the mater is engraved the geographical gazetteer with the names of 259 localities (*asmā’ al-buldān*), their longitudes (*al-ṭūl*), latitudes (*al-ᶜarḍ*) and the duration of the longest day (*al-sāᶜāt*) in five circles.[463] Each circle contains four rows of cells to accommodate the four elements of the gazetteer. The cartouche-like cells are created by intertwining chains drawn by two parallel lines.[464] Again in each circle, the design of the cartouches varies. The letters are oriented towards the centre of the astrolabe.

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463 Maddison & Savage-Smith 1997, I, p. 230, erroneously state that the gazetteer contains *inḥirāf,* but that is not the case.

464 The design of the cells as small cartouches has a distinct resemblance to the design in the preceding astrolabe A092.



Figure A093.10 – The Geographical Gazetteer on the Mater (detail)
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 53
Photo courtesy of the Khalili Family Trust © Nour Foundation

This is the largest gazetteer engraved by Ḍiyā’ al-Dīn. As in A062 and A072, this gazetteer is arranged according to regions. The names of the regions are engraved above the names of localities, in narrow bands between the main circles. However, there is an occasional mismatch between the headings mentioning the regions and the localities listed under the heading. For example, Bajja az Barbar (010) is placed in Andalus and not in Sudan where it rightly belongs to, Qulzum (017) is mentioned under Yemen while it is situated in Egypt, and so on. Towards the end of the gazetteer also, certain localities in Makran and Sindh are not correctly placed.

In A062 and A072, the duration of the longest day is not given (*al-sā*^{c}*āt*). This parameter occurs only in Allāhdād’s undated astrolabe (A002) and now again in the present astrolabe.

Table A093-3 Geographical Gazetteer

	Place Name (*asmā’ al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-ᶜarḍ*)**	**(*al-sāᶜāt*)**
	First Circle			
Iqlīmhā Maghrib (the region of the Maghreb)				
1	Sūs Aqṣā	15;30	32;0	14;08
2	Fās Qaṣba Tanja	18;00	22;0	13;22
3	Tāhart ᶜŪliyā’	35;30	29;0	13;53
4	Tāhart Suflī az Farīfta	36;0	29;0	13;53
5	Sijilmasa	37;0	31;30	14;6
6	Qayrawān	41;0	31;30	14;7
7	Mahadiyya	42;0	32;30	14;11
8	Ṭarābulus Maghrib	45;0	32;0	14;8
Andalus (Andalusia)				
9	Qurṭaba Dār al-Mulk Andalus	38;26	35;0	14;25
10	Bajja az Barbar[465]	65;0	14;0	14;54
Sūdān (Sudan)				
11	Jarmī Dār al-Mulk Habasha	65;0	9;30	12;10
12	Durqula Shahr Nūba	53;40	14;30	12;56
Miṣr (Egypt)				

[465] It is wrongly included in Andalus; it belongs to the next region Sudan.

	Place Name (*asmā’ al-buldān*)	L (*al-ṭūl*)	φ (*al-ʿarḍ*)	(*al-sāʿāt*)
13	Qūṣ az Ṣaʿīd Miṣr	61;30	24;30	13;32
14	Iskandariyya	61;54	30;58	14;2
15	Miṣr	63;20	30;20	14;1
16	Dumyāṭ	63;30	31;25	14;5
Yaman (Yemen)				
17	Qulzum az Kanār Darya[466]	64;0	29;30	13;55
18	ʿAdan	76;0	11;0	12;00
19	Ṣanʿā’ Dār al-Mulk Yaman77;0	14;30	12;56	
20	Zubayd	74;20	14;10	12;55
ʿUmān (Oman)				
21	Ṣajā Qaṣba ʿAmmān	84;0	14;20	12;55
22	Madīnat Rasūl ʿAlayhi al-Salām[467]	75;20	25;0	13;35
Hijāz (Hejaz)				
23	Makka Mubārak	77;10	21;40	13;20
24	Ṭā’īf	77;30	21;20	13;18
Baḥrayn (Bahrain)				

466 Qulzum should be placed in Egypt.

467 Should be placed in the next region

	Place Name (*asmā’ al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-ᶜarḍ*)**	**(*al-sāᶜāt*)**
25	Yamāma[468]	82;30	23;30	13;28
26	Hajar Baḥrayn	83;0	25;0	13;36
27	Ḥasā Jazīra	83;30	24;0	13;31
28	Qaṭīf Baḥrayn	75;0	25;0	13;35
Shām (Syria)				
29	Bayt al-Maqdis az Filisṭīn	66;30	31;50	14;6
30	Asqalān az Filisṭīn	66;30	32;15	14;10
31	Ramla az Filisṭīn	66;50	32;10	14;9
32	Qaysāriyya	66;30	32;30	14;11
33	Tiberiyyas	68;0	32;0	14;8
34	Ṣawar	68;30	32;40	14;12
35	Ṣaydā	68;35	32;40	14;12
36	Ṭarābulus	69;40	34;0	14;19
37	Dimashq	70;0	33;15	14;16
38	Baᶜalbak	70;45	33;15	14;16
39	Ḥims	70;45	34;0	14;19
40	Anṭākiyya az Thaghūr	71;26	35;30	14;27
41	Sarmīn	71;7	35;15	14;26
42	Qinnisrīn	72;0	35;30	14;27

[468] It should be in Hejaz.

	Place Name (*asmā’ al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-ᶜarḍ*)**	**(*al-sāᶜāt*)**
43	Ḥalab	72;10	35;50	14;26
44	Mankh	72;15	36;15	14;32
45	Raḥba	74;35	34;10	14;20
46	Ṭarṭūs	68;40	34;42	14;34
Thughūr Rūm (border lands of the Byzantines)				
47	Massīsa wa Kagharyānā	69;15	36;45	14;45
48	Malaṭiya	71;0	37;0	14;36
49	Saqalaba Jazīra Barbar Kinat	65;0	37;10	14;37
50	Rūmiya Kubrā	85;27	41;50	15;6
51	Athīna Madīnat al-Ḥikma	65;40	37;20	14;38
52	Būr Faṭbā (?) wa hua Qasṭantīn	59;50	45;0	15;30
53	Māqadūniyā	60;0	41;0	15;1
54	ᶜAmmūriya	64;0	43;0	15;15
55	Arz ar-Rūm	72;0	39;40	14;52
56	Arzankān	76;0	38;0	14;42
57	Sīwās	71;40	39;0	14;48
58	Sumaysāt	72;35	40;0	14;54
59	Qālīqalā	73;25	39;0	14;48
Jazīra (the region of ancient Mesopotamia)				
60	Qūniya	66;30	41;0	15;1
61	Ḥarrān az Jazīra	73;0	36;40	14;33

	Place Name (*asmāʾ al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-ʿarḍ*)**	**(*al-sāʿāt*)**
62	Raqqa	78;15	36;0	14;30
63	Rās al-ʿAyn	74;0	36;50	14;34
64	Mārdīn	74;0	37;15	14;37
65	Qarqīsiyā	74;40	37;20	14;38
66	Niṣibīn	75;20	37;0	14;36
67	Sinjār	76;0	36;0	14;30
68	ʿĀna	76;30	34;0	14;19
Armīniya (Armenia)				
69	Mawṣil	77;0	34;30	14;21
70	Irbīl	77;20	35;0	14;25
71	Takrīt	78;20	34;30	14;21
72	Amid	73;40	38;0	14;42
73	Malāzjird	75;0	38;45	14;46
74	Akhlāṭ	75;50	39;20	14;50
75	Arjīsh	77;0	38;30	14;44
76	Anī	79;0	41;0	15;1
77	Salmās	79;15	37;40	14;40
78	Khuway	79;40	37;40	14;40
79	Urmiya	79;45	37;0	14;36
80	Marand	80;45	37;50	14;51
Azarbayjān (Azerbaijan)				
81	Nakhjawān	81;15	38;40	14;46
82	Marāgha	82;0	37;20	14;39

	Place Name (*asmā’ al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-ᶜarḍ*)**	**(*al-sāᶜāt*)**
83	Tabrīz	82;0	38;0	14;42
	Second Circle			
Tatimma Azarbayjān (continuation of Azerbaijan)				
84	Ardabīl	82;30	38;0	14;42
Irān				
85	Mūqān	83;0	38;0	14;42
86	Bardaᶜa	83;0	40;30	14;54
87	Jankara	83;0	41;20	15;3
88	Samkūra	83;0	41;50	15;6
89	Tiflis Dār al-Mulk il-Khān	83;0	43;0	15;15
90	Alān	83;0	44;0	15;23
Karkh (the western shore of the Tigris River ?)				
91	Saflān	83;30	39;50	14;52
92	Bākaway	84;30	39;30	14;50
Alān (?)				
93	Shamākhī Qaṣba Shīrwān	84;30	40;50	14;54
94	Bāb al-Ābwāb	85;0	43;0	15;15
Rūs (Russia)				
95	Balanjar Dār al-Mulk Khazar	85;20	46;30	15;42
96	Kūya Madīnat Rūs	87;0	43;0	15;15
97	Saqsīn	86;30	43;0	15;15

	Place Name (*asmā’ al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-ᶜarḍ*)**	**(*al-sāᶜāt*)**
Bulghār (the Bulghars)				
98	Bulghār	90;0	49;30	16;9
99	Buzbāl Mābīn Rūs Bulghār	83;0	44;0	15;23
100	Sarmīn Rāyy	79;0	34;0	14;19
ᶜ*Arāqayn* (the two Iraqs)				
101	Kūfa	79;30	31;30	14;6
102	Madā’in	72;0	33;10	14;15
103	Baghdād	82;0	33;25	14;16
104	Wāsiṭ	81;30	32;20	14;10
105	Baṣra	84;0	30;0	13;58
106	Ubulla	84;0	30;15	14;1
107	ᶜAbbādān	84;30	30;0	13;18
108	Jundīsābūr	84;5	31;15	14;3
Khūzistān (a region of Iran)				
109	Tastīr	84;30	31;30	14;6
110	ᶜAskar Mukram	84;30	31;15	14;5
111	Ahwāz	85;0	31;0	14;3
112	Rāmhurmūz	85;45	31;0	14;3
113	Arrajān	86;30	30;30	14;1
114	Shāpūr	86;55	30;0	13;18
Fārs (Persia, a province in Iran)				
115	Kāzirūn	87;0	29;15	13;53
116	Nawbandjān	87;15	30;10	13;59

	Place Name (*asmā’ al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-ᶜarḍ*)**	**(*al-sāᶜāt*)**
117	Fīrūzābād	87;30	28;10	13;50
118	Sīrāf	88;0	29;0	13;53
119	Shīrāz	88;0	29;36	13;55
120	Iṣṭakhr	88;30	35;0	13;18
ᶜIrāq				
121	Yazd	89;0	32;0	14;8
122	Shahrazūr	82;20	32;30	14;10
123	Hulwān	82;15	34;0	14;19
124	Qirmāsīn	83;0	34;30	14;21
125	Dīnawar Mā’ al-Kūfa	83;0	35;0	14;25
126	Suhraward	83;20	36;0	14;30
127	Nahāwand Mā’ al-Baṣra (?)	83;15	34;20	14;21
128	Zankān	83;40	36;30	14;32
129	Abhar	84;30	36;45	14;34
130	Hamadān	83;0	35;10	14;26
131	Karaj	84;45	34;0	14;19
132	Sāwa	85;0	35;0	14;25
133	Qazwīn	85;0	36;0	14;30
134	Aba	85;0	34;40	14;28
135	Zarbādkān	85;0	34;15	14;20
136	Semīrum	85;40	32;15	14;9
137	Iṣfahān	86;40	32;25	14;10

	Place Name (*asmā’ al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-^{c}arḍ*)**	**(*al-sā^{c}āt*)**
138	Kāshān	86;0	34;0	14;19
Dīlmān				
139	Qumm	85;40	35;45	14;28
140	Rayy	86;20	35;0	14;19
141	Ḥuwār	87;10	35;40	14;29
142	Alamūt	85;37	36;21	14;33
Kīlān (Gilan, a province in Iran)				
143	Ṭāliqān	85;45	36;10	14;31
144	Hūsum az Jīlān	85;10	37;0	14;36
145	Kajūr wa Kalār	86;50	36;25	14;32
146	Dīma Qaṣba Damāwand	87;20	37;10	14;37
Ṭabaristān (or Tapuria, southern coastal region of the Caspian Sea)				
147	Amul Qaṣba Ṭabaristān	88;20	36;15	14;31
148	Sāriya	88;0	37;0	14;36
149	Astarābād	89;35	36;50	14;35
Jurjān				
150	Abaskūn Qaṣba Jurjān	89;30	37;15	14;37
151	Jurjān	90;0	36;50	14;35
152	Samnān	88;0	36;0	14;30
Qūmis (a region in Iran)				
153	Dāmghān	88;55	36;20	14;32
154	Basṭām	89;30	36;10	14;31

	Place Name (*asmā’ al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-ᶜarḍ*)**	**(*al-sāᶜāt*)**
	Third Circle			
Iqlīmhā tatimma Qūmis (continuation of the region of Qūmis)				
155	Biyār	89;50	38;45	14;28
156	Farāwa	90;0	39;0	14;48
157	Marīnān	90;30	37;0	14;36
Khurāsān (Khorasan, a region in Iran)				
158	Sabzawār	91;30	36;5	14;30
159	Nīshābūr	92;30	36;21	14;31
160	Ṭūs	92;30	36;0	14;30
161	Narshī (?)	92;0	35;0	14;25
162	Ṭūs Kīlakī (?)	92;0	33;0	14;3
163	Tūn	92;30	34;30	14;21
164	Qā’īn	93;20	33;40	14;16
165	Ṭabas Masīnā	94;15	33;15	14;14
166	Zūzan	93;30	35;20	14;27
167	Bushaᶜ	94;5	34;50	14;28
168	Harāt	94;20	34;30	14;21
169	Bādghīs	94;30	35;20	14;27
170	Sarakhs	94;30	37;0	14;36
171	Marw ar-Rūd	97;0	36;30	14;32
172	Marw	97;0	37;40	14;39
173	Jūzajān	98;0	35;30	14;27
174	Fāriyāb	99;0	36;45	14;33

	Place Name (*asmā’ al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-ᶜarḍ*)**	**(*al-sāᶜāt*)**
175	Ashbūrqān	105;0	36;45	14;33
176	Balkh	101;0	36;41	14;33
177	Bāmiyān	102;0	34;35	14;20
Khatlān (a province of Tajikistan)				
178	Samankān	102;0	36;0	14;30
179	Qayādyān (?)	102;0	37;45	14;39
180	Walwārij	102;20	36;55	14;34
181	Taliqān az Tukhāristān	102;50	37;25	14;37
Khwārizm				
182	Andarāb	103;45	36;0	14;30
183	Badakhshān	104;24	37;10	14;37
184	Bulūr	108;0	37;0	14;30
185	Būkarkānj	93;0	42;35	15;10
186	Kurkanj Dār al-Mulk Khwarizm	94;30	42;17	15;9
Mā warā’ al-Nahr (what is beyond the [Oxus] river, Transoxonia)				
187	Hazār Asf	95;0	41;0	15;1
188	Kāt	95;0	41;36	15;3
189	Darqān	94;15	39;30	14;50
190	Bukhārā	97;30	39;50	14;52
191	Samarqand	99;16	39;37	14;38
192	Nasaf	98;0	39;0	14;48
193	Kash	99;30	39;30	14;50

	Place Name (*asmā’ al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-ʿarḍ*)**	**(*al-sāʿāt*)**
194	Isfījāb az Shāsh	99;50	43;36	15;12
195	Ṭaraz	99;50	44;31	15;25
196	Abīr Washna (?)	105;0	40;0	14;54
197	Ṣafāniyā	105;30	38;14	14;43
198	Khujand	105;35	41;55	15;6
199	Binkat Qaṣba Shāsh	101;0	43;0	15;15
200	Tūnkat Qaṣba Aylān	101;0	43;25	15;27
201	Akhshikāt Qaṣba Farghāna	101;20	42;25	15;10
	Fourth Circle			
Iqlīmhā tatimma mā warā’ al-Nahr (continuation of of the region of Tansoxania]				
202	Ūzkand	102;50	44;0	15;28
203	Ūsh	102;20	43;20	15;12
204	Kāshghar	106;30	44;0	15;28
Tabaraknān (?)				
205	Jāj wa hua Shāsh	109;0	42;30	15;8
206	Khutan	107;0	42;0	15;8
207	Almāligh	102;30	44;0	15;28
208	Qabāligh	108;0	44;0	15;28
209	Ushsh Kalūrān	110;0	46;0	15;38
210	Pīsh Bāligh	102;0 !	45;50	15;35
211	Qarāqūrūm	112;0	46;0	15;38

	Place Name (*asmā’ al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-^{c}arḍ*)**	**(*al-sā^{c}āt*)**
212	Khān Bāligh	124;0	46;0	15;38
213	Nankyās	130;0	39;0	14;48
Kirmān (a province in Iran)				
214	Mahrī	140;0	30;0	13;58
215	Shīrjān	90;20	29;30	13;55
216	Hurmūz	92;0	25;0	13;35
217	Bardsīr	92;30	29;50	13;57
218	Jīruft	93;0	27;30	13;45
219	Bam	94;0	28;30	13;51
220	Narmāshīr	94;20	29;0	13;53
221	Khabīṣ	93;0	31;0	14;3
222	Zaranj Madīnat Sijistān	90;0	32;30	14;10
Zābalistān (a region in Afghanistan)				
223	Bust	100;0	33;0	14;13
224	Takināhād	101;55	33;20	14;15
225	Maymand	101;55	33;20	14;15
226	Ghazna Qaṣba Zābalistān	104;20	33;35	14;16
227	Banjahīr az Kābulistān	104;40	35;0	14;25
228	Ribāṭ Amīr	105;0	34;0	14;19
229	Tabar Qaṣba Makrān	98;0	26;15	13;41
230	Kīj az Makrān	99;0	28;0	13;49

	Place Name (*asmā’ al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-ʿarḍ*)**	**(*al-sāʿāt*)**
Makrān (coastal strip in the south of Sindh and Baluchistan, Pakistan)				
231	Jālq az Makrān	99;0	30;0	13;58
232	Daybul wa Hūtana ?	102;30	25;10	13;36
233	Manṣūra Qaṣba Sind[469]	105;0	27;40	13;48
234	Tāna az Sāḥil Bahr Hind[470]	102;0	19;20	13;12
Sind (Sindh)[471]				
235	Nahlāwārā	102;30	22;0	13;22
236	Sawmnāt	106;0	17;0	13;2
	Fifth Circle			
Iqlīmhā tatimma Sind (continuation of the region of Sindh)				
237	Mūltān	107;35	29;40	13;46
238	Qandahār	107;40	33;0	14;13
239	Lahūr Dar al-Salṭanat	109;20	31;50	14;54 !
Hind (India, south of the Indus)				
240	Qannawj	102;50	26;35	13;42
241	Bānārasī	117;20	26;55	13;45
242	Sarandīp	130;0	10;0	12;40

469 Manṣūra should be in Sindh.

470 ‘Tāna on the shore of the ocean of Hind’. It is actually Thane, near modern Mumbai; wrongly placed in Makrān.

471 The two places are in Gujarat, i.e., in the region Hind and not in Sindh.

	Place Name (*asmā’ al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-ᶜarḍ*)**	**(*al-sāᶜāt*)**
243	Kashmīr	108;0	35;0	14;25
244	Tubbat	110;0	40;0	14;54
245	Akbarābād Dar al-Khilāfat	114;0	27;0	13;45
246	S[h]āhjahānābād Dar al-Mulk Hind	113;0	28;39	13;52
247	Ajmīr	112;0	26;0	13;31
248	Kawāliyār	115;0	26;29	13;42
249	Burhānpūr	109;0	20;31	13;14
250	Sūrat	110;50	20;15	13;14
251	Dawlatābād	111;0	20;30	13;14
252	Ujjayn	112;0	22;30	13;24
253	Bījāpūr	115;30	17;20	13;42
254	Kūlkandā	114;39	18;4	13;9
255	Dhākā Bankālā	130;0	27;0	13;45
256	Patnā	120;45	26;40	13;44
257	Jawnpūr	119;6	26;36	13;44
258	Munkīr	121;45	26;40	13;44
259	Allāhābād	115;34	26;50	13;44

BACK

On the back of the astrolabe, the two altitude scales on the upper half of the rim contain three concentric bands as on the limb. The innermost band is divided into 0.25°, the middle one into single degrees and labelled in standard Arabic numerals and in the outermost band groups of 3° are marked in *Abjad* notation from 3 to 90, separately in

each quadrant, starting from the east and west points and reaching the south point at the top.



Figure A093.11 – The Back of the Khalili Astrolabe
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 53
Photo courtesy of the Khalili Family Trust © Nour Foundation

On the upper left is the trigonometric quadrant, with 60 equally spaced horizontal parallel lines and the same number of equally spaced vertical parallel lines, with every

third line dotted. Two radial lines divide the quadrant into three segments of 30° each. The 60 vertical lines are numbered along the radius at the bottom of the quadrant, first in standard Arabic numerals from 1 to 60 and then in groups of 3 in *Abjad* notation, both times starting from the apex of the quadrant and then proceeding towards the circumference. The horizontal parallels are numbered in the same manner along the vertical radius on the right.



Figure A093.12 – The Trigonometric Quadrant on the Back
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 53
Photo courtesy of the Khalili Family Trust © Nour Foundation

On the upper right is the solar quadrant, consisting of 90 equally spaced concentric declination arcs, one for each 2° of solar longitude. Every fifth arc is highlighted with dots. The names of the corresponding zodiac signs and the numbers of their subdivisions are engraved along the two radii.



Figure A093.13 – The Solar Quadrant on the Back
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 53
Photo courtesy of the Khalili Family Trust © Nour Foundation

Upon this grid are plotted three sigmoid graphs for the meridian altitude of the Sun throughout the year for the latitudes of 27°, 29° and 32° along with the labels *khaṭṭ nisf al-nahār bi-ᶜarḍ 27* (line of midday at latitude 27°), *khaṭṭ nisf al-nahār bi-ᶜarḍ 29*, and *khaṭṭ nisf al-nahār bi-ᶜarḍ 32* respectively.

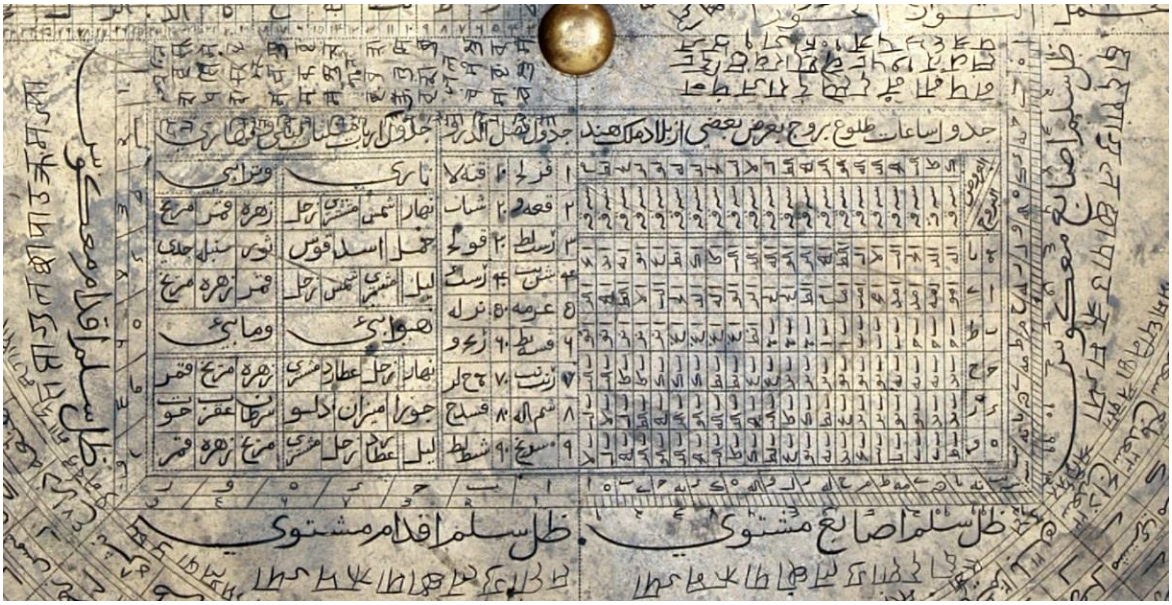


Figure A093.14 – Shadow Squares on the Back
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 53
Photo courtesy of the Khalili Family Trust © Nour Foundation

In the lower half, there are two shadow squares, on the left for a gnomon of 7 feet and on the right for a gnomon of 12 feet. The four scales are divided and numbered accordingly and are accompanied by the following labels:

Vertical scale on the left: *ẓill sullam aqdām maᶜkūs*

Horizontal scale on the left: *ẓill sullam aqdām mustawī*

Horizontal scale on the right: *ẓill sullam aṣabiᶜ mustawī*

Vertical scale on the right: *ẓill sullam aṣabiᶜ maᶜkūs*.

Inside these shadow squares are engraved three tables. The first table from the right is designated as *Jadwal sāᶜāt ṭulūᶜ burūj bi-ᶜarḍ baᶜḍī az bilād mulk Hind* (table of times of rising of the signs for the latitudes of some localities in India). In 8 columns and 23 rows, this table gives the rising times of the signs from latitudes 21° to 40°.[472]

The second table, named *Jadwal faḍl al-dawr*[473] (table of excess of revolution), displays the multiples of differences, in minutes and seconds, between the

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472 Ḍiyā’ al-Dīn’s astrolabe of 1656 at Jai Singh’s Observatory at Jaipur (Table A072-4) has a similar table for the latitudes of 29° to 39°; it is reproduced in Kaye 1918, p. 23; see also Table A092-2.

473 On the astrolabe the name is engraved as *Jadwal faḍl al-darū,* obviously by mistake.

approximately correct length of the tropical year and 365 days.[474] The number of days is written in standard Arabic numerals and the difference in *Abjad* notation.

The third table inside the shadow squares, designated as *Jadwal arbāb al-muthallathāt laylī wa nahārī* (table of regents of the triplicities by day and by night), shows the signs grouped as triplicities and their planetary regents of the day and of the night.[475]

These tables along with the additions in Sanskrit will be discussed in E005.



Figure A093.15 – Scales in the Lower Half of the Back
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 53
Photo courtesy of the Khalili Family Trust © Nour Foundation

474 See Kaye 1918, p. 24; Sarma 2003, pp. 50-52.

475 See Kaye 1918, p. 23, where the same table from Ḍiyā’ al-Dīn’s astrolabe of 1656 at Jai Singh’s Observatory at Jaipur is reproduced.

The rim of the lower half contains two cotangent scales; that on the left is designated as *ẓill aqdām mabsūṭ* (horizontal shadow in feet), with unequal divisions numbered from the vertical radius clockwise from 1 to 24, 26, 28, 30, 33, 36, 42, 48, 54, 64?, 69?, 70, ?, 90, followed by the designation. The scale on the right is named *ẓill aṣābiʿ mabsūṭ* (horizontal shadow in digits), with unequal divisions numbered from the vertical radius counterclockwise as 1-30, thereafter 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 54, 56, 60, 63, 66, 72, 78, 84, 90, followed by the designation.

The space between the rim containing the cotangent scales and the two shadow squares is filled with seven semicircular scales; each two rows are separated by a narrow band.

The first scale, as counted from the outside, consists of three rows. While the third row is filled with the 12 names of the signs of the zodiac, the first row is divided into single degrees and in the second row groups of 5° are numbered, separately for each sign (as, 5, 10, 15, 20, 25, 30).

The remaining scales show various kinds of subdivisions of the signs and their regents or functions: one-twelfth parts (duodenaries, Sanskrit: *dvādaśāṃśa*); [476] one-ninth parts (novenaries, Sanskrit: *navāṃśa*); terms or limits, i.e., one-fifth parts of the signs and the strengths of planets which preside over these limits (the name *ḥudūd miṣriyān* is engraved in the first cell of the row);[477] planets and their domiciles in one-thirds of the signs (the name *darjān kawākib* is engraved in the first cell);[478] and finally the regents of the decans of 10° (the designation *wujūh kawākib* is engraved in the first cell) .[479] The very last semi-circular scale carries the names of 28 lunar mansions in Arabic followed by their serial numbers.

BIBLIOGRAPHY

Fischel 2012.

Sarma 2017.

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476 The *Zarqālī* astrolabe made by Ḍiyā’ al-Dīn in 1680 which is now in Jai Singh’s Observatory [A091] carries a table of duodenaries; it is reproduced in Kaye 1918, p. 125.

477 See Kaye 1918, pp. 122-123; Sarma 2003, p. 49.

478 See Kaye 1918, p. 126.

479 See Kaye 1918, p. 123; Sarma 2003, p. 50.

A094 ASTROLABE ATTRIBUTABLE TO ḌIYĀ' AL-DĪN MUḤAMMAD[480]

Date not available, 17th century

Diameter ?

PLU

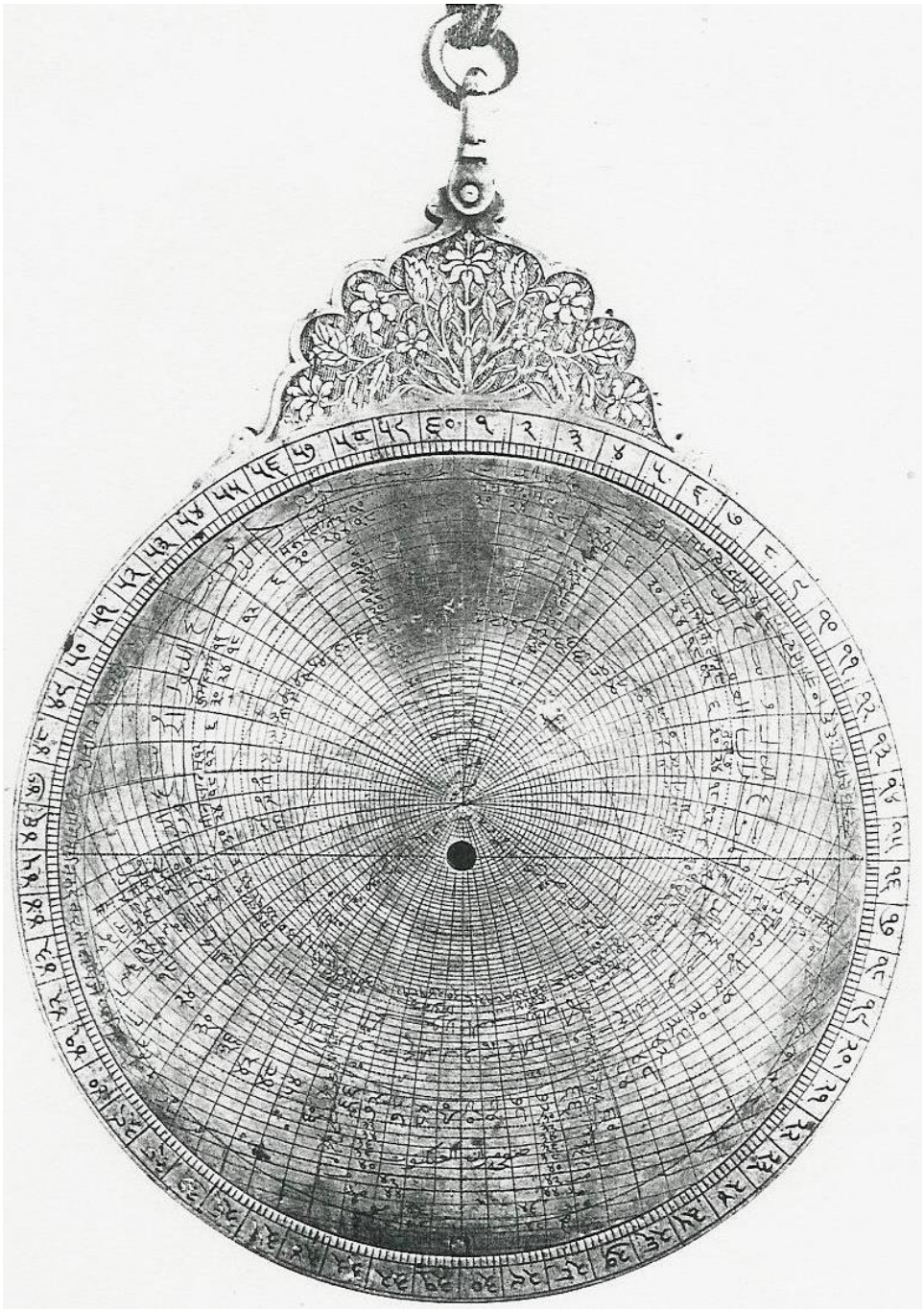


Figure A094.1 – Mater with the plate of ecliptic coordinates
(courtesy Museum of the History of Science, Oxford)

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480 Entry based on two photos in the archives of the Museum of the History of Science, Oxford.

Like the previous astrolabe, this too was reworked with Sanskrit labels, but more elegantly and in a scholarly manner. Even so, here also the name of the maker and the date of production had been erased, but it is easier to identify the maker of this astrolabe. The decoration on the *kursī* with large flowers and leaves points unambiguously to Ḍiyā' al-Dīn. Similar floral decorations can be seen on Ḍiyā' al-Dīn's astrolabes A072, A075, A077 and A092. As in A093, here also three graphs of the solar meridian altitude are traced on the back for the latitudes 27°, 29° and 32°, i.e., for the three Mughal Imperial cities of Agra, Delhi and Lahore. The graph for Delhi began to be engraved on Lahore astrolabe only after 1648 when Shāh Jahān shifted his capital to Delhi and renamed this city as Shāhjahānābād. Therefore, the presented astrolabe must have been produced after 1648. It is not known how large this astrolabe is; it must have been a fairly large one, of about 250 to 300 mm in diameter, in order to accommodate all the astrological scales on the back. A Devanagari inscription added on the back states that there were seven latitude plates (*akṣa-patra*) and one rete (*bha-patra*) in this astrolabe. The two available photos show only of the plate of ecliptic coordinates, besides the back.

In the present entry, the original features of the Indo-Persian astrolabe will be described as far as available; the reworking in Sanskrit and the labels added in Devanagari will be discussed in E004. These two entries must be read together.

Front

The suspensory mechanism includes a cord, a ring and shackle, the last two with a diamond cross-section. The *kursī* is solid with a trifoliate finial and lobed profiles. The front and back of the *kursī* are decorated with slightly different designs of bouquets with large flowers and leaves.

Originally the limb on the front and altitude scales on the back are divided in 1° and 5° and the groups of 5° are separated by dotted lines and numbered in *Abjad* numerals. In the process of reworking, the degree scale on the front is partially ground; the original divisions of 1° are retained, but the original divisions of 5° are replaced by divisions of 6° and numbered in Devanagari from 1 to 60 in accordance with the practice of Sanskrit astrolabes. On the back, the original altitude scales are retained, but Devanagari numerals are added next to the *Abjad* symbols.

PLATE OF ECLIPTIC COORDINATES

On this plate, the ecliptic itself becomes the horizon. Parallel to the ecliptic, latitude circles are drawn for every 2°. Longitude arcs are drawn for every 6°. The names of the 12 zodiac signs are engraved along the ecliptic circle; the 6° divisions are numbered as 6, 12, 18, 24, 30 separately for each sign. A little above the north point is engraved the name of the plate *ṣafīḥat mīzān al-ᶜankabūt.*

BACK

On the back, the rim of the upper half contains altitude scales divided 1° and 5° and labelled as 5---90; 90---5.

The trigonometric graph in the upper left is engraved with 60 horizontal and 60 vertical parallels with every fifth line highlighted with dots. These lines are numbered in 5s from 5 to 60 along both the radii.

In the solar quadrant in the upper right, declination arcs are drawn for every 6° of solar longitude; those for 30° are highlighted with dots. The names of the corresponding zodiac signs and their subdivisions, each of 6°, are marked along the two radii. Three curves of the midday altitude of the sun throughout the year at latitudes 27°, 29° and 32° are drawn across this quadrant, accompanied by labels *khaṭṭ niṣf al-nahār bi-ᶜarḍ 27, bi-ᶜarḍ 29* and *khaṭṭ niṣf al-nahār bi-ᶜarḍ 32* respectively.

In the lower half are drawn two shadow squares, on the left for a gnomon of 12 digits and on the right for a gnomon of 7 feet. The four scales on the left and right are divided accordingly and are accompanied by the following labels:

Vertical scale on the left: *.ẓill sullam aṣābiᶜ maᶜkūs*

Horizontal scale on the left: *ẓill sullam aṣabiᶜ mustawī*

Horizontal scale on the right: *ẓill sullam aqdām mustawī*

Vertical scale on the right: *ẓill sullam aqdām maᶜkūs*

Inside the shadow squares is a rectangular table with the heading *jadwal faḍl al-dawr* (table of excess of revolution).

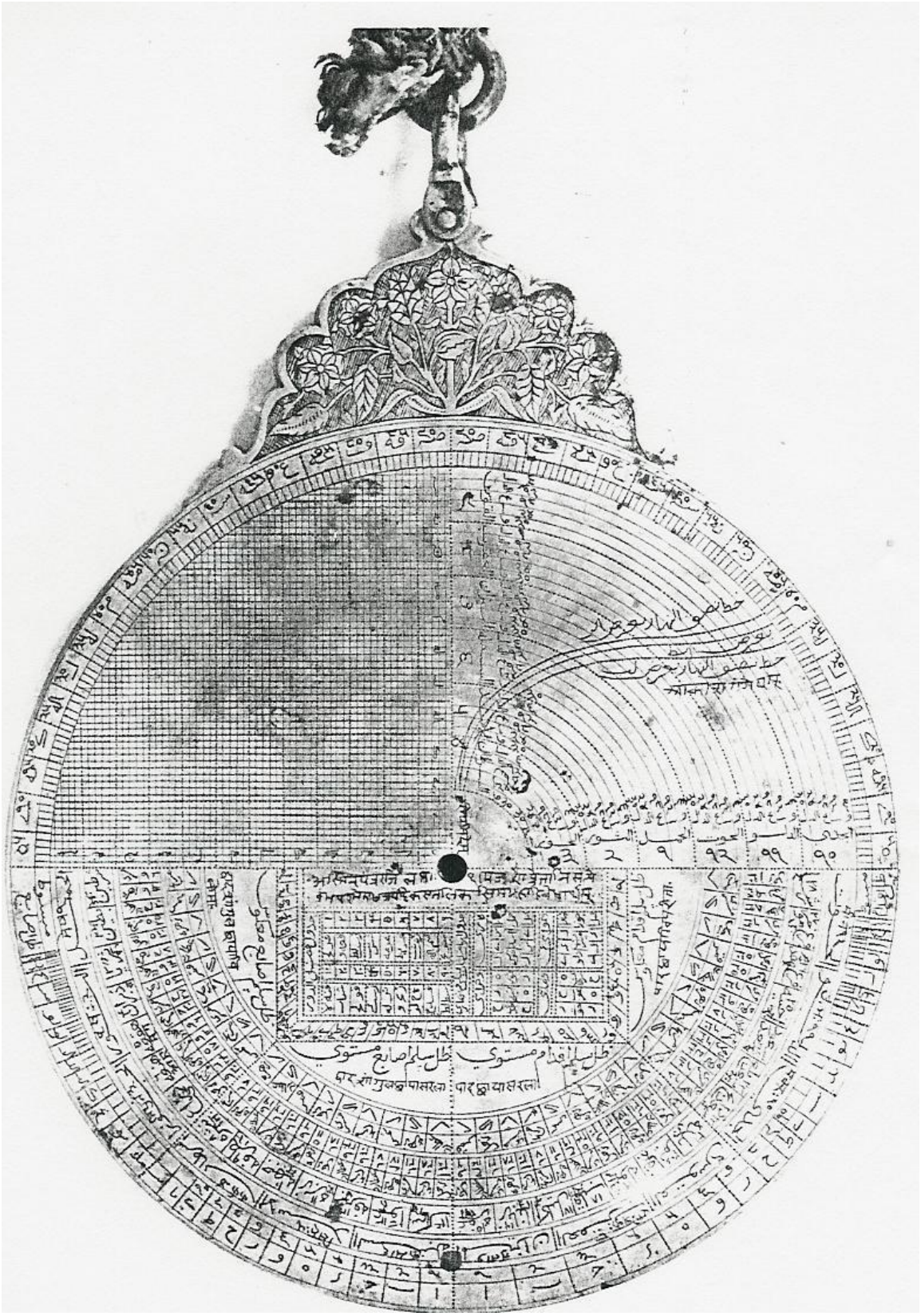


Figure A094.2 – Back of the astrolabe
(photo courtesy Museum of the History of Science, Oxford)

The shadow squares are enclosed by 9 semi-circular scales. Starting from the outside, the first two rows on the rim carry the cotangent scales and their subdivisions,

on the left in digits and on the right in feet. The unequal divisions on the left are numbered 1, 2, 3, … 12, 14, 16, 18, 20, 22, 24, 24 (sic!), 26, 36, 42, 48, 54, 60, followed by the label *ẓill aṣābiᶜ mabsūṭ.* The unequal divisions on the right are numbered 1, 2, 3, … 10, 12, 14, 16, 18, 21, 24, 30, 36, 38, followed by the label *ẓill aqdām mabsūṭ.*

Rows 3 and 4 are engraved with the names of the 12 signs of the zodiac and those of the 28 corresponding lunar mansions.

Rows 5, 6 and 7 contain the table of the limits: in row 5 are the full names of the 5 planetary regents of each sign, in row 6 their individual limits in *Abjad,* and in row 7 their cumulative limits in common Arabic/Persian numerals. For example, the limits of the sign *al-Ḥamal* (Aries) are shown thus:

***Al-Ḥamal* (Aries)**				
Mushtarī (Jupiter)	*Zuhara* (Venus)	*ᶜUṭārid* (Mercury)	*Mirrīkh* (Mars)	*Zuḥal* (Saturn)
6	6	8	5	5
6	12	20	25	30

Finally, in the last two rows are the decans or faces and their regents. The names of the planetary regents are engraved in full in row 8 and the numerical division into the decans 10, 20, 30 are engraved decoratively in a zig-zag manner in row 9. Narrow blank bands are inserted between certain rows so that the engravings in these semi-circular rows do not look too cluttered.

PROVENANCE

The two photos of this astrolabe are in the archives of the Museum of the History of Science, Oxford, in what is known as ‘G. R. Kaye Album’. Kaye is well known for his celebrated study of Jai Singh II astronomical observatories entitled *The Astronomical Observatories of Jai Singh.*[481] In this study, he also described some astrolabes which were collected by Jai Singh and which were preserved in Jaipur in 1918. After his death, his widow gifted a box of photographs to the Museum of the History of Science at

481 Kaye 1918.

Oxford. This box contains several sepia-tinted photographs of the astrolabes described and illustrated by Kaye in his book. Obviously these photographs were made during December 1915-January 1916 when Kaye was in Jaipur. Besides these photographs, there are also the two photographs showing front and back of the present astrolabe. Since this astrolabe is not mentioned by Kaye in his book, he may have acquired these photos after the book was completed.

The scholarly and careful manner in which the Sanskrit inscriptions are added suggests that the reworking may have been done at Jai Singh’s court at Jaipur in the first quarter of the eighteenth century. The astrolabe is not with Jai Singh’s observatory at Jaipur any more. Its present location is unknown.

A095 ASTROLABE ATTRIBUTABLE TO ḌIYĀ' AL-DIN MUḤAMMAD

Not dated, 17th century

Diameter 174 mm

Oxford, Museum of the History of Science (#33411)



Figure A095.1 – Front of the astrolabe (photo by S. R. Sarma)

This astrolabe is not signed, nor dated. It bears on the back sigmoid curves of the midday altitude of the sun for as many as nine different latitudes. Such preponderance

of these curves can be seen in Ḍiyā’ al-Dīn’s astrolabe of 1651 at the Salar Jung Museum, Hyderabad, which is engraved with curves for 8 different latitudes (A067). In the present astrolabe, the geographical gazetteer is arranged according to climates. After mentioning three places that are situated beyond the seventh climate, the gazetteer continues with the names and coordinates of 22 more places belonging mainly to India. Such additions are to the found in some gazetteers of Ḍiyā’ al-Dīn’s astrolabes, in particular the astrolabe made in 1663, now at Patna (A082). Therefore, this astrolabe may be attributed to Ḍiyā’ al-Dīn Muḥammad.

It has some unusual projections on three plate faces: projection for latitude 90°, triple projection for latitudes 0°, 48° and 90°, and a double projection for latitudes 24° and 30° showing the 12 astrological houses pertaining to both these latitudes.

Components

Body with crown (d. 174, h. 198, t. 11), ring and shackle, rete (d. 158) for 44 stars, 7 plates, alidade (length 166) with a sighting tube, pin and horse. All parts are in good condition. The rete and the plates (except no. 7) feel and sound as if they are made of a lighter metal. They are brighter in colour and the engraving on these appears as if written with black ink. Compared to these, the mater is quite heavy; thicker in the middle and tapering towards the edges.

Front

The ring is large with a diamond cross-section; the shackle is trifoliate with a diamond cross-section. The *kursī* is solid and low; it is lobed and terminates in a trifoliate finial. The limb is calibrated for 1° and 6° and labelled clockwise from 6 to 90, separately in each quadrant.

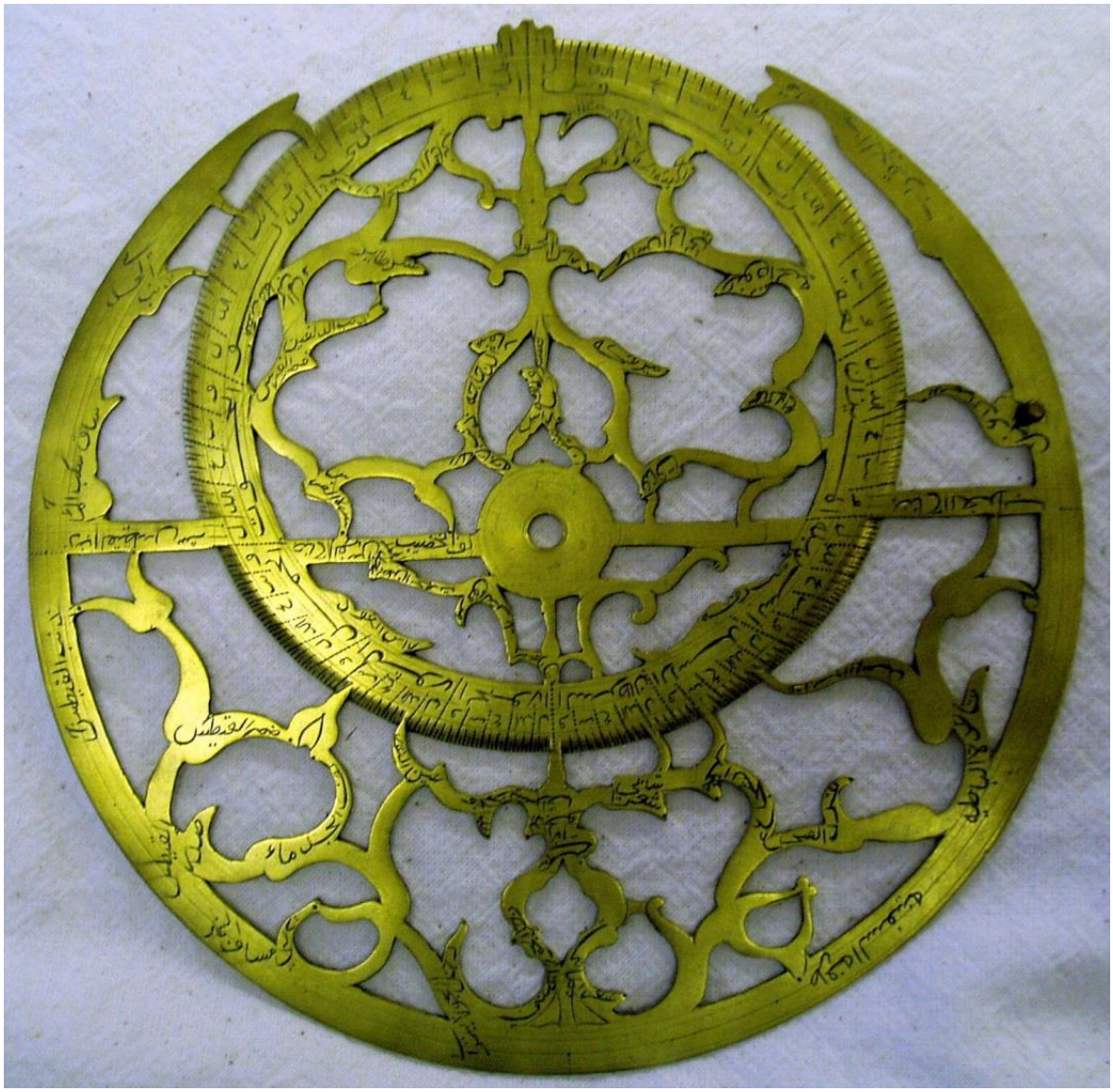


Figure A095.2 – Rete of the astrolabe (photo by S. R. Sarma)

RETE

The peripheral Capricorn ring and the ecliptic ring are held together by the equinoctial bar which has counter changes at its two intersections with the ecliptic ring. A part of the solstitial bar is also shown, joined with several star pointers. The tracery joining the star pointers is not particularly impressive. The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names, each sign is divided in groups of 6° and numbered from 6 to 30; the edge of the ring is marked with divisions of 2° and 1°. There are 44 named star pointers.

Table A095-1 Stars on the Rete

	Star Names	Identification
1	*Dhanab al-Qayṭus J[anūbī]*	β Ceti
2	*Baṭn al-Ḥūt*	β Andromedae
3	*Fam al-Qayṭus*	γ Ceti
4	*Ṣadr al-Qayṭus*	π Ceti
5	*Kaff al-Jadhmā’*	α Ceti
6	*Mirfaq*	α Persei
7	*Masāfat al-Nahr*	γ Eridani
8	*ᶜAyn al-Thawr*	α Tauri
9	*ᶜAyyūq*	α Aurigae
10	*Rijl al-Jawzā’ Yusrā*	β Orionis
11	*Yad al-Jawzā’ Yusrā*	γ Orionis
12	*Yad al-Jawzā’ Yumnā*	α Orionis
13	*Rijl al-Jawzā’ Yumnā*	κ Orionis
14	*Shiᶜrā Yamānī*	α Canis Majoris
15	*Shiᶜrā Shāmī*	α Canis Minoris
16	*Ṭarfat al-Safīna*	ρ Puppis
17	*Mankhar al-Shujāᶜ*	σ Hydrae
18	*Fard al-Shujāᶜ*	α Hydrae
19	*Qalb al-Asad*	α Leonis
20	*Qāᶜidat al-Bāṭiya*	α Crateris
21	*ᶜAnāq*	ζ Ursae Majoris
22	*Janāḥ al-Ghurāb*	γ Corvi
23	*Simāk Aᶜzal*	α Virginis

	Star Names	Identification
24	*Simāk Rāmiḥ*	α Bootis
25	*Nayyir Fakkah*	α Coronae Borealis
26	*ᶜUnuq al-Ḥayyah*	α Serpentis
27	*Qalb al-ᶜAqrab*	α Scorpii
28	*Rukbat al-Ḥawwā*	ζ Ophiuchi
29	*Rās al-Jāthī*	α Herculis
30	*Rās al-Ḥawwā*	α Ophiuchi
31	*Rās al-Tinnīn*	γ Draconis
32	*Nasr Wāqiᶜ*	α Lyrae
33	*Qarn al-Jadī al-Thānī*	α Capricorni
34	*Minqār al-Dajājah*	β Cygni
35	*Nasr Ṭā’ir*	α Aquilae
36	*Dhanab al-Dālfīn* !	ε Delphini
37	*Fam al-Faras*	ε Pegasi
38	*Dhanab al-Dajājah*	α Cygni
39	*Dhanab al-Jadī*	δ Capricorni
40	*Sāq Sākib al-Mā J[anūbī]*	δ Aquarii
41	*Dhanab al-Qayṭus Sh[amālī]*	ι Ceti
42	*Janāḥ al-Faras*	γ Pegasi
43	*Surrat al-Faras*	δ Pegasi
44	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are seven plates with the following specifications.

Table A095-2 Plates

	φ	Longest day
1a	18°	13 hours !
1b	21°	13 hours !
2a	24°	13 hours !
2b	27°	13 hours !
3a	29°	13;52 hours
3b	32°	14;8 hours
4a	34°	14 hours !
4b	36°	14 hours !
5a	26°	13 hours !
5b	0°+ 48°+ 72°	
6a	90°	
6b	24° + 30°	
7a	Plate of ecliptic coordinates	
7b	Plate of horizons	

Plates 3, 4, 7 have two notches each at the north and south points. In 3 and 4 the notch at the south point is unnecessary. The plate of horizons engraved on plate 7 ought to have four notches at the four points of the compass to be fully functional. Strangely the maximum duration of daylight is given inaccurately on plates 1, 2, 4 and 5.

On plates 1 to 5a, altitude circles are drawn for each 1° and every fifth is highlighted with dots. Azimuth arcs are drawn below the horizon for each 6°; those for 30° are dotted and extended above the horizon. Lines for seasonal hours and equal hours are drawn from the western horizon. Both sets are numbered clockwise from the western horizon in *Abjad.* On plate 3 serving the latitudes of 29° (Delhi) and 32° (Lahore), there are additional lines for equal *ghaṭīs* drawn from the western horizon and numbered from there in standard Arabic/Persian numerals from 1 to 34 or 35.

Plate 7 carries the plate of ecliptic coordinates on the obverse with the label *ṣafīḥat mīzān al-ᶜankabūt* and the plate of horizons of the reverse with the label *ṣafīḥa āfāqī.*

Plates 5b, 6a and 6b carry unusual projections which are not met with elsewhere.

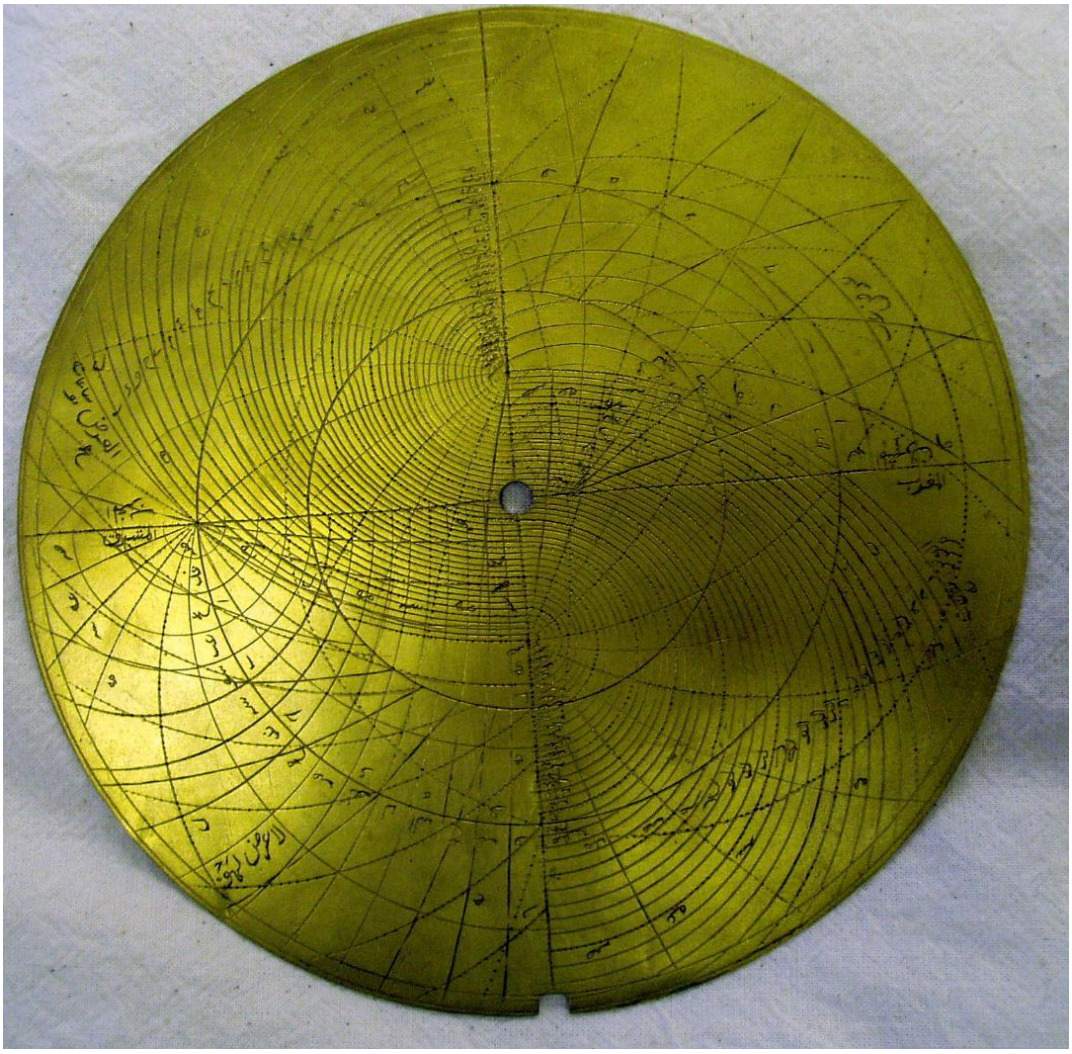


Figure A095.3 – Plate 5b with triple projection for latitudes 0°, 48° and 72° (photo by S. R. Sarma)

Plate 5b contains a combined projection for three latitudes. The lower quadrant on the left is calibrated for the latitude of 0° with altitude circles for every 6°. There is a label *lā ᶜarḍ lahū* (there is not latitude). The upper quadrant on the left carries projections for 48° with altitude circles for every 2°. There is a label *al-ᶜarḍ 48* (latitude 48) and *sāᶜāt 16* (maximum duration of daylight 16 hours). The upper and lower quadrants on the right are engraved with projections for latitude 72° with altitude circles for every 2°. In the upper right quadrant there are also lines for seasonal and equal hours. In both quadrants there are labels declaring the latitude to be 72°.

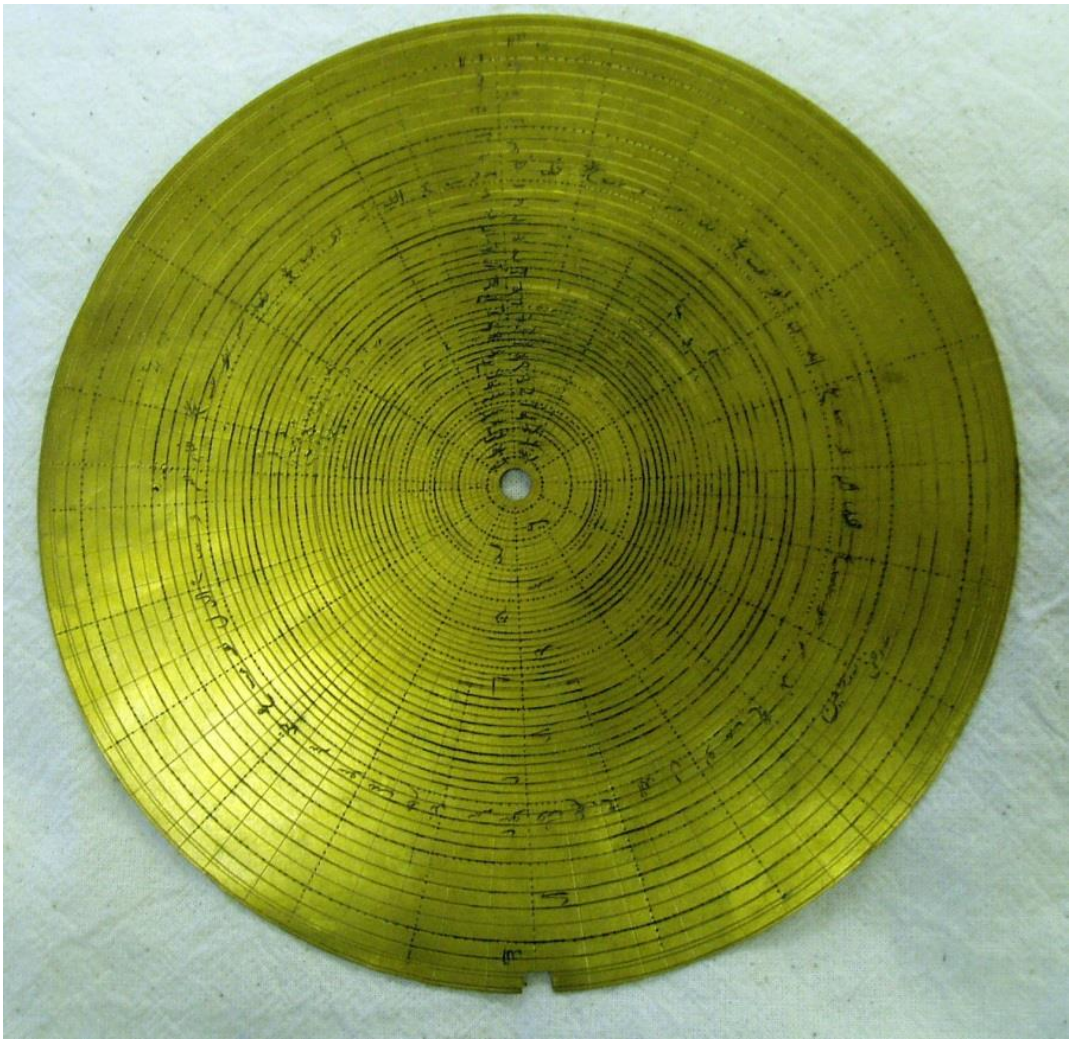


Figure A095.4 – Plate 6a for latitude 90° (photo by S. R. Sarma)

Plate 6a is calibrated for latitude 90°. Here the horizon coincides with the equator; the altitude circles merge with the declination circles and the azimuth circles with the hour lines. Therefore the altitude circles are drawn concentric around the centre; these are drawn at intervals of 2° with every fifth highlighted with dots. The azimuth arcs are radial lines from the centre; these are drawn for every 6°.

There is a label stating *ʿarḍ tisʿūn* (latitude ninety).

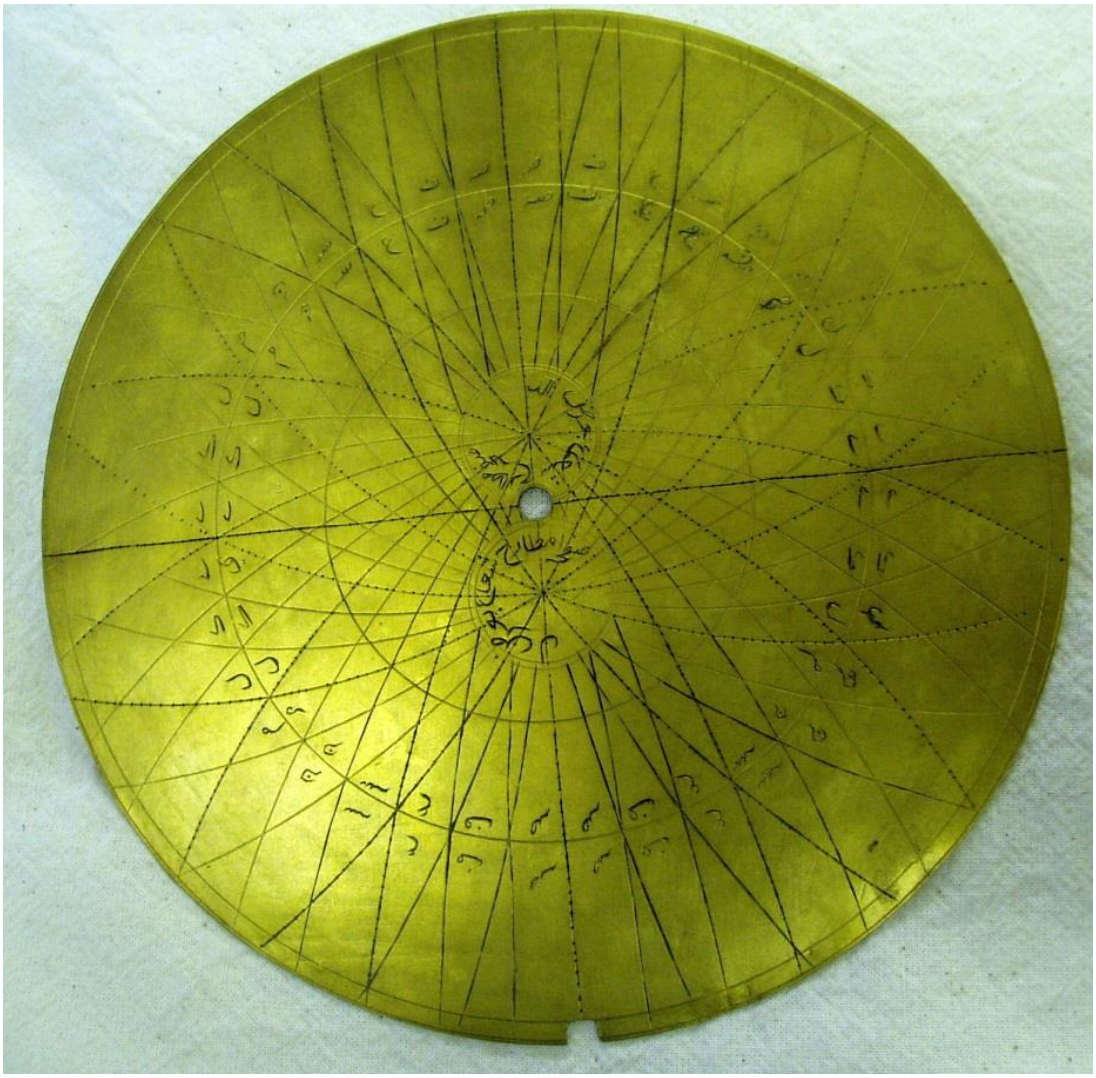


Figure A095.5 – Plate 6b for latitudes 24° and 30° (photo by S. R. Sarma)

Plate 6b carries double projections for latitudes 24° and 30° and shows the 12 astrological houses at both these latitudes. Each house is divided into 10°. These divisions are numbered, separately for each latitude, along the circle of equator as 10—90; 90—10; 10—90; 90—10. Around the centre in the upper half there is a label which reads *ṣafīḥat maṭāraḥ shuᶜāᶜ bi-ᶜarḍ 24* (plate for finding the astrological rays at latitude 24) and in the lower half *ṣafīḥat maṭāraḥ shuᶜāᶜ bi-ᶜarḍ 30* (plate for finding the astrological rays at latitude 30).

Geographical Gazetteer

On the inner surface of the mater, a geographical gazetteer is engraved in four concentric circles with the names, longitudes and latitudes of 119 localities, arranged in the order of climates. However, after mentioning three places which lie beyond the

seventh climate, the gazetteer adds 22 more names of places belonging mainly to India. Such additions are to be found in several gazetteers of Ḍiyā’ al-Dīn.



Figure A095.6 – Geographical Gazetteer (photo by S. R. Sarma)

In the Lahore astrolabes, great care is taken to engrave the gazetteers in different artistic patterns. Such care is not seen in this astrolabe. The circles separating the rows and the lines separating the columns are not engraved to the same depth as the entries themselves, with the result that the data looks much cluttered, as in Ḍiyā’s astrolabe of 1650 (A064) in the Brooklyn Museum. These two gazetteers may have been engraved by some assistants of Ḍiyā’ al-Dīn and not by himself.

Table A095-3 Geographical Gazetteer

	Place Names	L	φ
	First Circle		
[-I] *az khaṭṭ istiwā tā iqlīm awwal* (from the line of equator up to the first climate)			
1	Sāhil Baḥr Awqiyānūs	6;0	0;0
2	Jazīra Qanbula	21;0	3;0
3	Jamkūt	187;0	5;0
4	Thalā	189;0	5;0
5	Kūhkū	54;10	10;10
6	ᶜAdan	76;0	11;0
[I] *iqlīm awwal* (first climate)			
7	Jabal	75;0	13;30
8	Damār	77;15	13;30
9	Bajja Barbar	10;0	14;0
10	Dabīl	74;20	14;10
11	Ṣanᶜā’ Dār al-Mulk Yaman	77;30	14;30
12	Sawmnāt	107;0	17;0
13	Mandū	107;13	22;13
14	Bījāpūr	105;30	17;20
15	Burhānpūr	113;0	20;30
16	Dawlatābād	111;0	20;30
[II] *iqlīm dūyam* (second climate)			
17	Jadda	76;0	21;0
18	Ṭāᶜif	77;30	21;20

	Place Names	L	φ
19	Makkā Muᶜaẓẓama	77;10	21;40
20	Khanbayāt	109;20	22;20
21	Madīnah	75;20	25;0
22	Ajmīr	111.5	26;0
23	Qannawj	115;50	26;35
24	Jawnpūr	119;6	26;36
25	Akbarābād	114;0	26;43
26	Kara [wa] Mānikpūr	118;10	26;49
27	Awadh	118;6	27;22
28	Kawāliyār	119;0	26;29
[III] *iqlīm sīwum* (third climate)			
29	Kūl [wa] Jalālī	114;19	28;6
30	Fīrūzābād	106;30	28;7
31	Sultānkūt	115;0	28;30
32	Shāhjahānābād	113;35	28;39
33	Pānīpat	113;20	28;30
34	Hānsī	112;25	29;45
35	Multān	107;35	29;40
36	Iskandariya	61;54	30;18
37	Miṣr	68;20	30;20
38	Sunām	112;25	31;30
39	Kufa	79;30	31;30
40	Bayt al-Maqdis	66;30	31;50
41	Lāhūr	109;20	31;50

	Place Names	L	φ
42	Yazd	89;0	32;0
43	Iṣfahān	87;40	32;0
44	Qandahār	87;40	33;0
45	Siyālkūt	89;20	33;0
46	Baghdād	82;0 !	33;35
47	Dimashq	70;0	33;0
	Second Circle		
[IV] *iqlīm chahārum* (fourth climate)			
48	Ṭarābulus	69;40	34;0
49	ᶜĀna	76;0	34;0
50	Kāshān	86;0	34;0
51	Mawṣil	77;0	34;30
52	Harāt	94;30	34;30
53	Kābul	104;40	34;30
54	Qumm	85;40	34;45
55	Rayy	86;20	35;20
56	Sāwa	85;0	35;0
57	Kashmīr	108;0	35;0
58	Mashhad Maqdis	92;30	36;0
59	Balkh	101;0	36;0
60	Qazwīn	85;0	35;55
61	Badakhshān	84;24	37;10
62	Ṭāliqān	81;45	36;10
63	Sabzawār	91;30	34;5

	Place Names	L	φ
64	Ḥalab	72;10	35;50
66	Tūn	92;30	37;30
67	Sarakhsh	94;30	37;30
68	Marw	97;0	37;40
69	Tabrīz	82;0	38;0
70	Ardabīl	80;0	38;0
71	Nakhjawān	81;15	38;40
72	Bisṭām	89;30	36;0
[V] *iqlīm panjum* (fifth climate)			
73	Samarqand	99;36	39;37
74	Bukhārā	97;30	39;50
75	Tubbat	110;0	40;0
76	Barda[c]	83;0	40;30
77	Samākhī	84;30	40;50
78	Qūnyia	66;30	41;0
	Third Circle		
tatimma iqlīm panjum (continuation of fifth climate)			
79	Khujand	85;35	41;55
80	Khutan	107;0	42;0
81	Kāshān	101;35	42;0
82	Farghāna	102;0	42;20
[VI] *iqlīm shashum* (sixth climate)			
83	Kashghar	106;30	44;0
84	Bandqīya	92;0	44;0

	Place Names	L	φ
85	Shalkh	85;30	44;0
86	Ṭarāna ?	99;50	44;31
87	Pīsh Bāligh	111;0	44;50
88	Qarāqūrūm	115;0	46;0
89	Khān Bāligh	81;34!	46;0
90	Harqala	67;20	46;30
[VII] *iqlīm haftum* (seventh climate)			
91	Araq	105;0	48;0
92	Bulghār	95;0	49;30
93	Aqjākirmān	92;0	50;0
94	Qirqir	65;10	50;0
[VII+] *khāriz* (beyond [the seventh climate])			
95	Jazā’ir Rūdjard	68;50	60;0
96	Kirmān Mārī	65;45	50;45
97	Ṣūdāq	66;0	51;0
iqlīm ba^{c}ah (?)[482]			
98	Munkīr	121;45	26;40
99	Ilāhābād	115;34	26;50
100	Sūrat	108;50	20;15
101	Kūrakhpūr	119;15	27;20
	Fourth Circle		

[482] I do not understand the superscript. The 22 places that follow are mainly from India and should have been included in the respective climates. The gazetteer in Ḍiyā’s astrolabe of 1663 (A082) also has an addenda of 15 places, many of which are included here.

	Place Names	L	φ
102	Sarandīb	104;0	10;0
103	Bānāras	117;20	26;52
104	Dhākā Bankāla	130;0	27;0
105	Sonār Kānv	131;0	26;0
106	Bharūj	111;0	21;20
107	Sirhind	111;33	30;30
108	Patna	120;45	26;40
109	Rahtās	119;45	26;30
110	Janad	75;30	14;30
111	Zaytūn	114;0	17;15
112	Hurmūz	92;0	25;0
113	Lakhnawtī	114;33	26;30
114	Kūpāmāū	116;33	26;45
115	Badā’ūn	119;39	27;34
116	Kūlkanda	114;19	18;0
117	Bakar[483]	105;0	24;40
118	Baran	114;	28;43
119	Khaybar	75;20	25;20

[483] This and the next two places are engraved inside the fourth circle.



Figure A095.7 – Back of the astrolabe (photo by S. R. Sarma)

BACK

On the back, the degree scale on the rim is much wider than the scale on the limb in the front. The upper half of this scale, meant for measuring the latitude, is divided in 1°, 2° and 6° and labelled as 6—90; 90—6.

In the upper left quadrant is a sexagesimal sine-cosine graph with very finely drawn 60 horizontal parallels and 60 vertical parallels, where each sixth line is highlighted with dots. There are also engraved semi-circles on both the radii to determining the versed sines, 3 quarter circles around the centre at 24 units (the arc of the obliquity of the ecliptic), 12 units (?) and 8 units (?). There is a radial line joining the centre to 45° on the arc and another line joining the inner terminals of the arc.

In the upper right quadrant are drawn declination arcs for each 10° of solar longitude; those representing 30° and thus forming the boundaries between two successive signs are dotted. The names of the corresponding signs are engraved along the two radii; and their subdivisions are numbered in lines parallel to the names of the signs. On this quadrant are drawn dotted arcs of unequal hours, which are numbered from 1 to 6 in anti-clockwise direction and 7 to 12 in the reverse direction. There are also drawn 6 sigmoid curves to show the midday altitude of the sun throughout the year at 6 different latitudes, viz. 21° (Mecca), 24° (Tropic of Cancer), 27° (Agra), 29° (Delhi), 32° (Lahore), 36°(middle of the fourth climate, i.e., the middle of the inhabited world). These show the relation between the sun’s right ascension and the meridian altitude. Only the lowermost curve is accompanied by a full label which reads *khaṭṭ niṣf al-nahār bi-ᶜarḍ 36*. For other curves just the latitude is mentioned *ᶜarḍ 21, ᶜarḍ 24* and so on.

In the lower half are drawn the shadow squares, on the left a gnomon of 12 digits as well as of 60 divisions, on the right for a gnomon of 7 feet. The vertical and horizontal scales on the left are divided into 12 units and numbered from 1 to 12. Each unit is further subdivided into 5 divisions. The vertical scale carries the label *ẓill sittaynī aṣābiᶜ maᶜkūs* (reverse shadows of sexagesimal divisions and [twelve] digits) and the horizontal scale *ẓill sittaynī aṣābiᶜ mustawī* (direct shadows of sexagesimal divisions and [twelve] digits). The vertical and horizontal scales on the right are each divided into 7 units each and are numbered from 1 to 7. Here the vertical scale is accompanied by the label *ẓill aqdām maᶜkūs* (reverse shadows in feet) and the horizontal scale *ẓill aqdām mustawī* (direct shadows in feet).

These shadow squares enclose two rectangular tables. The upper one carries the heading *jadwal arbāb muthallathāt nahārī wa laylī* (table of the regents of the triplicities,

diurnal and nocturnal) and consists of four sub-tables related to the four elements: *nārī* (fiery), *tarābī* (earthy), *hawā'ī* (airy) and *māhī* (watery).

Below this there is a table giving the multiples of difference between the correct length of the year and 365 days. This is table is called *faḍl al-dawr* (excess of revolution). The heading appears to be engraved on the right, but it cannot be read clearly. The multiples given are for each number from 1 to 9 and then for tens from 10 to 90.

The rim of the lower half is engraved with cotangent scales in the outer semi-circular row and their subdivisions in the inner row.

Next two rows are engraved with names of the 12 signs of the zodiac and the names of the 28 corresponding lunar mansions respectively. These are followed by two rows containing the table of the limits of the signs (*al-ḥudūd*) while the last two rows carry the table of faces (*al-wujūh*).

ALIDADE

The alidade has ornate ends and an ornate centre-piece. It carries in the upper register on the right hand side a sexagesimal scale to match with the divisions in the upper left quadrant. In the lower register on the same side is a scale of unequal hours to be used when the alidade is employed as a sundial with the sighting plate on the right as the gnomon. The left hand side of the alidade is marked with a zodiac scale and the serial numbers of the signs to match the divisions in the upper right quadrant.

A096⊙ ASTROLABE ATTRIBUTABLE TO ḌIYĀ' AL-DĪN MUḤAMMAD[484]

Not dated, 17th century

Diameter 140 mm

Chicago, Adler Planetarium (#N 68)

CCA 2604



Figure A096.1 – Front of the Astrolabe
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

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[484] Entry based on Pingree 2009, No. 33, pp. 154-159; the star list has been rearranged according to increasing right ascension.

This elegantly made astrolabe is not signed nor dated. Pingree assigns it to 18th century, without mentioning any reason. But on the basis of the large number of sigmoid curves for the midday altitude of the sun engraved on its back, it can safely be attributed to Ḍiyā’ al-Dīn of the seventeenth century. The geographical gazetteer of this astrolabe is arranged according to climates in the same manner as some of the astrolabes by Ḍiyā’ al-Dīn. All the latitude plates carry lines for *ghaṭīs*, in addition to the usual lines of seasonal hours and equal hours. The maximum duration of the daylight is mentioned both in hours and in *ghaṭīs*.

COMPONENTS

Body with *kursī* (d. 140, h. 185, t. 7.5), shackle and ring, rete for 41 stars, 7 plates, alidade with sighting tube, 2 washers, pin and horse.

FRONT

The ring is plain; the shackle is trifoliate. The *kursī* elegantly reticulated with a large flower in the middle and two tulips with flared petals on either side, with their tendrils overlapping each other. The profiles are made up of ogees at the base and top with two lobes in between, a trifoliate finial at the top. The limb is graduated for 0.30°, 1° and 5° and labelled in 5s from 5 to 360.



Figure A096.2 – Rete of the astrolabe
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

RETE

The peripheral Capricorn ring and the broad ecliptic ring are held together by the equinoctial bar which has counter changes at its two intersections with the ecliptic ring. The ecliptic ring is divided into the 12 signs of zodiac and labelled with their names. Each sign is divided into groups of 6° and numbered from 6 to 30. The edge of the ecliptic ring is divided in 3° and 1°. The star pointers are joined by nearly symmetrical floral tracery.

Table A096-1 Stars on the Rete

	Star Names	Identification
1	*Dhanab a-Qayṭus*	β Ceti

	Star Names	Identification
2	*Baṭn al-Ḥūt*	β Andromedae
3	*Rijl Musalsala*	γ Andromedae
4	*Fam Qayṭus*	γ Ceti
5	*Ṣadr al-Qayṭus*	π Ceti
6	*Rās al-Ghūl*	β Persei
7	*Kaff al-Jadhmā’*	α Ceti
8	*Tālī Masāfat al-Nahr*	γ Eridani
9	*ᶜAyn al-Thawr*	α Tauri
10	*ᶜAyyūq*	α Aurigae
11	*Rijl Jawzā’ Yusrā*	β Orionis
12	*Yad al-Jawzā’ al-Yusrā*	γ Orionis
13	*Yad al-Jawzā’ al-Yumnā*	α Orionis
14	*Rijl Jawzā’ Yumnā*	κ Orionis
15	*Shiᶜrā Yamānī*	α Canis Majoris
16	*Shiᶜrā Shāmī*	α Canis Minoris
17	*Fard al-Shujāᶜ*	α Hydrae
18	*Ẓahr Dubb al-Akbar*	α Ursae Majoris
19	*Qāᶜidāt al-Bāṭiya*	α Crateris
20	*ᶜAnāk*	ζ Ursae Majoris
21	*Janāḥ al-Ghurāb*	γ Corvi
22	*Aᶜzal*	α Virginis
23	*Simāk Rāmiḥ*	α Bootis
24	*Fakkah*	α Coronae Borealis
25	*ᶜUnuq al-Ḥayyah*	α Serpentis

	Star Names	Identification
26	*Minkhār* (?) *Muqaddim*	ρ Serpentis ?
27	*Al-Jathī*	α Herculis
28	*Rās al-Ḥawwā*	α Ophiuchi
29	*ᶜAyn al-Tinnīn*	α Draconis
30	*Rukbat al-Ḥawwā Yusrā*	ζ Ophiuchi
31	*Nasr Wāqiᶜ*	α Lyrae
32	*Minqār Dajājah*	β Cygni
33	*Nasr Ṭā’ir*	α Aquilae
34	*Dhanab Dulphīn*	ε Delphini
35	*Fam Faras*	ε Pegasi
36	*Dhanab al-Jadī*	δ Capricorni
37	*Sāq Sākib al-Mā’*	δ Aquarii
38	*Dhanab al-Qayṭus*	ι Ceti
39	*Mankib Faras*	β Pegasi
40	*Surrat Faras*	δ Pegasi
41	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are seven plates. The first five carry altitude circles for every 1° with each third highlighted with dots. These are numbered in 3s and 6s on both sides. On these plates, azimuth arcs are drawn for every 10° below the horizon and numbered. Lines for seasonal hours are drawn and numbered from the western horizons. Dotted lines for equal hours and equal *ghaṭīs* are also drawn, but there is variation. On plates 1b, 3b, 4a, 4b, 5a, 5b these are drawn from the western horizon and the *ghaṭīs* are numbered from 1 to 30 from the western horizon along the equator. On the remaining plates, viz., 1a, 2a, 2b, 3a, the dotted lines for equal hours and equal *ghaṭīs* are drawn both from the

western and eastern horizons. Accordingly the *ghaṭīs* are numbered 1 to 15 from the western horizon up to the meridian and again from 1 to 15 from the western horizon up to the meridian. Moreover, on all plate faces are engraved the numerical value of the latitudes, and the maximum duration of daylight both in hours and *ghaṭīs* (engraved as *karhā*). In two cases, the *ghaṭī* values are not correctly calculated.

Table A096-2 Plates

	φ	Maximum Duration of Daylight *in hours*	*in ghaṭīs*	*ghaṭīs correct value*
1a	19°	13;11	32;58	32;57,30
2a	21°	13;21	33;22	33;22,30
3a	23;30°	13;24	33;30	33;30
2b	25°	13;25	33;34	33;32,30
4a	27°	13;46	34;25	34;25
5a	30°	13;58	34;55	34;55
4b	32°	14;8	35;8	35;20
5b	35°	14;21	35;52,30	35;52,30
3b	38°	14;50	37;11	37;05
1b	40°	14;54	37;15	37;15
6a	Plate of ecliptic coordinates			
6b	Plate of horizons			
7a	0°+44°			
7b	12°+72°			

Plate 6 is engraved on one side with the plate of ecliptic coordinates with the label *ṣafīḥat mīzān al-ᶜankabūt* and on the reverse side with the plate of horizons with the label *ṣafīḥa āfāqī*.

Plate 7a carries projections for 0° in the upper half with altitude circles for every 2°. Under the straight horizon, there are labels in the east as well as in the west stating *lā ᶜarḍ lah* (there is no latitude). In the two lower quadrants, there are separate projections for latitude 44° with the labels *al-ᶜarḍ 44.* The significance of this latitude eludes us. Plate 7b is engraved with the projections for latitude 72° in the two quadrants on the right; there are labels *al-ᶜarḍ 72* both quadrants. In the two quadrants on the left there are separate projections for latitude 12° with labels to this effect. Again the significance of this latitude eludes us.



Figure A096.3 Geographical gazetteer
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

GEOGRAPHICAL GAZETTEER

The geographical gazetteer provides the names, longitudes and latitudes of 109 places in three circles. The places are arranged according to climates. However, care is not taken arrange the places by increasing latitude within each climate, in particular, in the second climate between nos. 24 and 38. The enumeration begins in the inner circle.

Table A096-3 Geographical Gazetteer

	Place Names *al-bilād*	**L** *al-ṭūl*	**φ** *al-ᶜarḍ*	**Identification / Modern name**
	Inner Circle			
[-I] *az khaṭṭ istiwā* (from the line of equator)				
1	Qanbala Jazīra	21;0	3;5	Madagascar
2	Jamkūt	177;0	5;0	Yamakoṭi
3	Shalā	180;0	5;0	(in China)
4	Ghāna	39;0	10;0	Ghana
5	ᶜAdan	76;0	11;0	Aden, Yemen
6	Sarāndīb	130;0	10;0	Sri Lanka
[I] *al-iqlīm awwal* (the first climate)				
7	Bajja az Barbar	65;0	14;0	(in Somalia)
8	Ṣanᶜā’	77;0	14;30	Sana’a, Yemen
9	Jubla	75;0	13;30	Jubil
10	Janad	75;30	14;30	(in Yemen)
11	Sawmnāt	107;0	22;0	Somnath, India
12	Muᶜjam	74;15	17;15	
13	Jurash	77;50	17;15	Jurash, Saudi Arabia
14	Zaytūn	154;0	17;15	Hangzhou, China
15	Bījāpūr	105;30	17;20	Bijapur, India
16	Ṣuhār	84;15	19;20	Sohar, Oman

	Place Names ***al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***	**Identification / Modern name**
17	Ṭāᶜif	77;30	21;20	Taif, Saudi Arabia
[II] *al-iqlīm al-thānī* (the second climate)				
18	Makka Muᶜaẓẓam	77;10	21;40	Mecca, Saudi Arabia
19	Madīnat Tayyiba	75;20	25;0	Medina, Saudi Arabia
20	Jidda	76;0	21;0	Jeddah, Saudi Arabia
21	Khaybar	75;20	24;20	Khaybar, Saudi Arabia
22	Māhūra	116;0	24;40	Mathura, India
23	Nahlawara	108;20	28;30	Patan, India
	Middle Circle			
tatimma iqlīm al-thānī (continuation of the second climate)				
24	Akbarābād	115;0	26;46	Agra, India
25	Banāras	117;20	26;15	Varanasi, India
26	Kawāliyar	114;0	26;29	Gwalior, India
27	Qannawj	114;50	26;35	Kannauj, India
28	Kara	118;10	26;49	Kara, India
29	Jawnbūr	119;6	26;36	Jaunpur, India
30	Lakhnaw	114;53	26;30	Lucknow, India
31	Badāwān	114;59	27;32	Badaun, India
32	Awadh	118;6	27;22	Ayodhya, India
33	Ajmīr	111;15	26;0	Ajmer, India
34	Kūpāmaw	116;33	26;45	Gopamau, India
35	Burhānbūr	113;0	20;30	Burhanpur, India
36	Dawlatābād	111;0	20;30	Daulatabad, India

	Place Names *al-bilād*	**L** *al-ṭūl*	**φ** *al-ᶜarḍ*	**Identification / Modern name**
37	Aḥmadābād	108;40	23;15	Ahmedabad, India
38	Kanbayāt	109;20	22;20	Cambay, India
[III] *al-iqlīm al-thālith* (the third climate)				
39	Qayrawān	41;0	31;40	Kairouan, Tunisia
40	Maḥdiyya	42;0	32;31	Mahdia, Tunisia
41	Bayt al-Maqdis	66;30	31;50	Jerusalem, Israel
42	Dimashq	70;0	33;15	Damascus, Syria
43	Baghdād	82;0	33;25	Baghdad, Iraq
44	Kūfa	79;30	31;30	Kufa, Iraq
45	Miṣr	63;0	30;20	Cairo, Eqypt
46	Baṣra	84;0	30;0	Basra,Iraq
47	Yazd	89;0	32;0	Yazd, Iran
48	Madā’in	80;20	33;15	Ctesiphon, Iraq
49	Iṣfahān	87;40	32;25	Esfahan, Iran
50	Shīrāz	88;0	29;30	Shiraz, Iran
51	Fīrūzābād	87;30	28;10	Firuzabad, Iran
52	Kirmān	91;30	30;5	Kerman, Iran
53	Hurmūz	92;0	25;0	Hormoz, Iran
54	Siyālkūt	109;0	33;0	Sialkot, Pakistan
55	Lāhūr	109;20	31;50	Lahore, Pakistan
56	Thānīsar	112;33	30;10	Thanesar, India
57	Sunnām	112;25	30;30	Sunam, India
58	Bānīpathah	113;20	28;52	Panipat, India
59	Hānsī	112;25	29;45	Hansi, India

	Place Names *al-bilād*	L *al-ṭūl*	φ *al-ᶜarḍ*	Identification / Modern name
60	Dihlī	113;35	28;39	Delhi, India
61	Kūl [wa] Jalālī	114;19	28;4	Aligarh and Jalālī, India
62	Kūlkanda	114;9	28;4	Golconda = Hyderabad, India
	Outer Circle			
[IV] *al-iqlīm al-rābiᶜ* (the fourth climate)				
63	Karaj	84;45	34;0	Karaj, Iran
64	Tūn	92;30	34;30	Ferdows, Iran
65	Harāt	94;20	34;30	Herat, Afghanistan
66	Kābul	104;0	34;30	Kabul, Afghanistan
67	Qumm	85;40	34;45	Qom, Iran
68	Rayy	86;20	35;0	Shahr Rey, Iran
69	Sāwa	85;0	36;15	Saveh, Iran
70	Kashmīr	108;0	35;0	Srinagar, India
71	Hamadān	83;0	36;10	Hamadan, Iran
72	Ḥalab	72;10	35;50	Aleppo, Syria
73	Mashhad	92;30	36;0	Mashhad, Iran
74	Iskandariyya	61;54	30;58	Alexandria, Eqypt
75	Balkh	101;0	36;51	Balkh, Afghanistan
76	Nīshābūr	92;30	36;21	Neyshabur, Iran
77	Astarābād	89;35	36;50	Gorgan, Iran
78	Qazwīn	85;0	36;55	Qazvin, Iran
79	Badakhshān	104;24	36;10	Faizabad, Afghanistan
80	Marāgha	82;0	37;20	Maragheh, Iran

	Place Names *al-bilād*	**L** *al-ṭūl*	**φ** *al-ᶜarḍ*	**Identification / Modern name**
81	Marw	97;0	37;40	Mary, Turkmenistan
82	Tabrīz	82;0	38;0	Tabrīz, Iran
83	Nakhjawān	81;15	38;40	Nakichevan, Azerbaijan
[V] *al-iqlīm al-khāmis* (the fifth climate)				
84	Samarqand	99;16	39;37	Samarqand, Uzbekistan
85	Baykand	97;30	39;45	Baykand
86	Bukhārā	97;30	39;50	Bukhara, Uzbekistan
87	Tubbat	110;0	40;0	Tibet (Lhasa)
88	Bardaᶜa	83;0	40;30	Barda
89	Shamākhī	84;30	40;50	Shemakha, Azerbaijan
90	Qūnya	66;30	41;0	Konya, Turkey
91	Khujand	105;35	41;55	Leninabad, Uzbekistan
92	Ḥajāj	84;0	42;0	
93	Khutan	107;0	42;0	Khotan
94	Farghanā	102;0	42;20	Fargana, Uzbekistan
95	Īlāq	99;10	43;20	Angren, Uzbekistan ?
[VI] *al-iqlīm al-sādis* (the sixth climate)				
96	Kashghar	106;30	44;0	Kashghar, China
97	Bindiqiyya	42;0	44;0	Venice, Italy
98	Ṭarāz	99;50	44;31	Dzhambul, Kazakhstan
99	Bīsh Bāligh	111;0	45;50	Pochangtse
100	Khān Bāligh	124;0	46;0	Beijing, China
101	Haraqla	67;20	46;30	Eregli, Turkey

	Place Names *al-bilād*	L *al-ṭūl*	φ *al-ᶜarḍ*	Identification / Modern name
[VII] *al-iqlīm al-sābiᶜ* (the seventh climate)				
102	Araq	105;0	48;0	
103	Akla	108;0	49;0	
104	Bulghār	90;0	49;30	Bulgars
105	Aqjaḥ	62;0	50;0	Belgorod Dnestrovsky
106	Qirqir	65;30	50;0	
[VII+] *khārij iqlīm sābiᶜ* (beyond the seventh climate)				
107	Mārī	65;45	50;40	
108	Rudjard Jazā’ir	62;0	Hebrides	
109	Ṣūdāq	66;0	51;0	Sudak

BACK

On the back the rim of the upper half carries the altitude scales which are divided in 0;30°, 1° and 5° and labelled in 5s as 5—90; 90—5. The upper left quadrant is engraved with 60 horizontal and 60 vertical parallels, forming the sines and cosines for each one part of the Radius. Here each fifth line is emphasized with dots. In the upper right quadrant, declinations arcs are drawn for each 5° of solar longitude. The names of the corresponding zodiac signs are engraved along the two radii, together with the numerical value of the subdivisions of the signs as 6, 12, 18, 24 and 30. In this quadrant there are also curves for the midday altitude of the sun throughout the year at nine different latitudes. This is the highest number of curves to be found in the Lahore astrolabes. Their latitude values are engraved along the arc of the quadrant as 19°, 27°, 32°, 36°, 40°, 44°, 49°, 56° and 60°. Below the curves is the label *khuṭūṭ niṣf al-nahār bi-ᶜurūḍ mawḍūᶜah* (lines of midday at local latitudes).

In the lower half there are shadow squares, on the left for a base of 12 and on the right for a base of 7. The related scales, which are divided and numbered accordingly, are accompanied by the usual labels.



Figure A096.4. – Back of the astrolabe
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Inside the shadow squares there are two tables; on the left is the table of excess of revolution (*faḍl al-dawr*) for 1, 2, 3 … 9 and 10, 20, 30 … 90 years. Here the engraver made a mistake and engraved 11, 12, 13, 14, 15, 16, 17and 18 in the place of 10, 20, 30, 40, 50, 60, 70 and 80. On the right is the table of the planetary lords of the triplicities arranged according to the four elements.

The rim of the lower half carries the cotangent scales and their subdivisions in two semi-circular rows. Then follow two semi-circular rows with the names of the 12 zodiac signs and those of the 28 lunar mansions, two rows showing the planetary lords of the terms and the last two rows indicating the planetary lords of the decans.

ALIDADE

The alidade has ornate ends and an ornate centre-piece and is equipped with a sighting tube. The right half is engraved with a sexagesimal scale in the upper register and a scale of seasonal hours on the lower register. The left half carries a zodiac scale with the signs marked by their serial numbers.

BIBLIOGRAPHY

Pingree 2009, No. 33, pp. 154-159.

A097 ASTROLABE ATTRIBUTABLE TO ḌIYĀ’ AL-DĪN MUḤAMMAD

Not dated, 17th century

Diameter 202 mm

PLU, ex-Paris, Brieux



Figure A097.1 – Front of the Astrolabe (from the catalogue of Nouveau Drouot)

This astrolabe is not signed, nor dated. But it may be attributed to Ḍiyā' al-Din because of four sigmoid curves of the midday altitude of the sun engraved on the back and because of the very large number of star pointers on the rete.

Components

Body with *kursī* (d. 202, h. 298, t. 16), ring and shackle, rete for 90 stars, 8 plates, alidade, pin and horse.

Front

The ring is large and plain and the shackle is trifoliate. The *kursī* is solid with lobed profiles. The degree scale on the limb is divided in 1°, 3° and 6°. The groups of 6° are numbered in *Abjad* from 6 to 360 in the outer band, while the groups of 3° are numbered in common Arabic/Persian numerals (not in 'chiffres indiens' as the catalogue states) from 3 to 90, separately in each quadrant.

Rete

The Capricorn ring and the ecliptic ring are held together by the floral tracery which joins the star pointers. The equinoctial bar is represented as two small fragments to the east and west of the ecliptic ring and the solstitial bar just inside the ecliptic ring. There are said to be as many as 90 named star pointers. This is the largest number in the Lahore astrolabes. Unfortunately the photos printed in the catalogue do not allow the decipherment of the names.

Plates

There are said to be 8 plates serving latitudes between 21;40° and 36°, besides the tablet of the ecliptic coordinates and the plate of horizons. There is said to be also a plate on which the astrological houses are marked. Perhaps this is similar to the plate 6b in astrolabe A095 (Figure A095.5) at the Museum of the History of Science at Oxford.

Geographical Gazetteer

A geographical gazetteer with the names, longitudes and latitudes of 127 places is engraved in four circles on the inner side of the mater.

BACK

The rim of the upper half carries the altitude scales which are divided, like the degree scale on the limb, in 1°, 3° and 6°. Also like the degree scale in the front, here also groups of 6° in the outer band are labelled in *Abjad* from 6 to 90 as 6—90; 90— 6. The groups of 3° in the middle band are numbered in common Arabic/Persian numerals from 3 to 90 as 3—90; 90—3.

There is a close resemblance between this astrolabe and the astrolabe A095 in the manner in which the four quadrant are designed. The upper left quadrant is engraved with 60 vertical and 60 horizontal parallels, with every sixth highlighted with dots. As in the astrolabe A095, here also are engraved semi-circles on both the radii, 3 quarter circles around the centre at 24 units (the arc of the obliquity of the ecliptic), 12 units (?) and 8 units (?). There is a radial line joining the centre to 45° on the arc and another line joining the inner terminals of the arc.

In the upper right quadrant are drawn declination arcs for each 10° of solar longitude; those representing 30° and thus forming the boundaries between two successive signs are dotted. The names of the corresponding signs are engraved along the two radii; and their subdivisions are numbered in lines parallel to the names of the signs. There are also drawn 4 sigmoid curves to show the midday altitude of the sun throughout the year at 4 different latitudes, viz. 27° (Agra), 29° (Delhi), 32° (Lahore), 36°(middle of the fourth climate, i.e., the middle of the inhabited world). These carry the labels *ʿarḍ 27, ʿarḍ 29, ʿarḍ 32* and *khaṭṭ niṣf al-nahār bi-ʿarḍ 36°*.

In the lower half, there are shadow squares. On the left is the square for 12 digits and 60 divisions. The vertical and horizontal scales are divided into 12 units each; each unit is again subdivided into 5 divisions. These are numbered in 5s from 5 to 60. The vertical scale is accompanied by the label *ẓill sullam sittaynī aṣābiʿ maʿkūs* and the horizontal scale by *ẓill sullam sittaynī aṣābiʿ mustawī.*

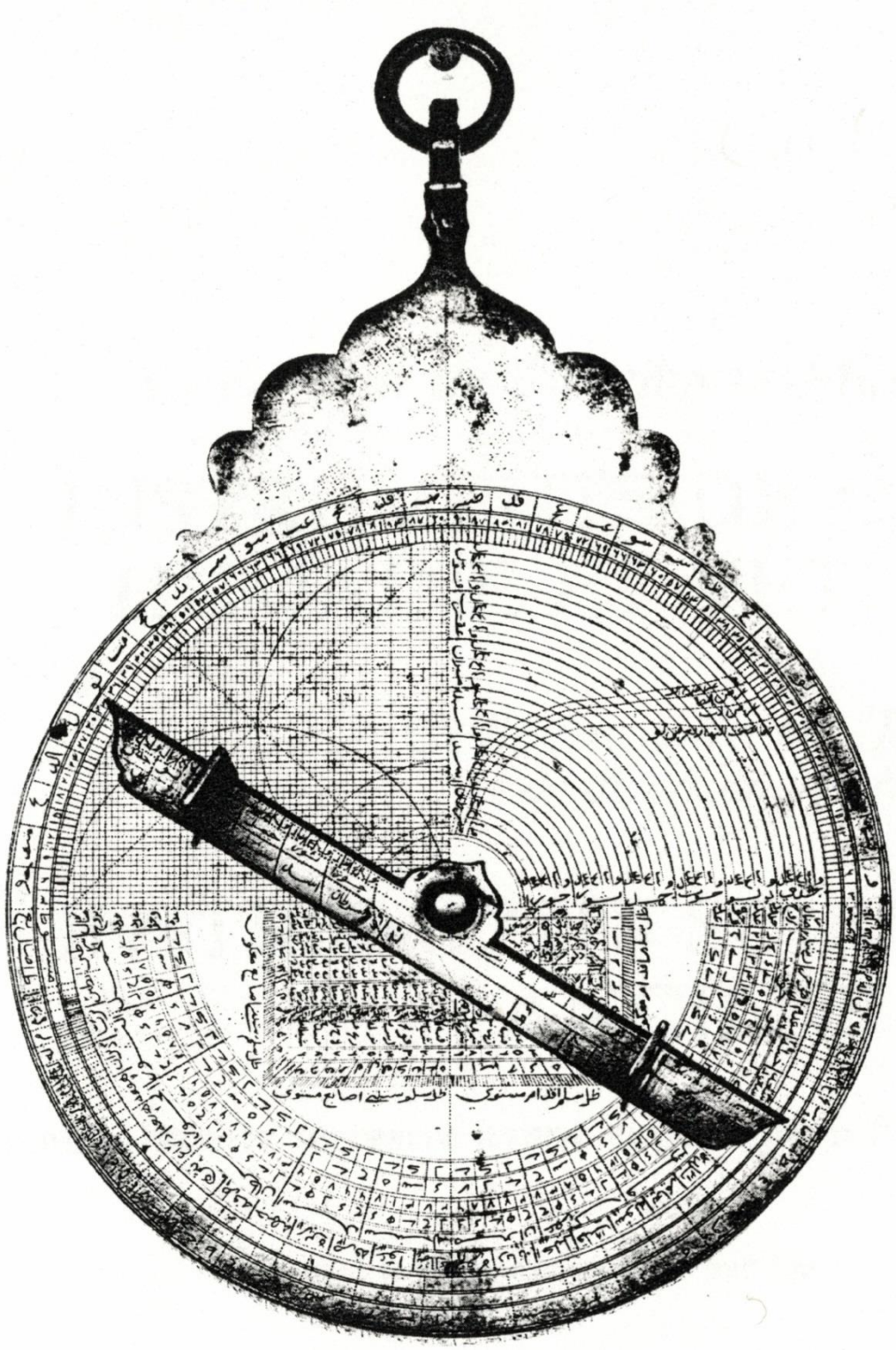


Figure A097.2 – Back of the Astrolabe (from the catalogue of Nouveau Drouot)

On the left is the square for 7 feet. Here the vertical and horizontal scales are divided into 7 units each and numbered from 1 to 7. Then, very unusually, each unit is further subdivided into 7 divisions. The vertical scale is accompanied by the label *ẓill sullam aqdām maᶜkūs* and the horizontal scale by *ẓill sullam aqdām mustawī.*

The shadow squares enclose several astrological tables. It is difficult to identify them in the available photos, especially because a large part is obscured by the alidade.

The rim of the lower half carries the cotangent scales and their subdivisions in three semi-circular rows. These are followed by 6 semi-circular rows. Interestingly, to the left and right of each row is a label stating the contents of the particular row. Thus the first row has the label *manājil* and carries the names of the 28 lunar mansions together with their serial numbers in common Arabic/Persian numerals. The second row has the label *burūj* and has the names of the 12 signs of the zodiac. The third row carries the label *ḥudūd* and carries the last syllables of the names of the five planetary lords governing the five limits of each sign. The fourth row has the label *adad* (number) and displays the numerical value of the five limits of each sign. The fifth row is labelled *wujūh* and has the last syllables of the names of the planetary lords of the decans while the sixth row has the label *adad* (number) and displays the numerical values of the three decans of each sign, viz. 10, 20 and 30.

Alidade

The alidade is well crafted with ornate ends and an ornate centre piece. The right arm carries a sexagesimal scale and the scale of unequal hours, while the left arm is engraved with the zodiac scale, the names of the signs and their subdivisions of 6°.

Provenance

Came up for auction at Nouveau Drouot, Paris, on 28 April 1982, lot 82; later included in Alain Brieux’s catalogue of November 1983, no. 14.

Bibliography

Catalogue of Nouveau Drouot, Paris, on 28 April 1982, lot 82, with the photos of the front and back.

Catalogue of Alain Brieux, Paris, of November 1983, no. 14, p. 32, with the same text as above, but with the photo of the front.

A098 ASTROLABE ATTRIBUTABLE TO ḌIYĀ' AL-DĪN MUḤAMMAD[485]

Not dated, 17th century

Diameter 80 mm

PLU, ex-London, Sotheby's (auction 24 October 2007, lot 196)



Figure A098.1 – Front of the astrolabe (© Sotheby's, London)

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485 Entry based on Sotheby's auction catalogue of 24 October 2007, lot 196, pp. 186-187.

This astrolabe is neither signed, nor dated, but the finely reticulated *kursī* shows that it is the work of Ḍiyā’ al-Dīn. In particular, the motif of the central flower with three elongated petals and the decorative engraving on the surface occurs in some of the astrolabes signed by Ḍiyā’ al-Dīn (A066, A070 and A071). There are several unusual features in this astrolabe. In the rete, both the equinoctial bar and the ring of the ecliptic are counter-changed at the equinoxes. The Sotheby’s catalogue says that this is ‘a feature not known from any other astrolabe’. But it can be seen in the astrolabe attributable to Qā’im Muḥammad (A014) and in the astrolabe with the *qibla*-indicator made by Ḥāmid in 1686 (A112). The degree scale on the limb is also somewhat unusual. The most unusual feature, however, is the configuration on the back where the lower half contains projections of an astrolabe plate for latitude 27° (Agra). Since special emphasis is given in this manner to Agra, and since in the upper half there are solar meridian altitude curves only for latitudes 27° (Agra) and 32° (Lahore) and not for 29° (Delhi), this astrolabe may have been produced before the Mughal capital was shifted to Delhi in 1648.

COMPONENTS

Body with *kursī* (d. 80, h. 102), shackle and ring, rete for ca. 25 stars, 5 plates, alidade, pin and horse.

FRONT

The reticulated *kursī* is elegantly crafted with decorative engravings on the surface on the front and on the back. The finial of the *kursī* is trifoliate, so also the shackle.

The limb carries three registers. The inner register is divided into 1°. The middle one is divided in 5° and labelled clockwise as 5, 10, 5, 20, 5 … 5, 90, separately in each quadrant. The *Abjad* symbols are written with their tops oriented towards the centre. In the outer register groups of 15° (= 1 hour) are numbered serially with common Arabic/Persian numerals from 1 to 12: on the right hand side, starting at the south point and proceeding clockwise up to the north point; on the left hand side, starting at the south point and proceeding anti-clockwise up to the north point. This is also an unusual feature, not met with in any Lahore astrolabe.

RETE

As mentioned above, both the equinoctial bar and the ecliptic ring are counter-changed at their two intersections at the equinoxes. The ecliptic ring is divided into the 12 signs of the zodiac and their names from Aries to Virgo are engraved on the outer band of the ring and the names from Libra to Pisces on the inner band. Each sign is divided into units of 6° and the numbers are engraved on the inner band of the ecliptic ring in the lower half and on the outer band in the upper half. This is exactly how it was done also in A014 and in A112.

The star pointers are joined by an almost symmetric floral tracery. The motif of the trifoliate flower in the *kursī* is repeated in the rete also, precisely below the *kursī* on the meridian line. The names of the stars engraved on the pointers are often drastically abridged. The following 25 names are listed in the Sotheby’s catalogue, to which we add the modern identifications.

Table A098-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus*	β Ceti
2	*Ṣadr al-Qayṭus*	π Ceti
3	*Ghūl*	β Persei
4	*[ᶜAyyū]q*	α Aurigae
5	*Tālī Masāfat al-Nahr*	γ Eridani
6	*Rijl al-Yusrā*	β Orionis
7	*Rijl al-Yumnā*	κ Orionis
8	*Yamānī*	α Canis Majoris
9	*Shāmī*	α Canis Minoris
10	*Muqaddam*	α Geminorum
11	*Fard*	α Hydrae
12	*Qalb Asad*	α Leonis
13	*Qā’idat al-Bāṭiya*	α Crateris

	Star Name	Identification
14	*ᶜAnāq*	ζ Ursae Majoris
15	*Ṣarfa*	β Leonis
16	*Fakkah*	α Coronae Borealis
17	*Aᶜẓal*	α Virginis
18	*Ḥayyah*	α Serpentis
19	*Jāthī*	α Herculis
20	*[Wā]qiᶜ*	α Lyrae
21	*Minqār Dajājah*	β Cygni
22	*Ṭā’ir*	α Aquilae
23	*Sāq Sākib al-Mā’ J[anūbī]*	δ Aquarii
24	*Mankib*	β Pegasi
25	*Khaḍīb*	β Cassiopeiae

PLATES

The catalogue does not specify which two sides belong to which plate. Therefore, the ten sides of the five plates are listed below serially. It is not known whether the tenth side contains the plate of ecliptic coordinates or the plate of horizons.

Table A098-2 Plates

	φ	Longest Day
1	28°	13;52 hours
2	29°	13;55 hours
3	32°	14;8 hours
4	33°	14;12 hours
5	35°	14;29 hours

	φ	Longest Day
6	37°	14;36 hours
7	39°	14;47 hours
8	32;30°	14;6 ! hours
9	34°	14;17 hours
10	?	

The selection of these latitudes is also unusual; it is incomprehensible which locality is specified by the latitude 32;30°. On these plates, altitude circles are drawn for every 6°. Azimuth arcs are drawn for every 10°; in plates 1 to 7, below the horizon and in others above the horizon.

Lines for seasonal hours are drawn on all plates. Dotted lines for equal hours vary:. On plates 1and 2, these are drawn both from the western and the eastern horizons up to the meridian. On plates 3 to 7, they are drawn from the western horizon. On plates 8 and 9, besides the lines drawn from the western horizon for the equal hours, there are also lines for each 15 minutes.

Geographical Gazetteer

The gazetteer engraved on the inner side of the mater lists 68 localities with their longitudes and latitudes.

Back

On the back, the altitudes scales on the upper half of the rim are divided in 1°, 3° and 6° by dotted lines and labelled in 6s as 6---90; 90---6. In the upper left is the trigonometric quadrant with 30 horizontal parallels, each third dotted. The solar quadrant on the right is divided into 6 zones by declination arcs. The corresponding signs are marked by their serial numbers along the two radii. Two curves for the midday altitude of the sun throughout the years are drawn for latitudes 27° (Agra) and 32° (Lahore) with the labels *ʿarḍ 27* and *ʿarḍ 32*.

The shadow squares, instead of being drawn in the lower half, are superimposed on the upper two quadrants, on the left for the base of 7 and on the right for the base of 12 with incomplete labels.

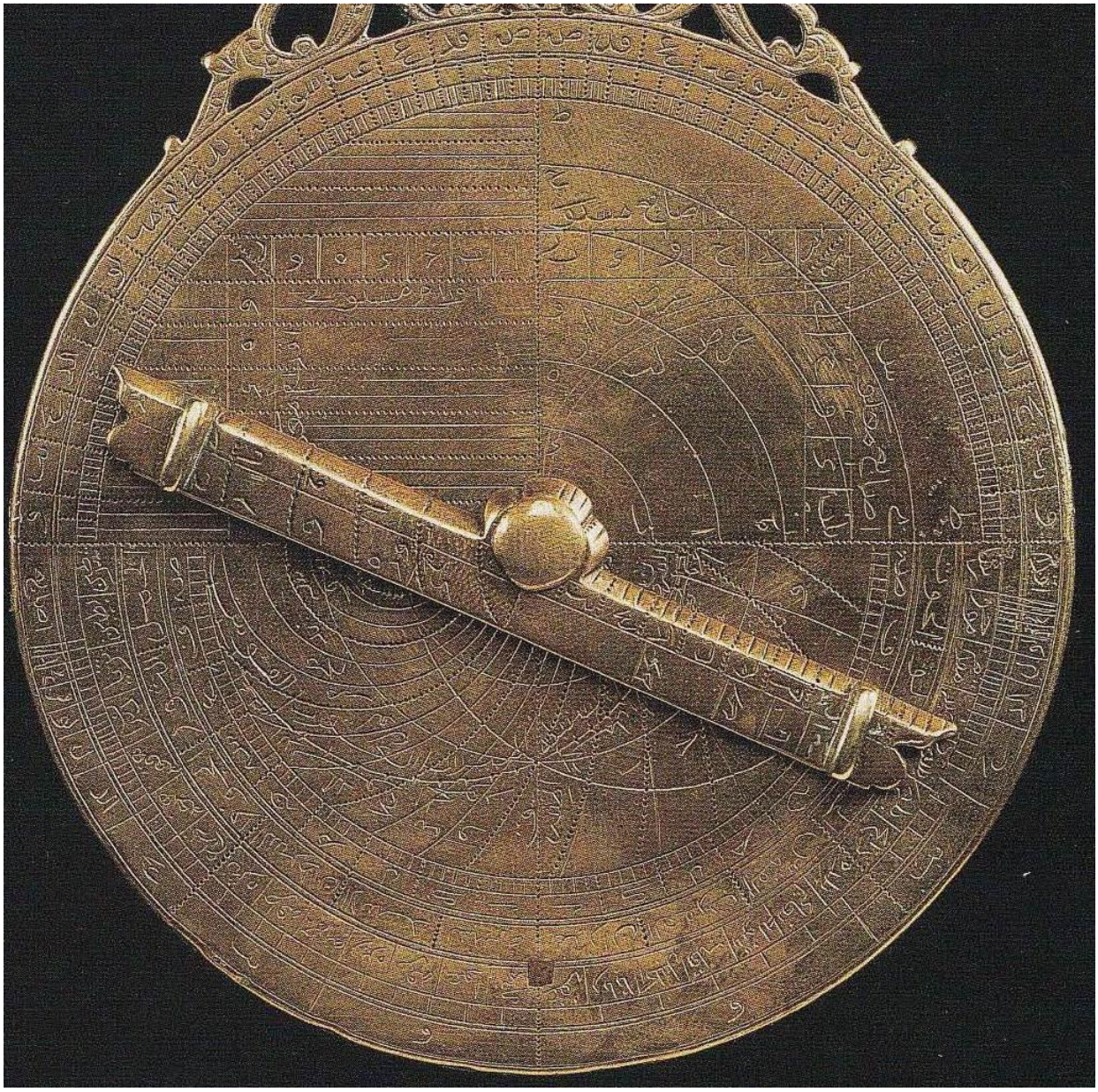


Figure A098.2 – Back of the astrolabe (© Sotheby’s, London)

The lower half the back is the most extraordinary feature of this astrolabe. It is engraved as the left half of a plate for latitude 27° with the altitude circles for each 6°(every third dotted) and with dotted lines for the equal hours before sunrise. Moreover, the circle of ecliptic is drawn along with the names of the 6 signs *al-Saraṭān* to *al-Qaws*. These projections are framed by a degree scale, divided in 2° and 10° and labelled in 10s, from 90 to 10 (from the south point to the east point) and again from 10

to 90 (from the east point to the north point). With this configuration, the standard operations can be performed by means of the alidade as is done on an astrolabe quadrant.

The rim of the lower half contains cotangent scales, on the left for digits and on the right for feet. Inside these scales are two semi-circular rows with the names of the 28 lunar mansions and those of the corresponding 12 zodiac signs.

ALIDADE

The alidade has ornate ends and an ornate centre-piece. The edge of the right hand side carries a sexagesimal scale, divided in 2 and 6 units and numbered in 6s from 6 to 60 from the centre onwards. The left hand side bears a zodiac scale marked with the serial numbers of the signs. In the lower register on the right is a universal scale for seasonal hours when the alidade is used as a sundial. The wedge appears to be horse-shaped.

A099⊙ SHIP ASTROLABE ATTRIBUTABLE TO ḌIYĀ' AL-DĪN MUḤAMMAD

Not dated, 17th century

Diameter 150 mm

Oxford, Museum of the History of Science (#33796)

CCA 90



Figure A099.1 – Front of the Astrolabe (photo by S. R. Sarma)

This unsigned and undated astrolabe can be attributed to Ḍiyā' al-Dīn Muḥammad because of the *zawraqī* horizons and masts on the rete and the four sigmoid curves of the midday altitude of the sun on the back. As will be shown below, latitude 29° of Delhi receives special emphasis in this astrolabe. This would indicate that the astrolabe was created after 1648 when the Mughal capital was shifted from Agra to Delhi. Although *zawraqī* horizons for the latitudes of 29° and 36° are incorporated in the rete, no plate was designed for the use with these *zawraqī* horizons. Instead there is a plate calibrated for 29° in the usual manner on which the positions of 40 stars are marked along with their names. A gazetteer of 69 localities is engraved on the inner side of the mater and another gazetteer of 15 places is engraved on the edge of the astrolabe. This too is unusual.

There is a certain affinity between this and the astrolabe A095 because the plates in both astrolabes look as if they are gilded; both contain a plate in which astrological houses are drawn for latitudes, and the maximum duration of the daylight is given as 13 hours or 14 hours for several latitudes.

Components

Body with *kursī* (d. 150, h. 180, t. 14), ring and shackle, rete (d. 130) for 46 stars, 8 plates (d. 130), alidade (l. 135), pin and wedge. The rete is heavily corroded, but the other parts are in good condition.

Front

It is a heavy instrument, the womb slighting tapering towards the centre. The ring has an octagonal cross-section, but not well formed; two ends are not welded together. The shackle is heavy, diamond cross-section, trifoliate form, with large bases. The reticulated *kursī* looks as if it is truncated at the top; it is very unusual among the *kursīs* in the Lahore astrolabes. But from the truncated top rises a trifoliate finial. Decorative lines are engraved on the surface on both the sides.

The degree scale on the rim is divided in 1° and 6° and numbered in 6s from 6 to 360 clockwise.

RETE

The peripheral Capricorn ring and the ecliptic ring are held together by the equinoctial and solstitial bars, both completely represented, the former with a counter change at its eastern intersection with the ecliptic ring.

The rete is thicker in the middle and tapers towards the periphery. It looks as if coated with a gold-coloured layer, but the layer is peeling off in places because of corrosion. It is difficult to read in many places. There is a handle on the peripheral ring some 36° west of the north point.

The ecliptic ring is divided into the 12 signs of the zodiac, engraved with their names; each sign is subdivided into 5 parts and numbered in 6, 12, 18, … 30.



Figure A099.2 – Rete with *zawraqī* horizons (photo by S. R. Sarma)

As in Ḍiyā’ al-Dīn’s astrolabe of 1663 (A082), in this astrolabe also two mutually intersecting arcs are incorporated at the middle of the rete. While in the former astrolabe

they are shown only inside the ecliptic circle, here they are extended up to the Capricorn ring on either side. Together with the segments of the solstitial bar, they resemble the outlines of ships with their masts. The arc with the convex side to the north is the oblique horizon for latitude 29°. The eastern and western halves of the arc carry the labels *ufq mujassam sharqī bi-ᶜarḍ 29* (eastern solid horizon for latitude 29) and *ufq mujassam gharbī bi-ᶜarḍ 29* (western solid horizon for latitude 29) respectively. The mast corresponding to this arc, i.e., the solstitial bar above the central hole, has the inscription *shaẓiya yatiru zawraq fawq al-ᶜard* (pointer spanning the *zawraqī* horizons above the earth).

The other arc, with the convex side to the south is the oblique horizon for latitude 36°. The two halves of this arc carry the labels *ufq mujassam sharqī bi-ᶜarḍ 36* (eastern solid horizon for latitude 36) and *ufq mujassam gharbī bi-ᶜarḍ 36* (western solid horizon for latitude 36). Its mast, i.e., the solstitial bar below the central hole, bears the label *shaẓiya yatiru zawraq taḥta al-ᶜard* (pointer spanning the *zawraqī* horizons below the earth). The equinoctial bar carries the labels *mastarat tarbī' sharqī* (eastern perpendicular rule) in the east *mastarat tarbī' gharbī* (western perpendicular rule) in the west.

Other *zawraqī* astrolabes (like A013, A082 and A093) contain a plate specially designed for use with the *zawraqī* horizons. There is no such plate in this astrolabe. But on the plate for 29°, the positions of the same stars are marked for which there are pointers on the rete. These star pointers, as Gunther remarks, 'are quite unlike those of any other astrolabes' of the Lahore family. In his effort to incorporate the *zawraqī* horizons and their masts, the astrolabe maker did not pay much attention to the star pointers and joined them to the various arcs and to the solstitial bar by indifferent extensions.

PLATES

There are eight plates with the following functions. Some are heavier than the others.

Table A099-1 Plates

	φ	longest day
1a	18°	13 hours!
1b	21°	13 hours!
2a	20°	13 hours!
2b	22°	13 hours!
3a	24°	13 hours!
3b	26°	13 hours!
4a	27°	13 hours!
4b	32°	14;8 hours
5a	34°	14 hours!
5b	38°	14 hours!
6a	Plate of ecliptic coordinates with the label *ṣafīḥat mīzān al-ᶜankabūt*	
6b	Plate of horizons with the label *ṣafīḥa āfāqī*	
7a	0°+72°+90°	
7b	29°+32° with astrological houses	
8a	29° with many star positions	13 hours!
8b	36°	14 hours!

The maximum duration of the daylight for the latitude of Lahore at 32° given correctly as 14;8 hours. For other latitudes, it is given either as 13 hours or as 14 hours, which is indeed very strange.

On these plates, as in A095, the lines are well drawn. They look as if drawn with black ink on bright golden background. Likewise the unusual plate 7a has a parallel in A095.

On plates 1-5, altitude circles are drawn for every 3° and labelled on both sides; every fifth of these is dotted. Azimuth arcs are traced for every 10° below the horizon. For every 30°, they are drawn above and below the horizon, with the lower part dotted. There are lines for seasonal hours and lines of equal hours drawn from the western horizon. Both sets are numbered from the western horizon.

Plate 4 for the two imperial cities of Agra (27°) and Lahore (32°) is heavy. 4a for 27° carries projections as above, but 4b made for 32° carries equal *ghaṭī* lines. In order to make space for these below the horizon, azimuth arcs for every 10° are drawn above the horizon. Those for 30° are extended below the horizon as well, but as dotted lines. Equal hour lines are drawn from the western horizon as dotted lines and numbered in *Abjad* system. Equal *ghaṭī* lines are also drawn from the western horizon, but as plain lines and numbered in common Arabic/Persian numerals from 1 to 35.

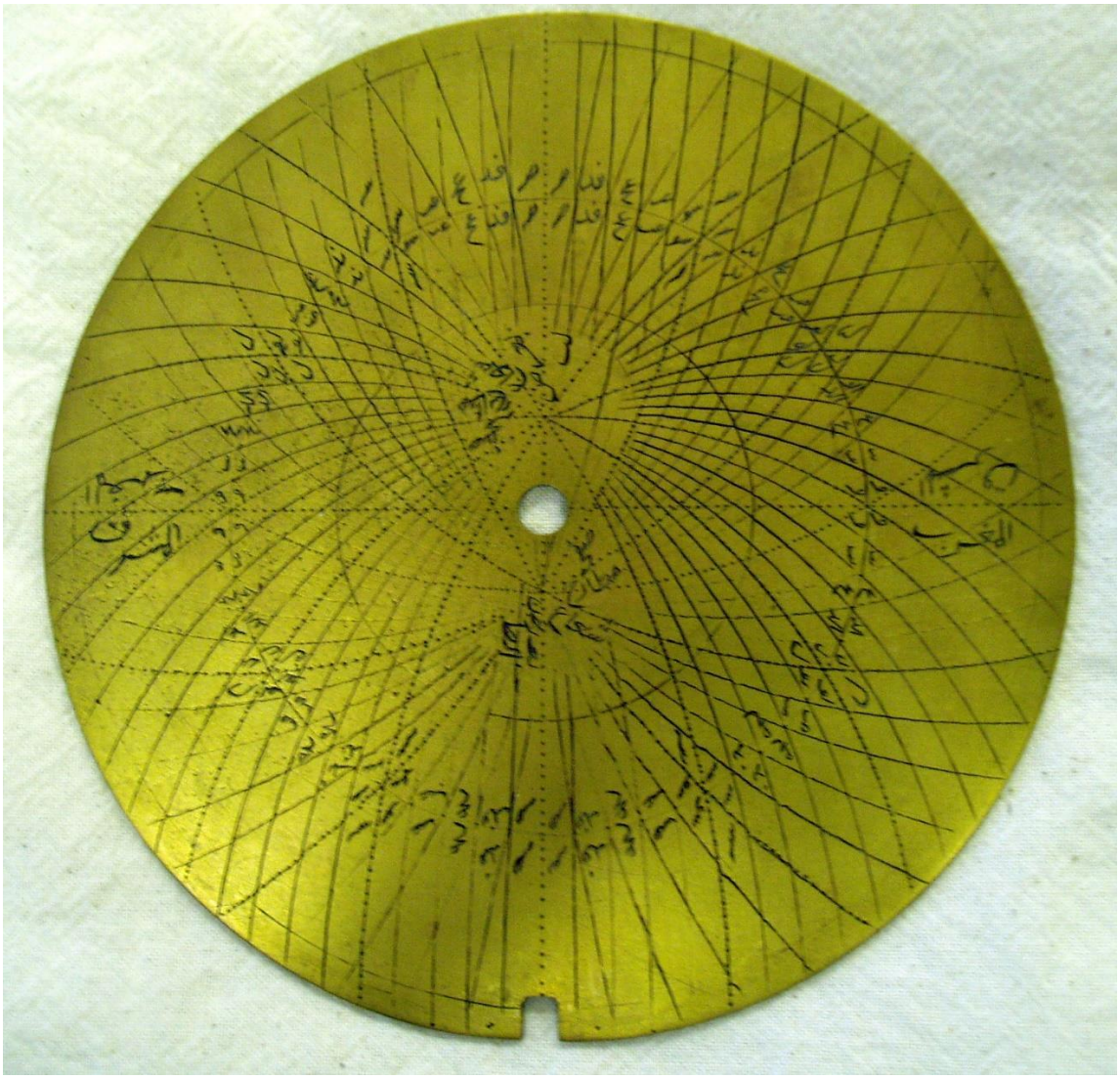


Figure A099.3 – Plate for 32° and 29° with astrological houses (photo by S. R. Sarma)

Plate 7b

The upper half is devoted to latitude 32° and carries the label *safīḥah muṭāraḥ shaᶜāᶜ bi-ᶜarḍ 32* and the lower part is devoted to 29° and carries the label *safīḥah muṭāraḥ shaᶜāᶜ bi-ᶜarḍ 32* (in A095, it is for 24° and 30°). The astrological houses are drawn for both the latitudes and each house divided in 6°.



Figure A099.4 – Plate for 29° with star positions (photo by S. R. Sarma)

Plate 8a

The plate is heavier than the others, slightly tapering towards the periphery. It is calibrated for latitude 29°. Altitude circles are drawn for every 3° and labelled on both sides of the meridian. Azimuth arcs are drawn at intervals of 10° below the horizon and at intervals of 30° above the horizon. There are lines for seasonal hours, numbered from

the western horizon onwards. Dotted lines for equal hours are drawn from the western horizon and numbered from there.

Superimposed on these projections is the ecliptic ring which is divided into the 12 zodiac signs and labelled with their names. Each sign is divided into groups of 6° and numbered 6, 12, 18, … 30, and again into units of 2°.

Finally positions of 46 stars are marked with dots enclosed in circles. These marks appear to have been punched and not engraved. Six of these are without names. The remaining 40 are accompanied by their names. A juxtaposition of the rete and this plate (see Figure A099.1 above) shows that the stars marked on this plate are the same as those marked on the rete. The names of the 40 named stars are tabulated below, as usual, in the order of increasing right ascension.[486]

Table A099-2 Stars on Plate 8a

	Star Name	Identification
1	*Dhanab al-Qayṭus Sh[amālī]*[487]	ι Ceti
2	*Dhanab al-Qayṭus J[anūbī]*	β Ceti
3	*Ṣadr al-Qayṭus*	π Ceti
4	*Tālī Masāfat al-Nahr*	γ Eridani
5	*ᶜAyn al-Thawr*	α Tauri
6	*ᶜAyyūq*	α Aurigae
7	*Rijl Yumnā*[488]	κ Orionis
8	*Yad Yumnā*	α Orionis
9	*Rijl Yusrā*	β Orionis

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486 This plate shows close resemblance to the back of an astrolabe by ᶜUmar ibn Dawlatshāh ibn Muḥammad al-Kirmānī in 726 AH (AD 1325-26); see Linton 1980; no. 163, pp. 90-91; see also King 2005, p. 57, Fig. 5.1.3.

487 This star should in the northern hemisphere.

488 The sequence of these four stars in Orion is not correct.

	Star Name	Identification
10	*Yad Yusrā*	γ Orionis
11	*Shiᶜrā Yamānī*	α Canis Majoris
12	*Shiᶜrā Shāmī*	α Canis Minoris
13	*Ṭarfat al-Safīna*	ρ Puppis
14	*Minkhir Shujāᶜ*	σ Hydrae
15	*Fard al-Shujāᶜ*	α Hydrae
16	*Qāᶜidat al-Bāṭiya*	α Crateris
17	*Ṣarfa*	β Leonis
18	*Janaḥ al-Ghurāb*	γ Corvi
19	*Simāk Aᶜzal*	α Virginis
20	*ᶜAnāq*	ζ Ursae Majoris
21	*Simāk Rāmiḥ*	α Bootis
22	*Fakkah*	α Coronae Borealis
23	*ᶜUnuq al-Ḥayyah*	α Serpentis
24	*Qalb al-ᶜAqrab*	α Scorpii
25	*Rukbat Yusrā*	ζ Ophiuchi
26	*Jāthī*	α Herculis
27	*Al-Ḥawwā*	α Ophiuchi
28	*Tinnīn*	γ Draconis
29	*Yad al-Muqaddam*	α Ophiuchi
30	*Nasr Wāqiᶜ*	α Lyrae
31	*Minqār al-Dajājah*	β Cygni
32	*Nasr Ṭā’ir*	α Aquilae
33	*Dhanab al-Dulfīn*	ε Delphini

	Star Name	Identification
34	*Dhanab al-Dajājah*	α Cygni
35	*Dhanb al-Jadī*	δ Capricorni
36	*Fam al-Faras*	ε Pegasi
37	*Sāk Sākib al-Mā’ J[anūbī]*	δ Aquarii
38	*Mankib al-Faras*	β Pegasi
39	*Surrat al-Faras*	δ Pegasi
40	*Kaff al-Khaḍīb*	β Cassiopeiae

GEOGRAPHICAL GAZETTEERS

There are two geographical gazetteers in this astrolabe. A larger one of 69 localities is engraved on the inner side of the mater in three circles, with the tops of the letters oriented towards the centre. A second gazetteer of 15 localities is engraved on the 14 mm wide edge of the astrolabe, starting from the top on the left and going up to the top on the right. Here the entries are in single file, the place name, longitude and latitude written one below the other. Apparently the second one was also engraved by the same person who took care to see that the length of each entry on the edge coincides with the 6° division on the rim, as can be seen in the photo below. But four places are repeated in the second gazetteer; these are marked with an asterisk*.



Figure A099.5 – The two geographical gazetteers, the first on the inner side of the mater and the second on the edge (photo by S. R. Sarma)

Table A099-3 Geographical Gazetteer

	Place Names *al-bilād*	**L** *al-ṭūl*	**φ** *al-ᶜarḍ*
	First circle		
1	Qayrawān	41;0	31;40
2	Miṣr	63;20	30;20
3	ᶜAdan	76;0	11;0
4	Madinat Ṭayyiba	75;20	25;0
5	Tā’īf	77;10	21;40
6	Bayt al-Maqdis	66;30	31;50
7	Dimashq	70;0	33;15
8	Ḥalab	72;10	35;50
9	Mawṣil	77;0	34;30

	Place Names ***al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***	
10	Nakhjawān	81;15	38;40	
11	Marāgha	82;0	37;20	
12	Tabrīz	82;0	38;0	
13	Bardaᶜa*	83;0	41;30	(also 77)
14	Kūfa	79;30	31;30	
15	Baghdād	80;0	33;25	
16	Baṣra	84;0	30;0	
17	Fīrūzābād	87;30	28;10	
18	Shīrāz	88;0	29;16	
19	Yazd	89;0	32;0	
20	Qazwīn	85;0	36;0	
21	Iṣfahān	86;40	32;25	
22	Kāshān	86;0	34;0	
23	Qumm*	85;40	34;45	(also 84)
24	Rayy	86;20	35;0	
25	Astarābād	89;35	36;50	
26	Biṣtām	89;30	36;10	
27	Mashhad	92;30	36;00	
28	Tūn	92;30	34;30	
29	Herāt	94;20	34;30	
30	Marw	97;00	37;40	
31	Balkh	101;0	36;41	
	Second Circle			
32	Badakhshān	104;24	37;10	

	Place Names *al-bilād*	**L** *al-ṭūl*	**φ** *al-ᶜarḍ*	
33	Bukhārā*	97;30	39;50	(also 76)
34	Samarqand*	99;19	39;37	(also 74)
35	Khujand	100;35	41;55	
36	Kāshghar	106;30	44;0	
37	Khutan	107;0	42;0	
38	Hurmūz	92;0	25;0	
39	Kirmān	91;30	30;5	
40	Ghazna	104;20	38;35	
41	Kābul	104;40	34;30	
42	Tubbat	110;0	40;0	
43	Kashmīr	108;0	35;0	
44	Tatah	102;30	25;10	
45	Bakar	105;0	27;40	
46	Qandahār	107;40	33;0	
47	Multān	107;35	29;40	
48	Lāhūr	109;20	31;50	
49	Sialkūt	109;0	33;0	
50	Pānīpatah	113;20	28;52	
51	Tānīsar	112;33	30;10	
52	Haḍrat Dihlī	113;35	28;39	
53	Akbarābād	115;0	26;43	
54	Qannawj	115;50	26;35	
	Third Circle			
55	Banāras	117;20	26;55	

	Place Names ***al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***	
56	Kawāliyār	115;0	36;29	
57	Jawnpūr	119;6	26;36	
58	Jadda	77;0	21;0	
59	Ujjayn	110;50	23;30	
60	Ajmīr	111;5	26;0	
61	Sarūj	72;40	34;50	
62	Ahmadābād	108;40	23;15	
63	Burhānpūr	103;0	20;30	
64	Bījāpūr	105;30	16;20	
65	Dawlatābād	111;0	20;30	
66	Kūlkanda	114;19	17;04	
67	Sarāndīb	130;0	10;0	
68	Kanbayāt	109;4	22;20	
69	Jamkūt	blank	blank	
	On the Edge			
70	Farghāniya	102;0	42;0	
71	Bāb al-Abwāb	85;0	43;0	
72	Ailāq	99;10	43;20	
73	Shalkh	85;30	44;0	
74	Samarqand*	99;19	39;37	(also 34)
75	Baykand	97;30	39;45	
76	Bukhārā*	97;30	39;50	(also 33)
77	Bardaᶜa*	83;0	40;30	(also 13with φ 41;30)

	Place Names *al-bilād*	**L** *al-ṭūl*	**φ** *al-ᶜarḍ*	
78	Samākhī	84;30	40;50	
79	?	104;0	42;0	
80	Khān Bāligh	124;0	46;0	
81	Pīsh Bāligh	111;0	45;50	
82	Harqala	66;20	46;30	
83	Bulghār	90;0	49;30	
84	Qumm*	85;40	34;45	(also 23)



Figure A099.6 – The second gazetteer on the edge, showing the last two entries on Bughār and Qumm, and also the well-formed horse and the trifoliate shackle (photo by S. R. Sarma)

BACK

On the back the upper half of the rim carries the altitude scales which are divided in 1° and 6° and numbered in 6s as 6—90; 90—6.

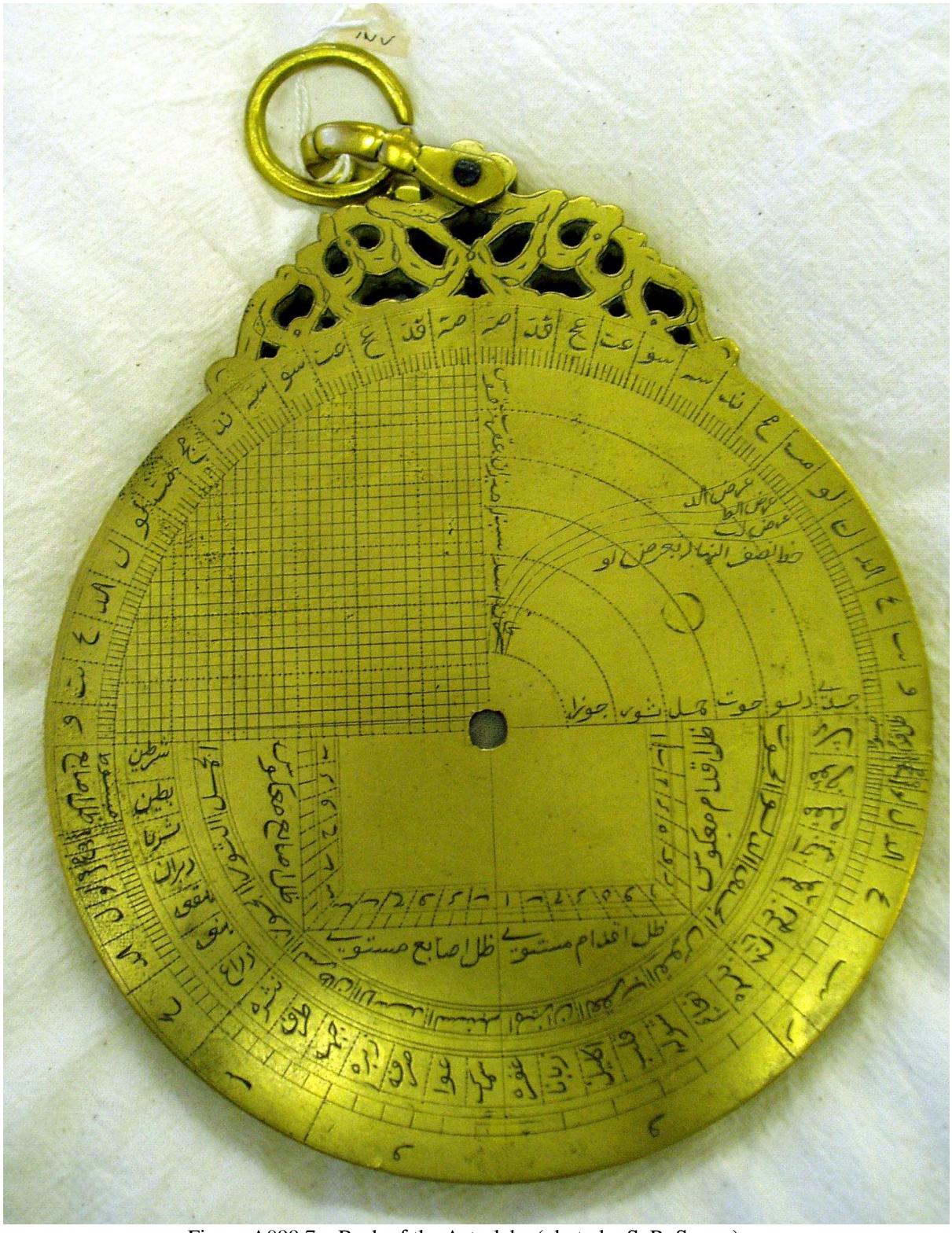


Figure A099.7 – Back of the Astrolabe (photo by S. R. Sarma)

A sine-cosine graph is engraved in the upper left quadrant with 60 horizontal and 60 vertical parallels with each fifth highlighted with dots. In the upper right quadrant are drawn declination arcs for each sign or 30° of solar longitude. The names of the corresponding signs are engraved along the two radii. Here are also plotted four sigmoid

curves for the midday altitude of the sun at latitudes 24°, 29°, 32° and 36°. As in the preceding three astrolabes (A095, A096, A097), here also the lower-most curve is endowed with a full label *khaṭṭ niṣf al-nahār bi-ᶜarḍ 36.* The other three carry just the latitude values, viz., *ᶜarḍ 24, ᶜarḍ 29* and *ᶜarḍ 32.*

In the lower half, there are shadow squares, on the left for a base of 12 and on the right for a base of 7. The vertical and horizontal scales on both sides are divided and numbered accordingly and carry the usual labels.

The space inside the shadow squares is not filled with astrological tables as in the other astrolabes and is left empty. The large empty spaces here, in the upper right quadrant and also in the lower rim lend a certain elegance to the back of this astrolabe.

The rim of the lower half is filled with the cotangent scales and their subdivisions in two rows. In the two following semi-circular rows are engraved the names of the 28 lunar mansions and those of the 12 zodiac signs.

Alidade

The alidade has ornate ends and an ornate centre-piece. The sighting vanes have three holes each. The very large upper hole was probably meant for a sighting tube which is no longer there. The surface of the alidade is engraved with three scales. On the right are a sexagesimal scale and a scale of unequal hours. On the left is a zodiac scale with the signs marked by their serial numbers.

The pin with round head may or may not be original. But the wedge, nicely shaped like a horse’s head with eyes, is original.

Bibliography

Gunther 1932, I, no. 90, pp. 218-220, plates XLVIII-XLIX and Fig. 113, showing the front, back, and plates 6a, 7b and 8a.

A100⊙ SHIP ASTROLABE ATTRIBUTABLE TO ḌIYĀ' AL-DĪN MUḤAMMAD

Not dated, 17th century

Diameter 241 mm

New Delhi, Red Fort, Mumtaj Mahal Museum (#40.416)



Figure A100.1 – Front of the astrolabe (photo by S. R. Sarma)

This unsigned and undated astrolabe with two *zawraqī* horizons shares many features with the preceding six astrolabes and also with A104 so that it can undoubtedly be attributed to Ḍiyā’ al-Dīn.[489]

COMPONE NTS

Body (d. 241, h. 278, t 9) with shackle and ring, rete and 5 plates. The alidade, pin and horse are missing.

FRONT

The ring is simple. The shackle is trifoliate in shape; its two bases are shaped like flowers with five petals. The *kursī* with lobed profiles is plain and solid. The *kursī,* the limb and the back plate are made separately and joined together. As in A104, there are four rotatable lugs affixed to the limb to hold the plates and the rete in position. While these are necessary in A104, they are redundant here because here all the plates have notches at the north point into which the lug inside the limb fits. Moreover, the astrolabe was originally equipped with a pin and a wedge. The limb has a higher content of copper; it is divided in 0;30°, 1° and 3° and numbered in 3s from 3 to 90 clockwise, separately in each quadrant.

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[489] Regrettably my photos do not do justice to this important astrolabe; it is also regrettable that my notes of 16, 17 and 19 February 1999 are partly mislaid.



Figure A100.2 – Rete with two horizons for 27° and 36° (photo by S. R. Sarma)

RETE

The rete contains a high proportion of copper or it is completely made of this metal. Here the peripheral ring of the Capricorn and the ecliptic ring are joined by the equinoctial and solstitial bars, both fully represented. There are counter changes in the equinoctial bar, but these are not clearly defined. The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names. Each sign is subdivided in groups of 6° and numbered accordingly. The edge of the ecliptic ring is divided in 1°. There are about 44 named stars which are joined by a floral tracery consisting of tulips with flared petals. There is a small handle on the peripheral ring at the north-west point.

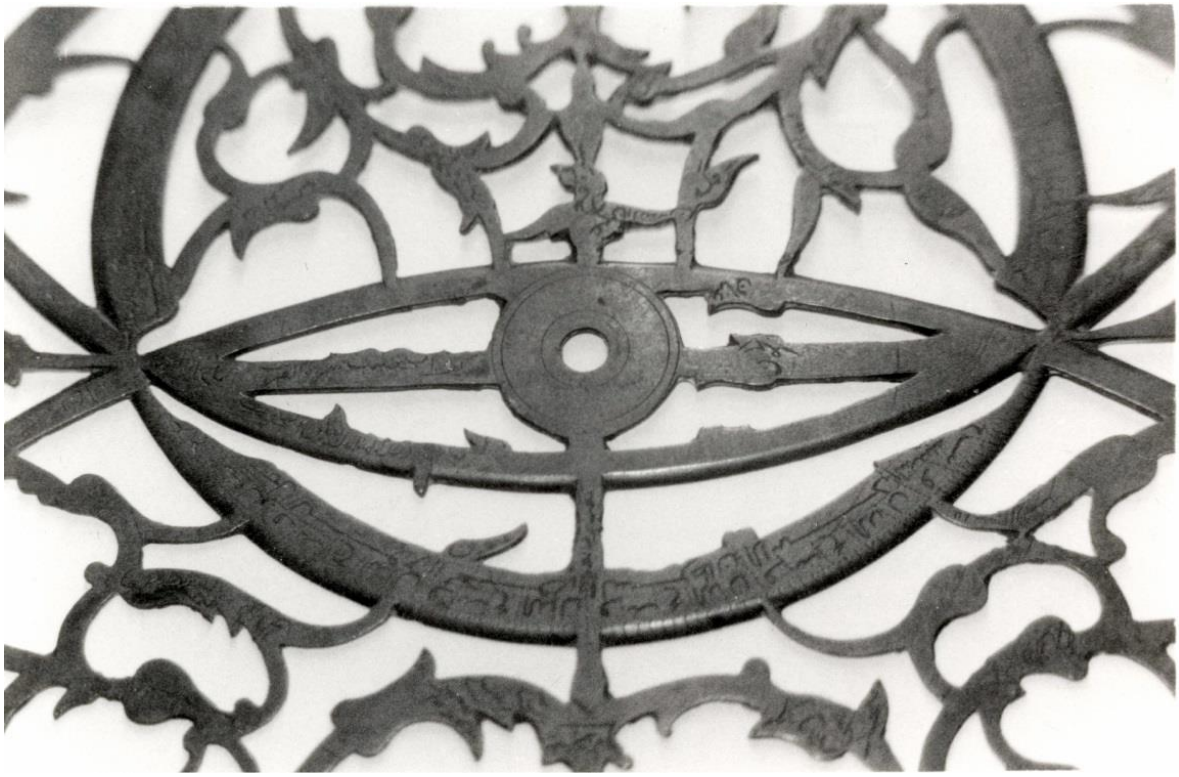


Figure A100.3 – Rete, detail (photo by S. R. Sarma)

Two *zawrāqī* horizons intersect at the two equinoctial points and extend up to the peripheral ring on both sides. The horizon with its convex side towards the south is for the latitude 27°. The eastern and western halves of the arc carry the labels *ufq mujassam sharqī bi-ᶜarḍ 27* (eastern solid horizon for latitude 27) and *ufq mujassam gharbī bi-ᶜarḍ 27* (western solid horizon for latitude 27) respectively. The second horizon with its convex side towards north is for the latitude 36°; its two halves carry the labels *ufq mujassam sharqī bi-ᶜarḍ 36* (eastern solid horizon for latitude 36) and *ufq mujassam gharbī bi-ᶜarḍ 36* (western solid horizon for latitude 36) respectively.

There is a long label on the segment of the equinoctial bar between the centre and its intersection with the ecliptic ring in the east, but I cannot decipher it.

As will be shown below, the plates serving the latitudes of 27° and 36° are specially prepared for use with these *zawraqī* horizons.

Plates

There are five plates with varying thickness; three have a thickness of less than 1 mm, one plate is a little thicker than 1 mm and plate 1 is very thick with 1.5 mm. On plates 1 to 4 altitude circles are drawn for 1° and every sixth is highlighted with dots; azimuth arcs are drawn below the horizon for each 6° and every fifth is dotted. There

are plain lines for seasonal hours and dotted lines for equal drawn from the western horizon. The values of the maximum duration of daylight are inaccurate in all cases save for 32° which is the latitude of Lahore.

Table A100-1 Plates

	φ	Longest day
1a	24°	13 hours!
1b	26°	13 hours!
2a	27°	13 hours!
2b	29°	13;14 hours!
3a	32°	14;8 hours
3b	38°	14 hours!
4a	34°	14 hours!
4b	36°	14 hours!
5a	Plate of ecliptic coordinates with the label *ṣafīḥat mīzān al-ᶜankabūt*	
5b	Plate of horizons with the label *ṣafīḥa āfāqī*	

On plate 2a for 27° the ecliptic circle is drawn, divided into the 12 signs, labelled with their names and further subdivided in 6° and 1°. About 24 star positions are marked with dots enclosed in circles with their names engraved. On plate 4b for 36° also the ecliptic is engraved in the same manner and about 23 star positions are marked; some of these not identical with those marked on plate 2a.

Geographical Gazetteer

There is a gazetteer in five circles with the names and the coordinates of 121 localities; the arrangement is as in A095.



Figure A100.4 – Geographical Gazetteer (photo by S. R. Sarma)

BACK

The rim of the upper half carries altitude scales divided in 0;30°, 1° and 3° and numbered in 3s, from 3 to 90, as 3—90; 90—3. The upper left quadrant resembles the same in A095, A097 and A101 with 60 horizontal and 60 vertical parallels, half circles over the two radii, a radial drawn from the centre to 45° on the arc, and a line joining the two extremities of the arc.

In the solar quadrant on the upper right are drawn 18 declination circles, i.e., one for each 10° of the solar longitude; each third is highlighted with the dots. The names of the related signs, along with the subdivisions 10° are engraved on the two radii. Here are drawn four sigmoid curves of the midday altitude of the sun at latitudes 24°, 26°, 29° and 36°. The last one is accompanied by the full label *khaṭṭ niṣf al-nahār bi-ᶜarḍ 36.* The others are given shorter labels *bi-ᶜarḍ 24, bi-ᶜarḍ 26* and *bi-ᶜarḍ 29.*

In the lower half are shadow squares. These are enclosed by a series of semi-circular rows. The outermost row on the rim contains cotangent scales; the rows that follow carry respectively the names of the lunar mansions, the names of the zodiac signs, the limits of signs, the triplicities, the decans and their respective regents. Inside the shadow squares, there other astrological tables, but my notes on them are mislaid.

A101 SHIP ASTROLABE ATTRIBUTABLE TO ḌIYĀ' AL-DĪN MUḤAMMAD[490]

Not dated, 17th century

Diameter not known

PLU



Figure A101.1 – Front of the astrolabe (photo courtesy Museum of the History of Science, Oxford)

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[490] Entry based on photos of the front, back and gazetteer, and photocopies of all plates in the archives of the Museum of the History of Science, Oxford.

This unsigned and undated astrolabe can be attributed to Ḍiyā’ al-Dīn Muḥammad because of the *zawraqī* horizon on the rete and the 6 sigmoid curves of the midday altitude of the sun on the back. The back and the geographical gazetteer have a close resemblance to those in A095. As in A095 and A099, the maximum duration of the daylight at different latitudes is given imprecisely.

COMPONENTS

Body with *kursī,* shackle and chain, rete, 5 plates. No information about the alidade, pin and wedge.

FRONT

There is no ring, but a broken chain. The shackle is not trifoliate. Probably both the chain and the shackle are replacements. The *kursī* is indifferently reticulated with some ornamental engravings on the surface, but without the customary trifoliate finial.

The degree scale on the limb is divided in 0;30°, 1°, 2°, 3°, 6° and 30°. The lines separating 2° are dotted. At the top of the 3° mark is engraved a glyph like ‘v’. Three dots are engraved above and below the line separating every 30°. Groups of 6° are numbered clockwise in bold *Abjad* symbols from 6 to 90, separately for each quadrant.

RETE

The peripheral Capricorn ring and the slightly wider ecliptic ring are held together by the equinoctial and solsticial bars, both represented completely; the former has two counter changes at its intersections with the ecliptic ring, the latter one counter change at the centre. The ecliptic ring is divided into the 12 signs and engraved with their names; each sign is divided in groups of 6° and numbered from 6 to 30; each of these 6° units subdivided to 2°. On the peripheral ring, there is a handle some 40° to the west of the north point.

A single oblique horizon for latitude 24° spans across the rete with its convex side to the south. The eastern half carries the labels *ufq mujassam sharqī bi-ᶜarḍ 24* (eastern solid horizon at latitude 24) and the western half *ufq mujassam gharbī bi-ᶜars 34* (obviously an error for *ᶜarḍ 24*) (western solid horizon at latitude 24).

There are 46 named star pointers, but many of these are not defined well.

Table A101-1 Stars on the Rete

	Star Names	Identification
1	*Dhanab al-Qayṭus Sh[amālī]*	ι Ceti
2	*Dhanab al-Qayṭus J[anūbī]*	β Ceti
3	*Baṭn Ḥūt*	β Andromedae
4	*Riǰl Musalala*	γ Andromedae
5	*Fam al-Qayṭus*	γ Ceti
6	*Ṣadr al-Qayṭus*	π Ceti
7	*Rās al-Ghūl*	β Persei
8	*Kaff al-Jadhmā’*	α Ceti
9	*Tālī Masāfat al-Nahr*	γ Eridani
10	*ᶜAyn al-Thawr*	α Tauri
11	*ᶜAyyūq*	α Aurigae
12	*Riǰl al-Jawzā’ al-Yusrā*	β Orionis
13	*Yad al-Jawzā’ al-Yusrā*	γ Orionis
14	*Yad al-Jawzā’ al-Yumnā*	α Orionis
15	*Riǰl al-Jawzā al-Yumnā*	κ Orionis
16	*??*	
17	*Shiᶜrā Yamānī*	α Canis Majoris
18	*Shiᶜrā Shāmī*	α Canis Minoris
19	*Minkhir al-Shujāᶜ*	σ Hydrae
20	*Ṭarfat al-Safīna*	ρ Puppis
21	*Fard al-Shujāᶜ*	α Hydrae
22	*Qā’idat al-Bāṭiya*	α Crateris
23	*Ṣarfa*	β Leonis

	Star Names	Identification
24	*Minqār al-Ghurāb*	α Corvi
25	*ᶜAnāq*	ζ Ursae Minoris
26	*Simāk Aᶜzal*	α Virginis
27	*Simāk Rāmiḥ*	α Bootis
28	*Siffah* (read: *Kiffa J*?)	α Librae ?
29	*Nayyir Fakkah*	α Coronae Borealis
30	*Qalb al-ᶜAqrab*	α Scorpii
31	*Rukbat al-Ḥawwā al-Yusrā*	ζ Ophiuchi
32	*Rās al-Jāthī*	α Herculis
33	*Rās al-Ḥawwā*	α Ophiuchi
34	*Yad al-Ḥawwā al-Muqaddam*	δ Ophiuchi
35	*Tinnīn*	γ Draconis
36	*Nasr Wāqiᶜ*	α Lyrae
37	*Minqār al-Dajājah*	β Cygni
38	*Nasr Ṭā’ir*	α Aquilae
39	*Dhanab al-Dālfīn*	ε Delphini
40	*Dhanab al-Dajājah*	α Cygni
41	*Fam al-Faras*	ε Pegasi
42	*Dhanab al-Jadī*	δ Capricorni
43	*Sāq Sākib al-Mā’ J[anūbī]*	δ Aquarii
44	*Surrat Faras*	δ Pegasi
45	*Janāḥ Faras*	γ Pegasi
46	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are photocopies of 10 plate faces, but it is not known which two faces belong together. Therefore they are numbered below from 1 to 10.

Table A101-2 Plates

	φ	Longest Day
1	18°	13 hours
2	21°	13 hours
3	24°	13 hours
4	27°	13 hours
5	29°	13;52 hours
6	32°	14;8 hours
7	34°	14 hours
8	36°	14 hours
9	Plate of ecliptic coordinates	
10	Plate of horizons	

It is remarkable that, as in astrolabes A095 and A099, the maximum duration of daylight at different latitudes is given imprecisely, either as 13 hours or as 14 hours. The exceptions are the latitudes 29° (Delhi) and 32° (Lahore). It does not need much effort to give the more exact values in hours and minutes. It is intriguing why it is not done so in otherwise well-crafted plates.

On plate faces 1-8, altitude circles are drawn for every 2°. Azimuth arcs are traced for every 6° below the horizon and those for every 30° are both up and below the horizon as dotted lines. There are lines for seasonal hours as well as dotted lines for equal hours drawn from the western horizon.

The plate of horizons has rather an unusual design. Here half horizons are drawn in four sets for every degree of latitude from 4° to 90° at intervals of 4°:

4	8	12	…	72	76	80	84	88	90
5	9	13	…	73	77	81	85	89	90
6	10	14	…	74	78	82	86		90
7	11	15	…	75	79	83	87		90

Declination scales are drawn between the two tropics at NW, NE, SW and SE points. The divisions in the scales are not clearly marked. They are numbered as 6, 12, 18, 24 from the equator to the Tropic of Capricorn and from the equator to the Tropic of Cancer.

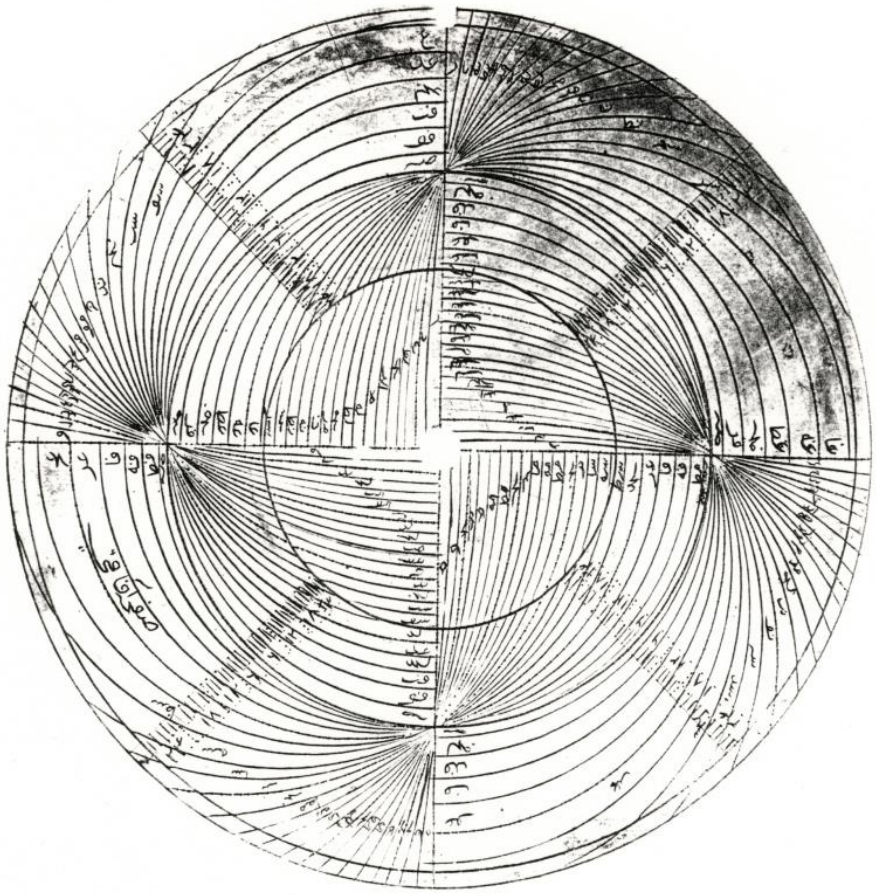


Figure A101.2 – Plate of horizons
(photocopy courtesyMuseum of the History of Science, Oxford)

Plate 4 also deserves a special mention. In the preceding astrolabe (A099), the plate for latitude 29° is stamped with several punch marks as star pointers. Here also the plate for latitude 24° is endowed in the same manner with punch marks with star names below. Probably because of the quality of the photo, these marks are not clearly visible, particularly to the south of the horizon. Listed below are the names of 31 stars which can be discerned.

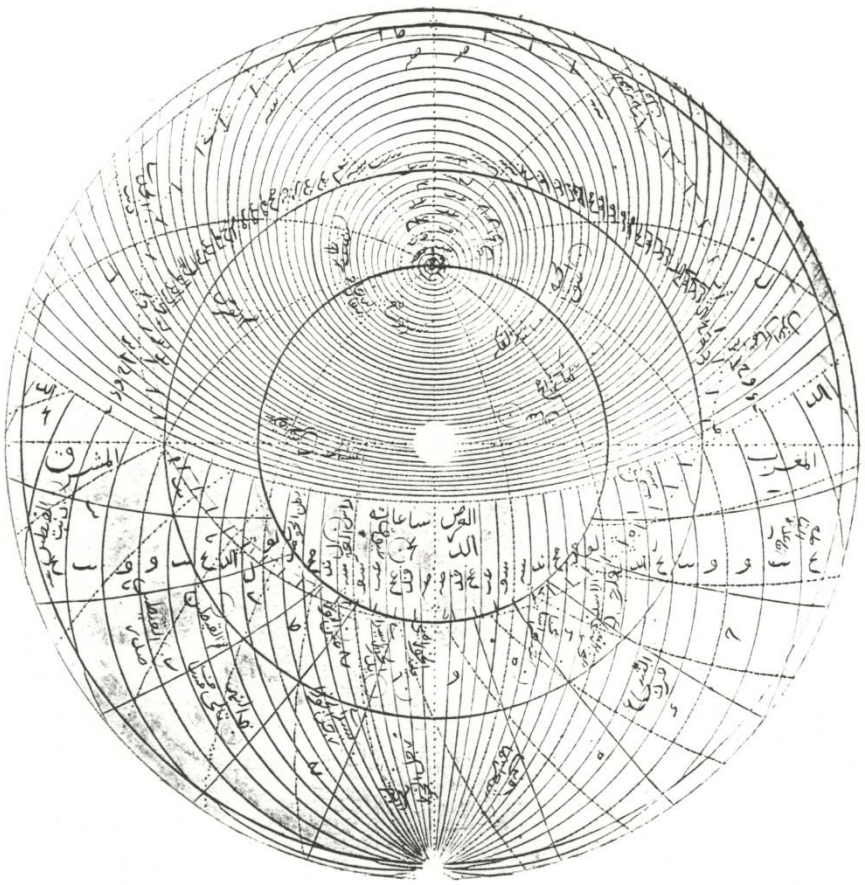


Figure A101.3 – Plate 4 for latitude 24 with star positions
(photocopy courtesy Museum of the History of Science, Oxford)

Table A101-3 Stars on Plate 4

	Star Name	Identification
1	*Dhanab al-Qayṭus Sh[amālī]*	ι Ceti
2	*Fam al-Qayṭus*	γ Ceti
3	*Ṣadr al-Qayṭus*	π Ceti
4	*Rās al-Ghūl*	β Persei
5	*Tālī Masāfat al-Nahr*	γ Eridani
6	*ᶜAyn al-Thawr*	α Tauri
7	*ᶜAyyūq*	α Aurigae
8	*Rijl al-Jawzā’ Yusrā*	β Orionis

	Star Name	Identification
9	*Yad al-Jawzā’ Yusra*	γ Orionis
10	*Yad al-Jawzā’ Yumnā*	α Orionis
11	*Rijl al-Jawzā’ Yumnā*	κ Orionis
12	*Shiᶜrā Yamānī*	α Canis Majoris
13	*Shiᶜrā Shāmī*	α Canis Minoris
14	*Minkhir al-Shujāᶜ*	σ Hydrae
15	*Fard al-Shujāᶜ*	α Hydrae
16	*Qalb al-Asad*	α Leonis
17	*Qā’idat al-Bāṭiya*	α Crateris
18	*Ṣarfa*	β Leonis
19	*Simāk Aᶜzal*	α Virginis
20	*ᶜAnāq*	ζ Ursae Majoris
21	*Simāk Rāmiḥ*	α Bootis
22	*ᶜUnq al-Ḥayyah*	α Serpentis
23	*Nayyir al-Fakkah*	α Coronae Borealis
24	*Qalb al-ᶜAqrab*	α Scorpii
25	*Nasr Wāqiᶜ*	α Lyrae
26	*Nasr Ṭā’ir*	α Aquilae
27	*Dhanab al-Dulfīn*	ε Delphini
28	*Fam al-Faras*	ε Pegasi
29	*Dhanab al-Jadī*	α Capricorni
30	*Surrat al-Faras*	δ Pegasi
31	*Kaff al-Khaḍīb*	β Cassiopeiae

Geographical Gazetteer

On the inner surface of the mater is engraved in four circles a geographical gazetteer of 108 localities, arranged according to climates. But the fourth circle is placed very close to the central hole and the entries there are cluttered and undecipherable. The sequence of the entries is not consistent in all circles. While the place name is followed by the longitude and latitude in the first, third and fourth circles, in the second circle the place name is followed by latitude and longitude. Moreover, the number 20 is represented by two different glyphs: the common symbol used in *Abjad* notation as well as ک . It appears that, like the gazetteer in A095, this one too may have been engraved by an assistant and not by Ḍiyā’al-Dīn himself.



Figure A101.4 – The geographical gazetteer, shown here upside down so that the beginning can be read easily (photo courtesy Museum of the History of Science, Oxford)

Table A101-4 Geographical Gazetteer

	Place Names	L	φ	
	First Circle			
[-I] *az khaṭṭ istiwā* (from the line of equator)				
1	Sāḥil bahr Awkiyānūs	6;0	0;0	
2	Jazīra Qanbala	21;0	3;0	
3	Jamkūt	180;0	5;0	
4	Shala	170;0	5;0	
[I] *iqlīm awwal* (first climate)				
5	Kūkū	54;10	10;0	
6	ᶜAdan	76;0	11;0	
7	Jubla	75;0	33;0	(read: 13;0)
8	Damār	77;10	33;30	(read: 13;30)
9	Bahr ---	110;0	14;0	
10	Dabīl	74;0	14;0	
11	Ṣanᶜā’ Dar al-Mulk Yaman	77;30	14;0	
12	Janad	75;30	14;30	
13	Sawmnāt	107;0	17;0	
14	Zaytūn	154;0	17;0	
15	Bījāpūr	105;30	17;20	
16	Burhānpūr	113;0	20;30	
17	Dawalatābād	111;0	20;30	
[II] *iqlīm dūyum* (second climate)				
18	Jadda	76;0	21;0	
19	Ṭāᶜif	77;30	21;20	

	Place Names	L	φ
20	Makka Muᶜaẓẓam	77;10	21;40
21	Kanbayāt	109;20	24;20
22	Khaybar	75;20	25;20
23	Madīnat Musharrafa	75;20	25;0
24	Hurmūz	92;0	25;0
25	Ajmīr	111.5	26;0
26	Lakhnawtī	114;30	26;30
27	Qannawj	105;50	26;15
28	Jawnbūr	119;4	26;36
29	Akbarābād	114;0	26;43
30	Kūpāmāū	116;33	26;45
31	Kara Mānikpūr	118;6	26;46
32	Awadh	118;10	27;22
33	Badāwan	119;36	27;32
34	Kwāliyār	116;0	26;29
[III] *iqlīm siwum* (third climate)			
35	Kūlkanada	114;19	18;6
36	Kūl Jalālī	114;19	28;6
37	Fīrūzābād	106;30	28;7
38	Sulṭānkūt	115;0	28;30
39	Shāhjahānābād	113;35	29;0
40	Baran	114;0	28;43
41	Pānīpat	113;20	28;20

	Place Names	L	φ	
42	Shīrāz	108;0	29;36	
43	Multān	107;35	29;40	
44	Hānsī	112;25	29;45	
45	Baṣra	87;0	30;0	
46	Kirmān	91;30	30;5	
47	Tahtaniṣr	112;33	30;10	(Tanesar)
	Second Circle			
tatimma iqlīm siwum (continuation of the third climate)				
48	Iskandariyya	61;15	30;33	
49	Miṣr	63;20	30;20	
50	Sunām	110;25	30;30	
51	Kūfa	106;0!	32;0	
52	Bayt al-Maqdis	66;30	31;50	
53	Lāhūr	109;20	31;50	
54	Yazd	89;0	32;0	
55	Iṣfahān	87;40	32;25	
56	Qandahār	107;40	33;0	
57	Sālkūt	109;0	33;0	
58	Madā’īn	72;0	33;0	
59	Dimashq	70;0	33;0	
60	Mīqand ?	80;0	33;25	
61	Baghdād	82;0	33;25	
[IV] *iqlīm chahārum* (fourth climate)				
62	Ṭarabīs (read: Ṭarābulus)	69;40	34;0	

	Place Names	L	φ
63	ᶜAnah	76;0	34;0
64	Kāshān	86;0	34;0
65	Mawṣil	77;0	34;30
66	Tūn	92;30	34;30
67	Harāt	104;30	34;30
68	Kābul	104;40	34;30
69	Qumm	105;40	34;45
70	Rayy	86;20	35;20
71	Sāwa	85;0	30;0
72	Kashmīr	108;0	35;0
73	Hamadān	83;0	35;10
74	Mashhad Maqdis	92;30	36;0
75	Ḥalab	72;10	35;50
76	Sabzawār	91;30	34;5
77	Balkh	101;0	36;41
78	Tāliqān	101;45	36;10
	Third Circle		
tatimma iqlīm chahārum (continuation of the fourth climate)			
79	Qazwīn	85;0	35;15
80	Badakhshān	84;24	37;10
81	Sarakhs	94;30	36;30
82	Marw	97;0	37;40
83	Tabrīz	82;0	38;0
84	Ardabīl	80;0	38;0

	Place Names	L	φ
85	Nakhjawān	81;15	38;40
86	Biṣtām	89;30	36;14
[V] *iqlīm panjum* (fifth climate)			
87	Samarqand	99;36	39;37
88	Bukhārā	97;30	39;50
89	Tubbat	110;0	40;0
90	Bardhaᶜa	83;0	40;0
91	Khujand	85;30	41;55
92	Khutan	87;0	42;0
[VI] *iqlīm shashum* (sixth climate)			
93	Kāshghar	106;30	44;0
94	Tarāz	101;0	44;50
95	Pīsh Bāligh	111;0	44;0
96	Shalj	85;30	44;0
[VII] *iqlīm haftum* (seventh climate)			
97	Araq	105;0	48;0
98	Bulghār	90;0	49;0
99	Qirqir	65;0	50;0
khāriẓ iqlīm -- ? (Beyond the --- climate)[491]			
100	Ṣūrath (read: Sūrat)	110;50	20;15
101	Banāras	117;20	26;0

[491] The third word is not clear. What follow are not localities beyond the seventh climate, but places in India.

	Place Names	L	φ
	Fourth Circle		
102	Dhākā Bankālā[492]	---	---
103	Ilāhābād	---	---
104	Sarhind	---	---
105	Patnah	---	---
106	Bahrūj	---	---
107	Munkīr	---	---

BACK

The rim of the upper half carries the altitude scales which are divided, as on the limb, in 0;30°, 1°, 2°, 3°, 6° and 30°. Groups of 6° are numbered in *Abjad* symbols which are bolder than on the limb, as 6—90; 90—6. The four quadrants are designed exactly as on the back of A091.

In the upper left quadrant is a sexagesimal sine-cosine graph with very finely drawn 60 horizontal parallels and 60 vertical parallels, where each sixth line is highlighted with dots. There are also engraved semi-circles on both the radii; 3 quarter circles around the centre at 24 units (the arc of the obliquity of the ecliptic), 12 units (?) and 8 units (?). A radial line is drawn from the centre to 45° on the arc and another line between two inner terminals of the arc.

In the upper right quadrant, declination arcs are drawn for each 10° of solar longitude; every third of these is dotted. The names of the corresponding signs and the numerical values of the subdivisions are engraved along the two radii. There are dotted arcs of unequal hours, numbered from 1 to 6 in an anticlockwise direction and 7 to 12 in the reverse direction. There are also drawn 6 sigmoid curves to show the midday

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[492] The coordinates of this and the next places are difficult to decipher.

altitude of the sun throughout the year at 6 different latitudes, viz. 21° (Mecca), 24° (Tropic of Cancer), 27° (Agra), 29° (Delhi), 32° (Lahore), 36°(middle of the fourth climate, i.e., the middle of the inhabited world). Only the lowermost curve is accompanied by a full label which reads *khaṭṭ niṣf al-nahār bi-ᶜarḍ 36°*. For other curves just the latitude is mentioned as *ᶜarḍ 21, ᶜarḍ 24* and so on.

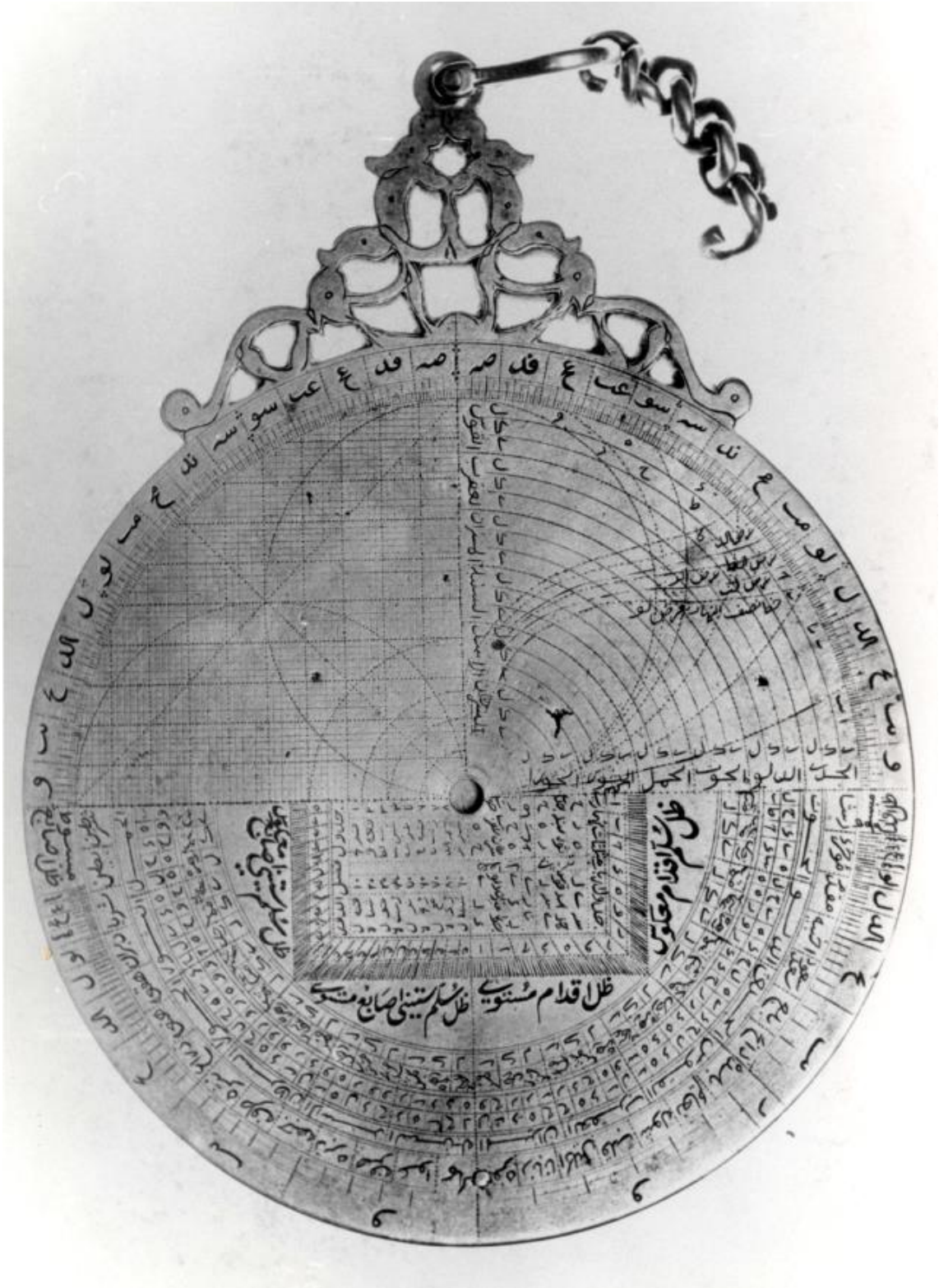


Figure A101.5 – Back of the astrolabe (photo courtesy Museum of the History of Science, Oxford)

In the lower half are drawn the shadow squares. On the left is the square for gnomons of 12 digits as well as of 60 divisions. The vertical and horizontal scales on the left are divided into 12 units and numbered from 1 to 12. Each unit is further subdivided into 5 divisions. The vertical scale carries the label *ẓill sittaynī aṣābiᶜ maᶜkūs*

(reverse shadows of sexagesimal divisions and [twelve] digits) and the horizontal scale the label *ẓill sittaynī aṣābiʿ* (direct shadows of sexagesimal divisions and [twelve] digits).

On the right is the square for gnomons of 7 feet and of 7 x 7 divisions. The vertical and horizontal scales on the right are each divided into 7 units each and are numbered from 1 to 7. As in A097, each unit is further subdivided in 7 divisions which is unusual. The vertical scale has the label *ẓill aqdām maʿkūs* (reverse shadows in feet) and the horizontal scale *ẓill aqdām mustawī* (direct shadows in feet). These four labels of the shadow squares are bold like the *Abjad* numbers on the rim.

Inside the shadow squares, there are two rectangular tables. The one on the right is a table of triplicities with the title *jadwal arbāb muthallathāt nahārī wa laylī* (table of the regents of the triplicities diurnal and nocturnal). Next to it is the table designated as *faḍl al-dawr* (excess of revolution).

The rim of the lower half is engraved with cotangent scales in the outer semi-circular row and their subdivisions in the inner row.

The next two rows are engraved with the names of the 12 signs of the zodiac and the names of the 28 corresponding lunar mansions respectively. These are followed by two rows containing the table of the limits of the signs (*ḥudūd*), while the last two rows carry the table of faces (*wujūh*).

A102⊙ SHIP ASTROLABE ATTRIBUTABLE TO ḌIYĀ' AL-DĪN MUḤAMMAD[493]

Not dated, 17th century

Diameter 100 mm

Chicago, Adler Planetarium (#M39)

CCA 91



Figure A102.1 – Front of the astrolabe
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

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493 Entry based on Pingree 2009, no. 20, pp. 88-93; the star list has been rearranged according to increasing right ascension.

This unsigned and undated astrolabe can be attributed to Ḍiyā’ al-Dīn Muḥammad because of the *zawraqī* horizons. Its construction is unusual. The mater has upraised limbs on both sides so that there are recesses where plates and retes can be inserted. There are two retes, one standard one and the other consisting just of two *zawraqī* horizons and the corresponding masts; these can be simultaneously used by inserting them into the mater on either side. Similar construction is adopted in another astrolabe to be discussed below (A104) where the mater is equipped with recesses on both sides to accommodate a northern rete and a southern rete.

COMPONENTS

Body with *kursī* (d. 100, h. 142) with ring and shackle, two retes (one standard for 33 stars; the other *zawraqī*), 4 plates, alidade, pin and horse.

FRONT

A large ring and trifoliate shackle. The profiles of the *kursī* are made up of ogees at the base followed by three lobes. Engraved with a pattern of tiny pearls, the rim forms an appropriate frame around the calligraphy *Yā Fattāh.* It is a sacred phrase in Islam addressing God as ‘O Fattāh, the Opener’.

On both sides, the degree scale on the limb is divided in 1° and 5° and numbered clockwise from 5 to 90, separately in each quadrant.

RETE I

In the larger rete, the peripheral Capricorn ring and the ecliptic ring are held together by the equinoctial bar which has counter changes at its two intersections with the ecliptic ring. The ecliptic ring is divided into the 12 signs of the zodiac and engraved with their names. Each sign is divided in groups of 6° and numbered from 6 to 30. The edge of the ecliptic ring is divided in 2°. There are 33 named star pointers, shaped like tiger’s claws, and these are joined by small unconnected traceries.

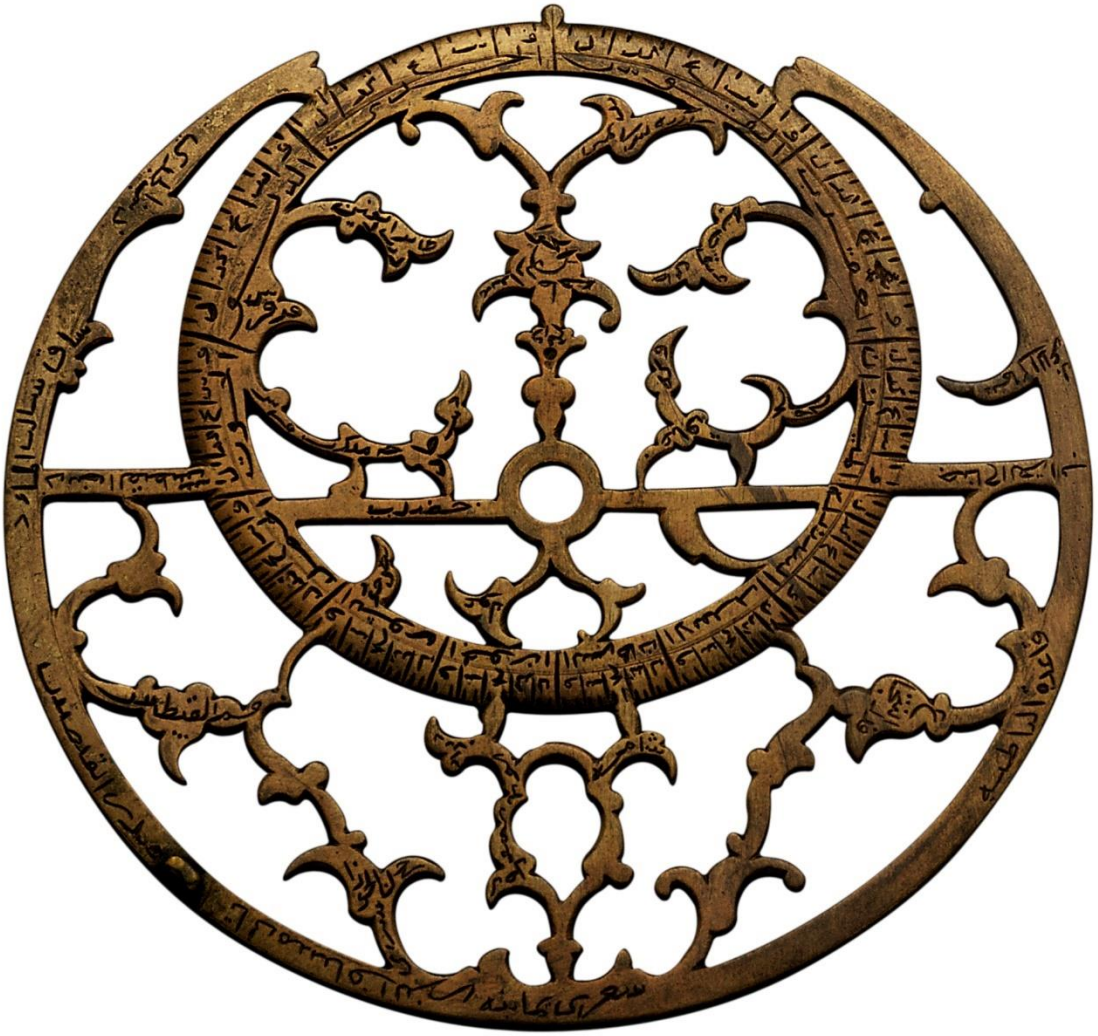


Figure A102.2 – The standard rete in the astrolabe
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Table A102-1 Stars on the Rete

	Star Name	Identification
1	*Baṭn Ḥūt*	γ Andromedae
2	*Fam al-Qayṭus*	γ Ceti
3	*Ṣadr al-Qayṭus*	π Ceti
4	*Ghūl*	β Persei
5	*Tālī Masāfat al-Nahr*	γ Eridani
6	*Dabarā[n]*	α Tauri
7	*Rijl al-Jawzā’ Yusrā*	β Orionis

	Star Name	Identification
8	*Yad Yamīn*	α Orionis
9	*Rijl Yumnā*	κ Orionis
10	*Shiʿrā Yamānī*	α Canis Minoris
11	*Shāmī*	α Canis Majoris
12	*Fard al-Shujāʿ*	α Hydrae
13	*Qā’idat al-Bāṭiya*	α Crateris
14	*ʿAnāq*	ζ Ursae Majoris
15	*Janāḥ al-Ghurāb*	γ Corvi
16	*Simāk al-Aʿzal*	α Virginis
17	*Fakkah*	α Coronae Borealis
18	*ʿUnq Ḥayyah*	α Serpentis
19	*Rukba Yusrā*	ζ Ophiuchi
20	*Jāthī*	α Herculis
21	*Al-Ḥawwā*	α Ophiuchi
22	*Yad Yamīn*	δ Ophiuchi (?)
23	*Wāqiʿ*	α Lyrae
24	*Minqār Dajājah*	β Cygni
25	*Ṭā’ir*	α Aquilae
26	*Dhanab al-Dulfīn*	ε Delphini
27	*Dhanab Dajājah*	α Cygni
28	*Fam Faras*	ε Pegasi
29	*Dhanab al-Jadī*	δ Capricorni
30	*Sāq Sākib al-Mā’*	δ Aquarii
31	*Dhanab al-Qayṭus Sh[amālī]*	ι Ceti

	Star Name	Identification
32	*Mankib Faras*	β Pegasi
33	*Khaḍīb*	β Cassiopeiae



Figure A102.3 – The *zawraqī* rete
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

RETE II

The second rete consists of a peripheral ring in which two mutually intersecting arcs are placed above and below the centre; the arcs extend up to the peripheral ring on both sides. Two segments of the solstitial bar above and below the centre are the masts.

The arc with its convex side to the north is the oblique horizon of latitude 38°. The two halves of this arc carry the labels *ufq mujassam sharqī bi-ᶜarḍ 38* (eastern solid horizon for latitude 38) and *ufq mujassam gharbī bi-ᶜarḍ 38* (western solid horizon for latitude 38) respectively. The mast corresponding to this arc, i.e., the solstitial bar above the central hole, has the inscription *ᶜayr dawraq* (?).

The second arc, with the convex side to the south is the oblique horizon for latitude 37°. The two halves of this arc carry the labels *ufq mujassam sharqī bi-ᶜarḍ 37* (eastern solid horizon for latitude 37) and *ufq mujassam gharbī bi-ᶜarḍ 37* (western solid horizon for latitude 37). Its mast, i.e., the solstitial bar below the central hole, bears the label *tayr dawraq* (?). The significance of these two latitudes is not known.

There are notches in the peripheral ring at the south and north points so that the rete can be fitted appropriately when using either of the two oblique horizons. There are also such notches at the east and west points, but on the inner side of the ring. Their precise function is not understood. Moreover, there is no plate designed to use with these *zawraqī* horizons as in A013 or A082, or a plate with star positions marked as in A099 and A100.

PLATES

The astrolabe has four plates with the following specifications.

Table A102-2 Plates

	φ	Longest Day
1a	22°	13;22 hours
1b	25°	13;25 (read 13;35) hours
2a	27°	13;43 hours
2b	32°	14;8 hours
3a	30°	13;58 hours
3b	36°	14;42 hours
4a	0°+72°	
4b	Substitute for normal back	

The first three plates are engraved with altitude circles for every 2° and with lines for seasonal and equal hours, but not with azimuth arcs. They are crudely produced and are given a silver finish. They are probably replacements for the original plates which are lost.

Plate 4a carries a double projection. The upper half is designed for latitude 0°. Under the straight horizon in the east and west is engraved *lā ʿarḍ lahū* (there is no latitude). The lower half is designed for latitude 72°; there are labels on both sides stating *al-ʿarḍ 72*.

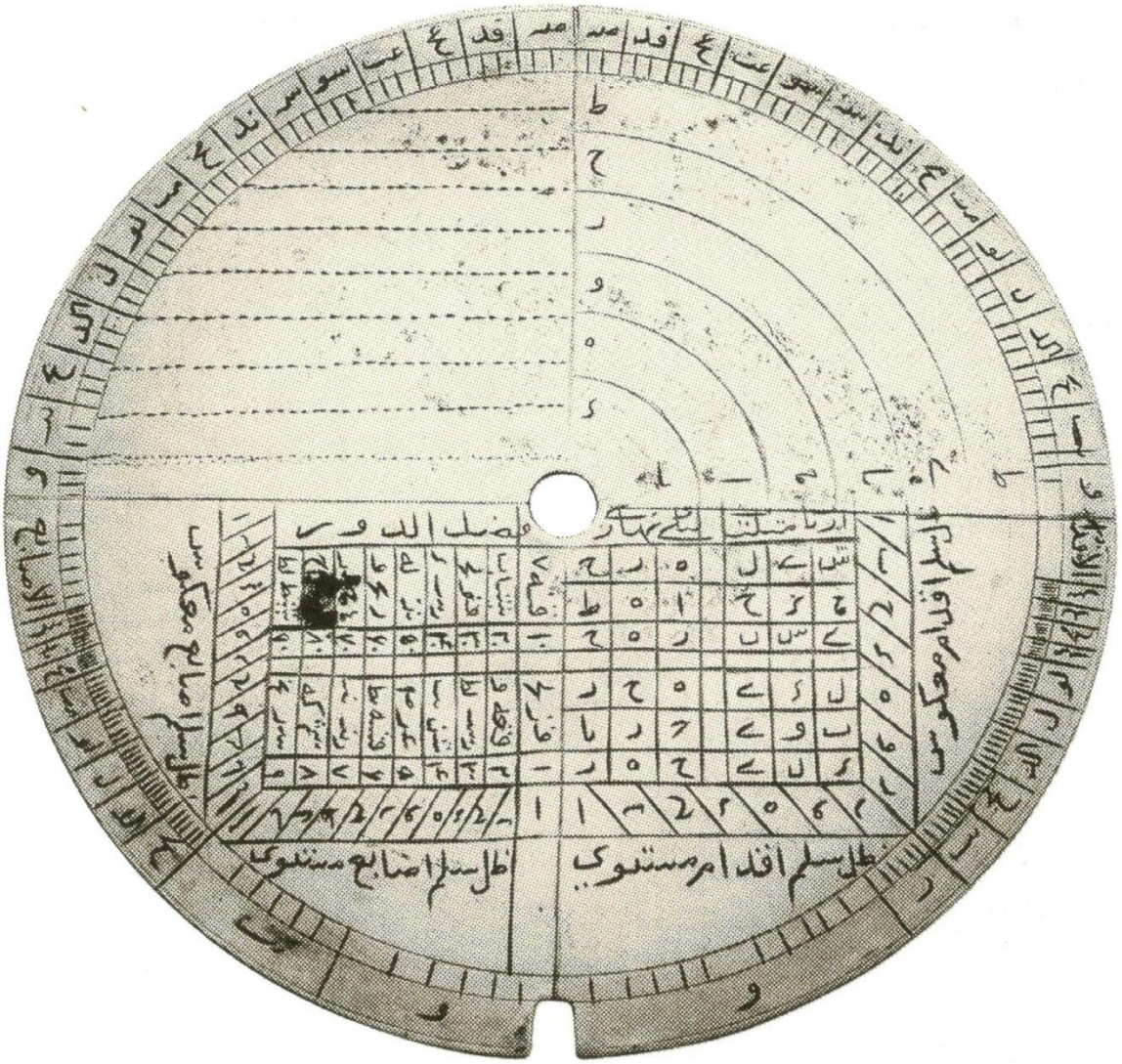


Figure A102.4 – Plate 4b designed as the Back of the Astrolabe
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Plate 4b is designed as the normal back of the astrolabe. The rim of the upper half carries altitude scales while that on the lower half bears cotangent scales. In upper left is the trigonometric quadrant with 9 horizontal parallels. In the upper right quadrant, declination arcs are drawn for each 30° solar longitude, i.e., for each sign. The signs are marked with their serial numbers on both the radii. In the lower half, there are the shadow squares for 12 digits and 7 feet with the usual labels.



Figure A102.5 – The first part of the geographical Gazetteer on the reverse side of the mater
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

GEOGRAPHICAL GAZETTEER

A geographical gazetteer is engraved on the two sides of the recessed mater. The gazetteer is organised according to the climates and provides the names, longitudes and latitudes of 108 localities. The gazetteer begins on the reverse side of the mater and continues on the obverse side.

Table A102-3 Geographical Gazetteer I

	Place Name	L	φ	Identification/Modern Name
	Part I			
	Outer Circle			

	Place Name	L	φ	Identification/Modern Name
[-I] *az khaṭṭ istiwā tā iqlīm awwal* (from the line of equator up to the first climate)				
1	Jamkūt	180;0	5;0	Yamakoṭi
2	ᶜAdan	76;0	11;0	Aden, Yemen
3	Sarāndīb	130;0	10;0	Sri Lanka
4	Zabīd[494]	74;20	14;10	Zabid, Yemen
5	Jabal	75;0	13;30	Zuqar Island, Yemen
[I] *al-iqlīm awwal* (the first climate)				
6	Janad	75;30	14;30	Janad, Yemen
7	Sawmnāt	106;0	17;0	Somnath, Gujarat, India
8	Zaytūn	154;0	17;55	Hangzhou, China
9	Bījābūr	105;30	17;20	Bijapur, Karnataka, India
10	Ṭāᶜif	77;30	21;20	Taif, Saudi Arabia
11	Makka Musharraf	77;10	21;40	Mecca, Saudi Arabia
12	Madīnat Ṭayyība	75;10	25;0	Medina, Saudi Arabia
[II] *al-iqlīm dū[yu]m* (the second climate)				
13	Khaybar	75;20	74;30[495]	Khaybar, Saudi Arabia
14	Hurmūz	94;0	25;0	Hormoz, Iran
15	Akbarābād	115;0	26;43	Agra, UP, India
16	Kawāliyar	114;0	26;29	Gwalior, MP, India
17	Qannawj	115;50	26;35	Kannauj, UP, India

494 This and the next locality should be in the first climate.

495 This value is clearly absurd.

	Place Name	L	φ	Identification/Modern Name
18	Ajmīr	111;5	26;0	Ajmer, Rajasthan, India
19	Jadda	76;0	21;0	Jeddah, Saudi Arabia
20	Aḥmadābād	103;40	23;15	Ahmedabad, Gujarat, India
21	Burhānbūr	103;0	20;30	Burhanpur, MP, India
[III] *al-iqlīm siwum* (the third climate)				
22	Dawlatābād	111;0	20;30	Daulatabad, Maharashtra, India
23	Kanbāyat	109;20	22;20	Cambay, Gujarat, India
24	Qayrawān	41;0	31;40	Kairouan, Tunisia
25	Bayt al-Maqdis	66;30	31;50	Jerusalem, Israel
26	Kūfa	79;30	31;30	Kufa (ancient city in Iraq)
27	Miṣr	63;20	30;20	Cairo, Egypt
28	Madā’in	72;0	33;15	Al-Madā’in, Iraq
29	Dimashq	70;0	33;15	Damascus, Syria
30	Baghdād	82;0	33;25	Baghdad, Iraq
31	Fīrūzābād	87;30	28;10	Firouzabad, Iran
32	Yazd	89;0	32;0	Yazd, Iran
33	Iṣfahān	87;40	32;25	Isfahan, Iran
34	Shīrāz	83;0	29;36	Shīrāz, Iran
35	Kirmān	91;30	30;5	Kerman, Iran
	Inner Circle			
tatimma iqlīm siwum (continuation of the third climate)				
36	Qandahār	107;46	33;0	Qandahar, Afghanistan
37	Multān	107;35	29;42	Multan, Pakistan
38	Burushwar	105;15	35;24	Peshawar, Pakistan

	Place Name	L	φ	Identification/Modern Name
39	Siyālkūt	109;0	33;0	Sialkot, Pakistan
40	Lahāwar	109;20	31;50	Lahore, Pakistan
41	Tanīsar	112;33	30;10	Tanesar, Haryana, India
42	Dihlī	118;35	28;19	Delhi, India
43	Kūlkunda[496]	114;19	18;20	Golconda=Hyderabad, India
44	ᶜĀna	76;0	34;0	Ana, Iraq
45	Mawṣil	77;0	34;30	Mosul, Iraq
46	Karaj	85;45	34;0	Karaj, Iran
[IV] *al-iqlīm chahārum* (the fourth climate)				
47	Kāshān	86;0	34;0	Kashan, Iran
48	Qumm	85;40	35;45	Qom, Iran
49	Rayy	86;20	35;45	Shahr Rey, Iran
50	Sāwa	85;0	34;40	Saveh, Iran
51	Jurfādaqān	85;30	34;45	Golpayegan, Iran
52	Hamadān	83;0	35;0	Hamadan, Iran
53	Raqqa	73;15	36;0	Raqqa, Syria
54	Mashhad	92;30	36;0	Mashhad, Iran

[496] It should be in the first climate.



Figure A102.6 – Continuation of the geographical gazetteer on the obverse side of the mater
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Table A102-4 Geographical Gazetteer II

	Place Name	L	φ	Identification/Modern name
	Part II			
	Outer Circle			
Tatimma iqlīm chahārum (continuation of the fourth climate)				
55	Suhraward	83;20	36;0	Suhraward, Iran
56	Sabzawār	91;30	36;5	Sabzevar, Iran
57	Biṣtām	89;30	36;10	Bistam, Iran
58	Nīshābūr	92;30	36;21	Neyshabur, Iran
59	Abhar	84;30	36;45	Abhar, Iran

	Place Name	L	φ	Identification/Modern name
59	Astarābād	89;35	36;50	Gorgan, Iran
60	Qazwīn	85;0	36;15	Qazvin, Iran
61	Marāgha	82;0	37;20	Maragheh, Iran
62	Tabrīz	82;0	38;0	Tabriz, Iran
63	Nakhjawān	81;15	38;40	Nakhichevan, Azerbaijan
64	Balkh	101;0	36;51	Balkh, Afghanistan
65	Badakhshān	104;24	37;10	Badakhshan, Afghanistan
66	Marw	97;0	37;40	Mary, Turkmenistan
67	Harāt	94;30	34;30	Herat, Afghanistan
68	Kābul	104;40	34;30	Kabul, Afghanistan
69	Kashmīr	108;0	35;0	Kashmir=Srinagar, India
70	Ardabīl	80;30	38;0	Ardabil, Iran
71	Nawshahr	78;20	38;10	Nowshahr, Iran
72	Arjīsh	77;0	38;30	Ercis, Turkey
73	Sarakhs	94;30	37;30	Sarakhs, Iran
74	Bulūr	108;0	36;0	Khatlon region, Tajikistan
75	Andarāb	108;45	36;0	Andarab, Iran
76	Ṭāliqān	85;45	36;10	Taloqan, Afghanistan
77	Fāryāb	99;0	36;44	Doulatabad, Iran
78	Jurjān	90;0	36;50	Jurjān, Iran
79	Bākawiyya	84;30	39;30	Baku, Azerbaijan
[V] *al-iqlīm panjum* (the fifth climate)				
80	Samarqand	94;17	39;37	Samarqand, Uzbekistan
81	Bukhārā	97;30	39;50	Bukhara, Uzbekistan

	Place Name	L	φ	Identification/Modern name
82	Bardaᶜa	83;0	40;30	Barda, Azerbaijan
83	Shamākhī	84;30	40;50	Shemakhi, Azerbeijan
84	Qūnya	66;30	41;0	Konya, Turky
85	Khujand	105;35	41;55	Sughd, Tajikistan
86	Ṭāj	104;0	42;0	Tashkent, Uzbekistan
87	Khutan	107;0	42;0	Khotan, China
88	Farghāna	102;0	42;0	Fergana, Uzbekistan
	Inner Circle			
tatimma iqlīm panjum (continuation of the fifth climate)				
89	Bāb al-Abwāb	85;0	43;0	Derbent, Dagestan, Russia
90	Īlāq	99;10	43;20	Angren, Uzbekistan
91	Kāshghar	106;30	44;0	Kashghar, China
[VI] *al-iqlīm shashum* (the sixth climate)				
92	Alān	83;0	44;0	in Dagestan, Russia
93	Nabalūna	42;0	44;0	Naples, Italy
94	Shulakh	100;30	44;0	Chulakkurgan, Kazakhstan
95	Ṭarāz	99;50	44;31	Taraz, Kazakhstan
96	Bīsh Bāligh	111;0	44;50	Pochongtse, Uighur (ruins)
97	Qarāqūrūm	115;0	46;0	Karakorum, Mangolia
98	Khān Bāligh	124;0	46;0	Beijing, China
99	Haraqla	67;20	46;30	Eregli, Turkey
100	Araq	100;0	48;0	
[VII] *al-iqlīm haftum* (the seventh climate)				
101	Akla	108;0	49;0	

	Place Name	L	φ	Identification/Modern name
102	Bulghār	90;0	49;30	(Bulgars)
103	Aqjakirmān	62;0	50;0	Bilhorod-Dnistrovskyi, Ukraine
104	Qirqir	65;30	50;0	in Crimea
105	Mārīkirmān	65;45	50;40	
[+VII] *khāriz iqlm haftum* (beyond the seventh climate)				
107	Jina Jurābṣūr	68;40	62;0	Hebrides Islands
108	Ṣūdāq	66;0	51;0	Sudak, Crimea

ALIDADE

The uninscribed alidade must be a replacement.

BIBLIOGRAPHY

Pingree 2009, No. 20, pp. 88-93

A103⊙ NORTH-SOUTH ASTROLABE ATTRIBUTABLE TO ḌIYĀ' AL-DĪN

Not dated, 17th century

Diameter 194 mm

London, Victoria & Albert Museum (#809-1889)



Figure A103.1 – Front of the astrolabe with the northern projection of the ecliptic
(© Victoria and Albert Museum, London)

Like A090, this astrolabe also consists of a single plate on which the two sides carry the northern and southern projections of the ecliptic respectively along with several star positions. In A090, each side of the plate serves a single latitude, but here

the obverse side is engraved with a double projection for two latitudes and the reverse with a quadruple projection for four latitudes. It is doubtful whether any serious observation can be done with this astrolabe, but the virtuosity exhibited by these complex projections is truly amazing.

Of this astrolabe, only the plate is extant. The rete, alidade and the pin are lost. The *kursī* is very delicately reticulated, with decorative lines engraved on the surface. But the upper part of the *kursī*, most probably a trifoliate finial, is broken and lost. Along with it, the shackle and ring are also missing.

The *kursī* is adorned with a prominent central motif of a tulip with three petals; this is a favourite motif of Ḍiyā’ al-Dīn Muḥammad and occurs in several of his astrolabes.[497] Because of this and because of the fact that this astrolabe carries north-south projections in the same manner as A090, this astrolabe can be attributed to Ḍiyā’ al-Dīn.

OBVERSE SIDE WITH THE NORTHERN PROJECTION OF THE ECLIPTIC

The rim of the astrolabe is divided in 1° and 5° and numbered in 5s clockwise from 5 to 360. The upper half carries the projection for the latitude 36° (Samarqand, or the middle of the fourth climate). The latitude is mentioned under the western end of oblique horizon as *al-ᶜarḍ 36* and the maximum duration of the daylight under the eastern end as *sāᶜāt 14;42*. The lower half is engraved for latitude 32° (Lahore). Here the latitude and the maximum duration are given in the same manner as *al-ᶜarḍ 32* and *sāᶜāt 14;8.*

In both halves are drawn the oblique horizons, altitude circles for every 2° (each fifth highlighted), azimuth arcs for every 10° above the horizon, plain lines for seasonal hours and dotted lines from the western horizon for equal hours. The hour lines related to latitude 36° are drawn in the lower half and those for latitude 32° in the upper half. All these lines are numbered in *Abjad.*

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497 For example, A067, A071, A076, A082, A084, A085 and A088. A somewhat stylized version of the motif occurs in some other astrolabes like A070 and A080.



Figure A103.2 – Reverse side of the plate with the southern projection of the ecliptic
(@ Victoria and Albert Museum, London)

Upon these is superimposed the ecliptic circle in its northern projection. It is divided, as usual, in the 12 signs and labelled with their names from the vernal equinox onwards in an anti-clockwise direction. Each sign is divided in groups of 6° and numbered from 6 to 30 in the same direction. Single degrees are marked on the edge.

On the entire plate are marked the positions of over 50 stars with dots enclosed in circles and their names are engraved next to their positions.

REVERSE SIDE WITH THE SOUTHERN PROJECTION OF THE ECLIPTIC

As on the obverse side, the rim is divided here also in 1° and 5° and numbered clockwise in 5s from 5 to 360 in *Abjad*. On the rim of the upper right quadrant, however, the groups of 5° are numbered once again, but anti-clockwise from the west point to the south point, in common Arabic/Persian numerals from 5 to 90 which are engraved just above the *Abjad* numerals. On the rim of the upper left quadrant, the cells are divided in two by diagonal lines. The lower parts of the cells are filled with the *Abjad* numerals from 271 to 360 from the east point up to the north point. In the upper part are engraved the common Arabic/Persian numerals from 5 to 90 in the same direction for measuring the angles of altitudes, and once more in *Abjad* notation from 5 to 90 in the reverse direction, i.e., from the south point to the east point.

The four quadrants inside these degree scales are designed for four different latitudes, viz. 22° (Mecca), 25° (Medina), 27° (Agra) and 29° (Delhi).

The upper left quadrant carries projections for latitude 29°; here altitude circles are drawn for every 3° (each fifth highlighted) in such a manner that the south point of the plate is also the south point of the projection. The labels *al-ᶜarḍ 29* and *sāᶜāt 13;52,* are engraved above the eastern part of the horizontal diameter.

The upper right quadrant is engraved with the projections for latitude 22°; altitude circles are drawn for every 3° in such a manner that the west point of the plate becomes its south point. The labels *al-ᶜarḍ 22* and *sāᶜāt 13;26* are engraved along the upper half of the vertical diameter.

The lower right quadrant carries the projections for latitude 27°; altitude circles are drawn for every 3°, treating the north point of the plate as the south point of the projection. The labels *al-ᶜarḍ 27* and *sāᶜāt 13;43* are written below the western half of the horizontal diameter.

The lower left quadrant is calibrated for latitude 25°; altitude circles are drawn for every 3°, treating the east point of the plate as its south point. The labels *al-ᶜarḍ 25* and *sāᶜāt 13;35* are written along the lower half of the vertical diameter.

In all the four quadrants azimuth arcs are drawn above the horizon for every 10°; lines for seasonal hours and dotted lines from the western horizon for equal hours are drawn with appropriate orientation. Consequently, the plate looks very cluttered, especially around the centre.

Upon this plethora of projections is superimposed the southern projection of the ecliptic circle. It is divided into the 12 signs and labelled with their names, starting from the vernal equinox and proceeding anti-clockwise. However, the vernal equinox on the reverse side is situated at western intersection of the ecliptic with the equinoctial colure, or horizontal diameter. Each sign is divided in groups of 6° and numbered from 6 to 30 in the same direction. Single degrees are marked on the edge. Here also the positions of over 50 stars are marked with dots enclosed and their names engraved, but with southern orientation.

A104⊙ NORTH-SOUTH ASTROLABE ATTRIBUTABLE TO ḌIYĀ' AL-DĪN[498]

Not dated, 17th century

Diameter 128 mm

Chicago, Adler Planetarium (# L-100)



Figure A104.1 – Front of the astrolabe with the northern rete
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

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[498] Entry based on Pingree 2009, no. 19, pp. 82-87; the two star lists have been rearranged according to increasing right ascension. This astrolabe was previously in the Time Museum, Rockford, Illinois, and was described and illustrated in Turner 1985, no. 4, pp. 74-83.

This is one of most ambitious astrolabes produced in the Lahore family. It has an ingenious construction akin to that of A102. While the latter is equipped with limbs on the front and the back, the main body of the present astrolabe consists of just the limb and *kursī* both cast in one piece. The limb carries degrees scales on both sides and accommodates seven plates and a northern rete in the front and a southern rete in the back. In the thickness of the ring, there are slots at the north and south points, so that the tabs on plates can be inserted in either slot. The retes and plates are held in the limb by four rotatable lugs affixed to the limb on each side. Because of these lugs which rise from the surface of the limb, a conventional alidade cannot be used. Therefore, sighting plates with holes are set up on either side of the east-west bar on both the retes. There is a ruler which can be used on either side.

This astrolabe is not signed, nor dated. But Turner has already drawn attention to the fact that it closely resembles five other astrolabes from Lahore, namely A076, A090, A099, A102 and A103. The north-south projections in the retes and in plates, *ghaṭī* scales on the plates, sigmoid curves of the midday altitude of the sun, gazetteer arranged according to climates, the style of the reticulated *kursī* and many other features strongly indicate that it must have been made by Ḍiyā’ al-Dīn.

Components

Limb with *kursī* (d. 128, h. 173, t. 28), shackle and chain, 2 retes, 7 plates, ruler, pin and horse.

Front

There is no ring, but a chain which may not be original. The shackle is trifoliate in shape. The *kursī* very beautifully reticulated with ornate engravings on the surface. The limb is divided on both sides in 1°, 3° and 6° and numbered clockwise in 6s from 6 to 90 in each quadrant.



Figure A104.2 – The northern rete
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Northern Rete

The peripheral Capricorn ring and the ecliptic ring are held together by the equinoctial bar which has counter changes at its two intersections with the ecliptic ring. The ecliptic ring is divided in the 12 signs of the zodiac and engraved with their names. Each sign is divided into groups of 6° and numbered from 6 to 30. These groups are further subdivided into single degrees on the edge of the ecliptic ring. Traces of the circles of equator and the Tropic of Cancer are visible. The 38 star pointers are joined by a tracery of leaves or leaf-clusters.

Table A104-1 Stars on the Northern Rete

	Star Name	Identification
1	*Dhanab Qayṭus*	β Ceti
2	*Baṭn*	β Andromedae
3	*Fam Qayṭus*	γ Ceti
4	*Ṣadr Qayṭus*	π Ceti
5	*Ghūl*	β Persei
6	*Kaff al-Jadhmā’*	α Ceti
7	*Tālī Masāfat al-Nahr*	γ Eridani
8	*Dabarān*	α Tauri
9	*ᶜAyyūq*	α Aurigae
10	*Rijl*	β Orionis
11	*Yad Yusrā*	γ Orionis
12	*Yad Yumnā*	α Orionis
13	*Rijl Yumnā*	κ Orionis
14	*Shiᶜrā Yamānī*	α Canis Majoris
15	*Shiᶜrā Shāmī*	α Canis Minoris
16	*Ṭarfat al-Safīna*	ρ Puppis
17	*Fard Shujāᶜ*	α Hydrae
18	*Qā’idat al-Bāṭiya*	α Crateris
19	*ᶜAnāq*	ζ Ursae Majoris
20	*Janāḥ Ghurāb*	γ Corvi
21	*Simāk Aᶜzal*	α Virginis
22	*Simāk Rāmiḥ*	α Bootis
23	*Nayyir Fakkah*	α Coronae Borealis
24	*ᶜUnuq Ḥayyah*	α Serpentis

	Star Name	Identification
25	*Rās al-Jāthī*	α Herculis
26	*Rās al-Ḥawwā*	α Ophiuchi
27	*ᶜAyn Tinnīn*	α Draconis
28	*Yad Ḥawwā*	δ Ophiuchi
29	*Wāqiᶜ*	α Lyrae
30	*Minqār Dajājah*	β Cygni
31	*Nasr Tā’ir*	α Aquilae
32	*Dhanab al-Dulfīn*	ε Delphini
33	*Dhanab al-Dajājah*	α Cygni
34	*Fam Faras*	ε Pegasi
35	*Dhanab al-Jadī*	α Capricorni
36	*Sāq Sākib al-Mā’*	δ Aquarii
37	*Surrat Faras*	δ Pegasi
38	*Mankib Faras*	β Pegasi



Figure A104.3 – The southern rete
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Southern Rete

In the southern rete, the Tropic of Cancer passes through the peripheral ring. This Cancer ring and equinoctial ring are held together by the equinoctial bar which has a counter change at the centre. The upper half of the solstitial bar is also represented. As in the northern rete, the ecliptic ring here is divided into the 12 signs of the zodiac and engraved with their names and each sign is divided into 6° and 1°. However, in this southern rete, the signs commence at the west point and proceed anti-clockwise. Likewise the right ascension of the stars also increases anti-clockwise.

The upper half of the solstitial bar is engraved with a declination scale, such as normally to be found on the alidade. On the surface of the bar, 6 divisions are created

and each of these is marked with the serial numbers of a pair of signs. Each of these divisions is subdivided (somewhat unevenly) into 6 units on the edge.

The 26 stars marked on the rete are listed below, starting from the west point and proceeding anti-clockwise in the order of increasing right ascension.

Table A104-2 Stars on the Southern Rete

	Star Name	identification
1	*Dhanab Qayṭus J[anūbī]*	β Ceti
2	*Muqaddam*	β Arietis
3	*Mu’akkhir Sharaṭayn*	γ Arietis
4	*Ṣadr Qayṭus*	π Ceti
5	*Tālī Masāfat Nahr*	γ Eridani
6	*Riǰl*	β Orionis
7	*Yad Yumnā*	α Orionis
8	*Riǰl yumna*	κ Orionis
9	*Shiᶜrā Shāmī*	α Canis Minoris
10	*Ṭarfat Safīna*	ρ Puppis
11	*Fard al-Shujāᶜ*	α Hydrae
12	*Qāᶜidat al-Bāṭiya*	α Crateris
13	*Ṣarfa*	β Leonis
14	*Simāk Rāmiḥ*	α Bootis
15	*Kiffa Sh[amālī]*	β Librae
16	*ᶜUnuq al-Ḥayyah*	α Serpentis
17	*Rukbat Ḥawwā Yasra*	ζ Ophiuchi
18	*Rās al-Jāthī*	α Herculis
19	*Rās al-Ḥawwā*	α Ophiuchi
20	*Yad al-Ḥawwā Yumnā*	δ Ophiuchi

	Star Name	identification
21	*ʿIsbāt al-Rāmiḥ*	ρ Sagittarii (?)
22	*Nasr Ṭā’ir*	α Aquilae
23	*Qarn al-Jadī al-Thānī*	β Capricorni
24	*Fam Faras*	ε Pegasi
25	*Mankib Sāk Sākib*	α Aquarii
26	*Dhanab al-Qayṭus Sh[amālī]*	ι Ceti

PLATES

There are seven plates. The first four are calibrated for specific latitudes. The fifth plate carries on both sides combined projections for two latitudes each. Some of the plate faces carry northern projections and some others southern projections. In the following table, the northern and southern projections are listed separately. The sixth plate is engraved with the plate of ecliptic coordinates on the obverse side and with the plate of horizons on the reverse. The last plate carries what is normally engraved on the mater, namely a geographical gazetteer on the obverse and the trigonometric quadrant, the zodiac quadrant, the shadow squares and astrological tables on the reverse side.

Table A104-3 Plates

	φ	Maximum duration of daylight hours	*ghaṭī*
4a	11° N	12;48	---
1a	19° N	---	---
3a	27° N	---	34
4b	29° N	---	---
2a	32° N	---	35
1b	22° S	---	34

	φ	Maximum duration of daylight hours	*ghaṭī*
3b	36° S	---	35
2b	40° S	---	36.6
5a	0° + 30° S		
5b	34° S 38° S	14;26 14;42	
6a	Plate of ecliptic coordinates		
6b	Plate of horizons		
7a	Geographical gazetteer		
7b	What is usually on the back of the astrolabe		

Plates 1-4 carry altitude circles for every 2°, with each third one dotted, and azimuth arcs for every 10° above the horizon. There are lines for seasonal hours numbered from 1 to 12 from the western horizon onwards. The lines for equal hours vary considerably. On 1a (19° N), 2a (32° N), 2b (40° S), 3a (27° N), 3b (36° S) dotted lines for equal hours are drawn from the western horizon. Each hour is then divided by plain lines in five parts of 12° minutes each. Two of these parts constitute a *ghaṭī*. These *ghaṭīs* are numbered serially from the western horizon onwards.

On 1b (11° N) these lines for equal hours and for 12° minutes are drawn from both the western and eastern horizons. Here the *ghaṭīs* are numbered from 1 to 14 from each horizon up to the meridian.

On 4b (29° N) there are dotted lines for equal hours and plain lines for *ghaṭīs* drawn from the western horizon. The *ghaṭīs* are numbered serially from the western horizon onwards.

On 4a (11° N) dotted lines for equal hours and plain lines for *ghaṭīs* are drawn from both the eastern and western horizons and counted from both the horizons; the hours are numbered in *Abjad* from 1 to 7 from each horizon up to the meridian; the *ghaṭīs* are numbered in common Arabic/Persian numerals from 1 to 16 from each horizon up to the meridian.

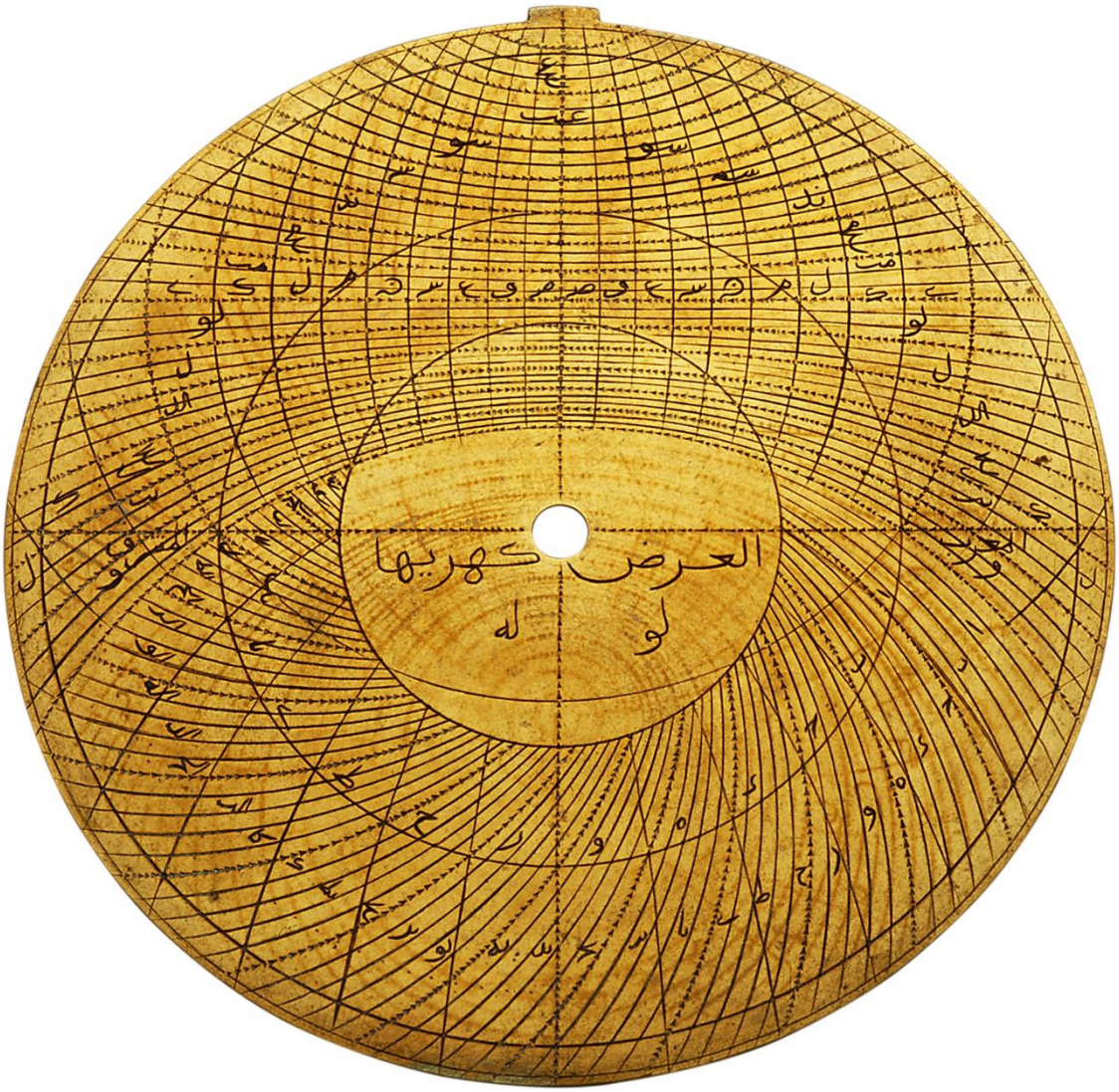


Figure A104.4 – Plate 3b with southern projection for latitude 36°.
Note the dotted lines for equal hours and plain lines for ½ *ghaṭīs*
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Surprisingly there is great laxity in engraving the labels mentioning the latitude and the maximum duration at that latitude. While the latitude is mentioned in all cases, the other parameter is not. Only in one case (4a for 11° N) the duration is mentioned in hours and minutes together with the argument: *sāᶜāt* 12;48. On 1a (19° N) the argument *sāᶜāt* is engraved without the actual value. As can be seen from the table above, the maximum duration is given in *ghaṭīs* and *palas* in 5 cases. The engraver had difficulty in transliterating the term *ghaṭī* (or *ghaḍ/rī* as it is commonly pronounced) in Persian/Arabic script; sometimes *karī-hā* and some other times *kahrī-hā,* with two different types of glyphs for ‘h’, ‘*-hā’* being the plural suffix.

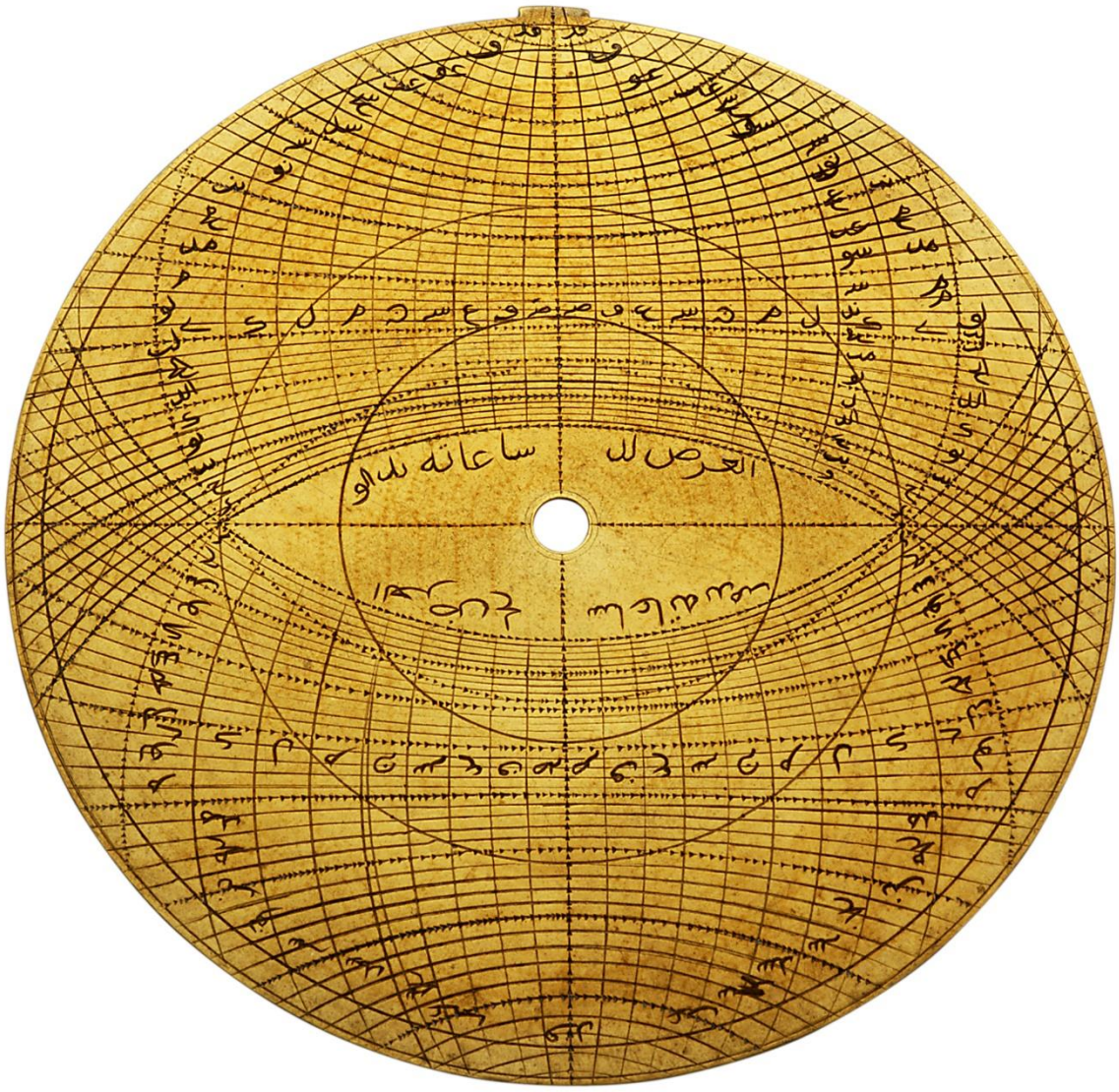


Figure A104.5 – Plate 5b with double projection of latitudes 34° S and 38° S
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Plate 5 has double projections of latitudes 0° and 30° on the obverse and of 34° and 38° on the reverse, with altitude circles for every 3° and azimuth arcs for every 10° above the horizon. On the obverse side, under the projection for 0° is engraved *lā ᶜarḍ lahu* (there is no altitude). Under the projection for 30° there is an incomplete label (*ᶜarḍ 30 sāᶜāt*) which omits the maximum duration. On the reverse side, however, the two latitudes receive full labels *ᶜarḍ 34 sāᶜāt 14;26* and *ᶜarḍ 38 sāᶜāt 14;42*.

Plate 6 has the plate of ecliptic coordinates on the obverse and the plate of horizons on the reverse, the former with the usual label and the latter without.



Figure A104.6 – Plate 7a with the geographical gazetteer
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

GEOGRAPHICAL GAZETTEER

On 7a is engraved a geographical gazetteer in three circles providing the names, longitudes and latitudes of 77 localities, arranged according to climates.[499]

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499 There are some misreadings in Pingree 2009, p. 87. These are mentioned with the prefix ‘P’ in brackets after the relevant entry.

Table A104-4 Geographical Gazetteer

	Place Name	L	φ	
	Outer Circle			
[-I] *az khaṭṭ istiwā tā iqlīm awwal* (from the line of equator up to the first climate)				
01	Jazīra Qanbala	21;0	3;0	
02	Jamkūt	170;0	5;0	
03	Shalā	180;0	5;0	
04	Ghānā[500]	19;0	10;0	
05	ᶜAdan	76;0	11;0	
06	Sarāndīb	130;0	10;0	
[I] *mabdā iqlīm awwal 12;48* (beginning of the first climate [at latitude] 12;48°)				
07	Jubil	75;0	13;30	
08	Janad	75;30	14;30	
09	Burhānbūr	103;0	20;30	
10	Junīr	110;5	19;48	(P 108;0)
11	Tānah	114;5	19;20	(P 104)
12	Juyūl	106;40	19;0	
13	Bījābūr	105;30	17;20	(P 104;30 17;10)
14	Dawlatābād	111;5	20;30	(P 102;0)
[II] *mabdā iqlīm dūyum 20;31* (beginning of the second climate [at latitude] 20;31°)				
15	Tā’if	77;30	21;20	(P in climate I)
16	Makka Musharraf	77;10	21;40	

[500] The entries of this and the next place are mixed up in Pingree 2009, p. 87.

	Place Name	L	φ	
17	Madīnat Ṭayyiba	75;20	25;0	
18	Hurmūz	92;0	25;0	
19	Akabarābād	114;0	26;43	
20	Qannawj	115;50	26;35	(P Ganawj)
21	Ajmīr	111;5	26;0	(P 111)
22	Kwāliyar	114;0	26;29	
23	Lahknaw	114;53	26;30	
24	Jawnbūr	119;6	36;36	(read: 26;36)
25	Awadh	118;6	27;22	
26	Balāwan	119;59	27;22	(read Badāwan)
27	Banāras	107;20	26;55	(P 117;20 26;15)
28	Aḥmadābād	108;40	23;15	
29	Kanbāyat	109;20	22;20	
[III] *mabdā iqlīm siwum 27;34* (beginning of the third climate [at latitude] 27;34°)				
30	Kūlkanda	114;19	28;4	(read: 18;4)
31	Firūzābād	87;30	28;10	
32	Dihlī	113;35	28;39	
33	Hānsī	112;25	29;45	(P 28;45)
34	Bānībahtah	113;20	28;52	
35	Baran	114;5	28;48	
36	Multān	107;35	29;40	
37	Shīrāz	108;0	29;16	(read 88;0)
38	Baṣra	84;0	30;0	

	Place Name	L	φ	
39	Kirmān	91;30	30;5	
	Middle Circle			
40	Tahānīsar	112;33	30;10	(P 112;13)
41	Miṣr	66;30	30;20	
42	Sunām	112;25	82	(read latitude 30;30)
43	Parshūr	85;55	31;0	(read 105;55)
44	Kūfa	79;30	31;30	
45	Qayrawān	41;0	31;40	
46	Bayt al-Maqdis	66;30	31;50	
47	Lāhūr	109;20	31;50	
48	Yazd	89;0	32;0	
49	Iṣfahān	87;40	32;25	(P 81;40)
50	Qandahār	107;40	33;0	
51	Baghdād	82;0	33;25	
[IV] *mabdā iqlīm chahārum 33;43* (beginning of the fourth climate [at latitude] 33;43°)				
52	Kāshān	86;0	34;0	
53	Harāt	94;20	34;30	(P 62;10 34;20)
54	Sāwa	85;0	35;0	
55	Kashmīr	108;0	35;0	
56	Ḥalab	72;10	35;50	
57	Mashhad	92;30	36;0	
58	Balkh	101;0	36;11	(P 36;51)
59	Marāgha	82;0	37;20	

	Place Name	L	φ	
[V] *mabdā iqlīm panjum 39;1* (beginning of the fifth climate [at latitude] 39;1°)				
60	Samarqand	99;19	39;37	
61	Bukhārā	97;30	39;50	
62	Tubbat	110;0	40;0	
	Inner Circle			
63	Khutan	107;0	42;0	(P 101;0)
64	Farghāna	102;0	42	
65	Īlāq	99;0	43;20	(P 99;30 43;6)
66	Khujand	97;45	43;30	
[VI] *mabdā iqlīm shashum 43;30* (beginning of the sixth climate [at latitude] 43;30°)				
67	Kāshghar	106;30	44;0	
68	Alān	43;0	44;0	(P ‘read 73;0’)
69	Bīsh Bāligh	111;0	45;50	
70	Khān Bāligh	124;46	46;0	
71	Harqala	67;20	46;30	
[VII] *mabdā iqlīm haftum 47;30* (beginning of the seventh climate [at latitude] 47;30°)				
72	Araq	105;0	48;0	(P 85;0)
73	Akla	88;0	49;0	(P 108;0)
74	Qirqir	65;30	50	
[+VII] *khāriz iqlīm haftum* (beyond the seventh climate)				
75	Marīkirmān	64;45	50;40	
76	Jazīra Fard	---	64;41	
77	Ṣūdāq	66;0	51;0	

Place Name	L	φ



Figure A104.7 – Plate 7b to be used as the back of the astrolabe
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

BACK

There is no back as such in this astrolabe; its function is discharged by the reverse side of plate 7, where the various elements are arranged somewhat differently from the usual backs of astrolabes. Here the lower half contains six semi-circular rows. Reading from the outside, these contain successively the names of the 28 lunar mansions, the names of the 12 zodiac signs, the planetary lords of the terms (indicated by the final

letters of their names), the degrees in each term, cotangent scales in feet and digits and their subdivisions. These rows are extended into the upper half, where they remain completely blank. Then follows a circular row carrying in each quadrant altitude scales, divided in 6° and 1°, and numbered from 6 to 90. Inside this altitude scale, the upper half is occupied by a double solar quadrant with declination arcs for 5° of solar longitude, with each third arc dotted. The serial numbers of the relevant signs are written along the horizontal diameter; 8, 7, 6, 5, 4, 3 from the periphery in the east up to the centre (i.e., from winter solstice to summer solstice) and 2, 1, 0, 11, 10, 9 from the centre up to the periphery in the west (i.e. from summer solstice to winter solstice). The declination arcs are also numbered along the vertical radius, but all the numbers are not clearly visible in the available photo.

On the quadrant on the right are drawn three sigmoid curves of the midday altitude of the sun at latitudes 19°, 27° and 32°. There are no labels with these curves, merely the latitude values are engraved.

In the lower left quadrant are engraved two shadow squares, one inside the other. The outer one is for 12 digits and the inner one for 7 feet. They are accompanied by the usual labels. In the lower right is the trigonometric quadrant with 30 vertical parallels, each third line is dotted.



Figure A104.8 – Graduated ruler
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

RULER

There is no alidade; instead each of the retes is equipped with sights at the two ends of its equinoctial bar. There is a graduated ruler with ornate ends which can be used on either side. Each of its arms is divided in 6 units. These units are engraved with *Abjad* numbers in two registers as shown below. But the significance of these numbers eludes us.

40 64	42	12	20	?	45	?	42	12	22	8?	10
42	26	24	31	18	32	48	29	24	18	42	65

Provenance

This astrolabe was previously with the Time Museum, Rockford, Illinois.

Bibliography

Pingree 2009, No. 19, pp. 82-93

Turner 1985, no. 4, pp. 74-83.

ḤĀMID

Ḥāmid ibn Muḥammad Muqīm (*fl.* 1655-1691) belongs to the fourth generation of the Lahore family of instrument makers. He is known though 11 astrolabes and 3 celestial globes produced between August 1655 and June 1691.[501] In an astrolabe preserved in the Houghton Library of the Harvard University, the year of production is engraved as 1038 (= AD 1628-29). But this year is too early for Ḥāmid's work since his own father's Muḥammad Muqīm's instruments begin to appear only from AH 1031/ AD 1021-22. Therefore, the year on the astrolabe at the Houghton Library must have been wrongly inscribed as 1038 instead of 1068.

Apart from producing astrolabes and celestial globes, Ḥāmid also copied a manuscript of Naṣīr al-Dīn al-Ṭūsī's highly popular manual on the astrolabe entitled *Bist Bāb* on 10 Sha'bān 1087 (=17 September 1678).[502]

Ḥāmid's astrolabes are relatively small, with diameters ranging between 77 and 142 mm, and they lack the elegance of the astrolabes crafted by his father Muḥammad Muqīm and by his elder cousin Ḍiyā' al-Dīn. Ḥāmid attempts to make his mark in other respects. The most remarkable of these is that, in 10 out of the 14 instruments which bear his signature, he mentions the precise date (*tārīkh*) and month (*shahr*), besides the year of production.

We have seen that in his gazetteers, Allāhdād wished to provide *inḥirāf* along with longitudes and latitudes, but failed to do so, and that thereafter Allāhdād's descendants limited their gazetteers to just longitudes and latitudes. Ḥāmid tries to revive this older tradition and gives *inḥirāf* and *jihat,* in addition to longitudes and latitudes in some of his astrolabes (A112 - A116, A119).

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501 His three globes are dated 1655 (Cambridge, Whipple Museum), 1682 (Hyderabad, Salar Jung Museum) and 1690 (Pune, Kelkar Museum). Their full descriptions will appear in section F.

502 Cf. *Catalogue of the Persian Manuscripts in the Salar Jung Museum and Library, Hyderabad*, Vol. IX, Hyderabad 1988, Ms. no. 3877: *Bist Bāb*, with an anonymous commentary, copied by Ḥāmid Aṣturlābī ibn Muḥammad Muqīm on 10 Sha'bān 1087/17 September 1678. While showing me the manuscript, Dr Rahmat Ali Khan, the then Keeper of Manuscripts, Salar Jung Museum, remarked about the particularly poor calligraphy of Ḥāmid.

In the Lahore astrolabes, the arcs of declination are drawn at equal spaces in the solar quadrants at the back. Ḥāmid follows this family tradition in some of his astrolabes, but in others, he projects them stereographically as is done in Safavid astrolabes. In drawing the graphs of the midday altitude of the sun in all seasons (*khaṭṭ niṣf al-nahār*), he gives greater importance to the latitude of Mecca (at 20° or 21°) than to the latitudes of Lahore, Agra and Delhi.

The most remarkable piece of his work is the highly complex and massive astrolabe and qibla-indicator which he completed on 6 December 1686. It is constructed like a round casket in which are stacked the rete and seven plates. Five of these plates are calibrated for different latitudes, but inside the circle of Cancer on each plate are drawn lines radiating from the centre, indicating the azimuths of *qibla* of certain places with their names. The remaining two plates are exclusively devoted to *qibla*-lines from various localities. A very elaborate set of astrological tables is engraved on the back . The geographical gazetteer is engraved on the inner side of the lid, providing the longitude, latitude, the *inḥiraf* or the azimuth of qibla, and *jihat* for 142 localities. This and other gazetteers of Ḥāmid contain names of several Indian cities for the first time, such as Rajmahal and Gaur in Bengal, Bandar Sūrat (the seaport of Sūrat) in Gujarat and Gulbarga in Karnataka.

Apparently, this instrument was meant as presentation piece for some high noble at the Mughal court whose name must have been engraved on the front side of the *kursī*. About a hundred years later, a new owner got the original erased and had his name engraved at the apex of the upper right quadrant on the back as Mālik Qadirdād Khān Muhandis 1186 sanah (owner Qadirdād Khān, engineer/technician, AD 1772-73).

A105⊙ ASTROLABE BY ḤĀMID, 1068 AH (AD 1657)

2 Muharram 1068 = 9 October 1657

Diameter 131 mm

London, Nasser D. Khalili Collection of Islamic Art (SCI 13)



Figure A105.1 – Front of the astrolabe (photo by S. R. Sarma)

Components

Body with *kursī* (d. 131, h. 170, t. 1), shackle and ring, rete for 38 stars, 5 plates, uninscribed alidade, washer, pin and horse.

Front

Large ring, trifoliate shackle, *kursī* pierced with an elaborate symmetric pattern, trifoliate finial. The limb is divided in 1° and 6° and labelled from 6 to 90, separately in each quadrant.

Rete

The equator is not represented in the rete. The two rings of the Capricorn and ecliptic are held together by the complete equinoctial bar (with counter changes at its intersections with the ecliptic ring) and by the almost complete solstitial bar, which is interrupted by two heart-shaped ornaments, on either side of the equinoctial bar.



Figure A105.2 – Rete of the astrolabe (photo by S. R. Sarma)

The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names. Each sign is divided into groups of 6° and numbered accordingly from 6 to 30. The sloped edge of the ecliptic ring is graduated in 3°.

There is an arch-shaped Capricorn index (*al-mūrī*). A handle was provided in the outer ring at about 140° NW, but it got detached and there remains the just the hole where it was affixed.

The star pointers are generally shaped like tiger's claws; in two cases, Ḥāmid shapes them like the petals of tulip flowers, following the style of his father Muqīm. The star ι Ceti is placed in the lower half, just above β Ceti, both in the sign Aries. Star names are often abbreviated.

Table A105-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus Sh[amālī]*	ι Ceti
2	*Dhanab al-Qayṭus Janūbī*	β Ceti
3	*Baṭn al-Ḥūt*	β Andromedae
4	*Rijl al-Musalsala*	γ Andromedae
5	*Fam al-Qayṭus*	γ Ceti
6	*Ṣadr al-Qayṭus*	π Ceti
7	*Rās al-Ghūl*	β Perse
8	*Kaff al-Jadhmā'*	α Cet
9	*Tālī Masāfat al-Nahr*	γ Eridani
10	*ᶜAyn al-Thawr*	α Tauri
11	*ᶜAyyūq*	α Aurigae
12	*Rijl al-Jawzā' [al-]Yusrā*	β Orionis
13	*Yad al-Jawzā' [al-Yusrā]*	γ Orionis
14	*Yad al-Jawzā' [al-Yumnā]*	α Orionis
15	*Rijl al-Jawzā' [al-]Yumnā*	κ Orionis
16	*Shiᶜrā Yamānī*	α Canis Majoris
17	*Shiᶜrā [Shāmī]*	α Canis Minoris
18	*Ṭarfat al-Safīna*	ρ Puppis
19	*Mankhar al-Shujāᶜ*	σ Hydrae
20	*Fard al-Shujāᶜ*	α Hydrae
21	*[Qāᶜidat] al-Bāṭiya*	α Crateris
22	*Janāḥ al-Ghurāb*	γ Corvi
23	*[Simāk] Aᶜzal*	α Virginis

	Star Name	Identification
24	*Simāk Rāmiḥ*	α Bootis
25	*Nayyir Fakkah*	α Coronae Borealis
26	*ᶜUnuq al-Ḥayyah*	α Serpentis
27	*Qalb al-ᶜAqrab*	α Scorpii
28	*Rās al-Jāthī*	α Herculis
29	*Yad al-Ḥawwā [al-Yumnā] al-Muqaddam*	δ Ophiuchi
30	*Nasr Wāqīᶜ*	α Lyrae
31	*Nasr Ṭā'ir*	α Aquilae
32	*Dhanab al-Dulfīn*	ε Delphini
33	*Dhanab al-Dajājah*	α Cygni
34	*Fam al-Faras*	ε Pegasi
35	*Dhanab al-Jadī*	δ Capricorni
36	*Sāq Sākib al-Mā' J[anūbī]*	δ Aquarii
37	*Surrat al-Faras*	δ Pegasi
38	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are 5 plates. The duration of the longest day is given in hours, minutes and seconds, but there are inconsistencies in the first two entries.

Table A105-2 Plates

	φ	Longest day
1a	21°	13;36,56 hours
1b	22°	13;20,56 hours!
2a	25°	13;33,36 hours

	φ	Longest day
2b	27°	13;42,46 hours
3a	32°	14;8,0 hours
3b	36°	14;27,10 hours
4a	18°	13;3,56 hours
4b	0°+72°+90°	
5a	Plate of ecliptic coordinates	
5b	Plate of horizons with the label *safīḥa āfāqī*	

Surprisingly there is no plate for Delhi. On plates 1 to 4a, altitude circles are drawn for every 3°, with every fifth circle dotted. Azimuth arcs are drawn for every 6° below the horizon and numbered in a straight line. Plain lines for seasonal hours and dotted lines for equal hours counted from the western horizon. Under the western horizon *al-maghrib* and under the eastern horizon *al-mashriq.*

Plate 4b contains a combined projection for the latitudes of 0°, 72° and 90° with the labels *lā ᶜarḍ lah, li ᶜarḍ 72* and *li ᶜarḍ tisᶜūn* respectively.

Plate 5 is engraved with the plate of ecliptic coordinates on the obverse and with the plate of horizons on the reverse.

Geographical Gazetteer

The gazetteer is engraved in two concentric circles for 38 localities with their longitudes and latitudes. In the outer circle the tops of the letters are towards the centre; in the inner circle they are towards the circumference of the astrolabe.



Figure A105.3 – Geographical Gazetteer (photo by S. R. Sarma)

Table A105-3 Geographical Gazetteer

	Place Name	L	φ
	Outer Circle		

	Place Name	L	φ
1	Makka Muᶜaẓẓam	77;10	21;40
2	Madīnat Rasūl ᶜAlīyat al-Salām	75;20	24;50
3	Ṭāᶜif	77;30	21;20
4	ᶜAdan	76;0	11;0
5	Jidda	76;0	21;0
6	Bayt al-Maqdis	66;30	31;50
7	Miṣr	63;0	30;20
8	Kūfa	79;30	31;30
9	Baghdād	80;15	33;20
10	Madā’in	80;20	33;0
11	Iṣfahān	86;40	34;25
12	Shīrāz	88;0	29;0
13	Multān	107;35	29;30
14	Lāhūr	109;20	31;50
15	Bust	100;0	33;0
16	Qandahār	107;40	33;0
17	Akra	115;4	26;43
18	Dihlī	113;18	28;13
19	Hamadān	103;0	36;8
20	Badakhshān	104;25	36;10
21	Balkh	101;0	36;41
22	Kābul	104;40	34;30
23	Kashmīr	105;0	35;0
24	Ṭūs	92;30	36;0

	Place Name	L	φ
25	Bukhārā	96;30	39;10
26	Samarqand	99;0	40;0
27	Tubbat	110;0	40;0
	Inner Circle		
28	Dawlatābād	111;0	20;30
29	Pījāpūr	114;20	17;17
30	Kūlkand	114;19	18;4
31	Burhānpūr	112;0	21;21
32	Janīr[503]	110;0	18;48
33	Kanbāyat	109;20	22;20
34	Lakhnaw	114;13	26;30
35	Kawāliyār	114;0	26;29
36	Bānāras	117;20	26;15
37	Jawnpūr	119;6	26;30
38	Ajmīr	111;5	26;0

BACK

The rim of the upper half bears the altitude scales divided in 1° and 6° and labelled 6—90; 90—6. In the upper left is a trigonometric quadrant with 60 horizontal parallels. In the upper right quadrant are drawn six declination arcs, labelled along the vertical and horizontal diameters with the serial numbers of the signs from 0 to 11. Three graphs of solar meridian altitude for the latitudes 20° (Mecca?), 27° (Agra) and 32° (Lahore),

[503] This locality is mentioned also in the next three astrolabes (A106, A107and A108) with the same coordinates. It ought to be in south India, but cannot be identified

with labels *khaṭṭ niṣf al-nahār bi-ᶜarḍ 20*, *khaṭṭ niṣf al-nahār bi-ᶜarḍ 27* and *khaṭṭ niṣf al-nahār bi-ᶜarḍ 32*.

In the lower half, there are shadow squares, on the left for a base of 12 and on the right for a base of 7 with the usual labels.

Inside the shadow squares is a table of triplicities. Outside the shadow squares are two semi-circular tables that show the correlation between the 28 lunar mansions and the 12 signs of the zodiac. The rim of the lower half bears the cotangent scales.



Figure A105.4 – Back of the astrolabe (photo by S. R. Sarma)

ALIDADE

The alidade has ornate ends and an ornate centre-piece, but is without any graduations or labels.



Figure A105.5 – Signature of the Astrolabe Maker (photo by S. R. Sarma)

INSCRIPTION

Below the shadow squares is the maker's signature which is continued on the left and right of the shadow squares:

ṣanah qalīl al-ʿibād ḥāmid ibn muḥammad muqīm ibn ʿīsā
ibn allāhdād asṭurlābī lāhūri humāyūnī
fī al-tārīkh 2 shahar muharram
fī sanah 1068 hijrī.

'Made by the least of the servants [of God], Ḥāmid, son of Muḥammad Muqīm, son of ʿĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, on the date 2 in the month of Muharram in the year 1068 of the Hijra.'

The date translates to 9 October 1657.[504]

BIBLIOGRAPHY

Maddison & Savage-Smith 1997, Part 1, p. 223, no. 128.

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504 Khalili catalogue gives 10 October.

A106⊙ ASTROLABE BY ḤĀMID, 1038 AH (AD 1628-1629)!

Diameter 125 mm

Cambridge, Mass., Harvard University, Houghton Library (552-1)



Figure A106.1 – Front of the astrolabe (photo courtesy Professor Owen Gingerich)

In a heart-shaped cartouche on the back, the year of manufacture is clearly engraved as *sanah 1038*. The era is not mentioned, but it can be assumed that it is the Hijri era; this would correspond to AD 1628-29. This year is problematic, because this is just about the time when his father Muḥammad Muqīm began producing astrolabes (his first extant one is dated 1621). Moreover, the next extant astrolabe by Ḥāmid is dated 1657, with a gap of almost 30 years! The Répertoire accepts this early date and exclaims that Ḥāmid was active until his mid-eighties.[505] But this cannot explain the long gap of about 30 years.



Figure A106.2 – Detail of Figure A106.5

It is possible that (i) he made here a mistake, just as he did in the spelling of his great grandfather's name and in certain *Abjad* numbers on the rim of the front of the

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505 The Répertoire writes: "Of this son of Muḥammad Muqīm, the brother of the Jamāl al-Dīn, there exist 9 instruments, 8 of which are dated: and all are dated to a precise day and not only to a running year as is the common usage. These dates are distributed from AH 1038 to AH 1102, that is to say from 1628/29 to 1691 AD. The earliest extant instrument is dated 1038: it shows an ornamentation quite remarkable, even a bit too affected. One is inclined to imagine a major work of apprenticeship composed under the vigilant eyes of Muḥammad Muqīm himself. Towards the end of his life, Ḥāmid has a style more hasty, his handwriting is less careful. But if the astrolabe no. 1 has been put together by a young man of say 18 years in AH 1038 = AD 1628-29, astrolabe no. 8 has been made by a man of 83 or 84 years!

astrolabe; or (ii) that the date was added by somebody later on, or (iii) that the whole thing was a forgery because of all the three reasons mentioned in (i). However, the astrolabe is too good to be a forgery. I am inclined think that these three cases should be attributed to certain carelessness on the part of Ḥāmid.

It is obvious that the engraver made a mistake in writing 1038 (١٠٣٨) instead of the correct year 1068 (١٠٦٨), for in all probability the astrolabe was made in AH 1068= AD 1657-58. Moreover, the present astrolabe contains several errors in the *Abjad* symbols with which the degree scale on the limb is numbered. The calligraphy is rather poor.

Stylistically this astrolabe has similarities with A109 of 1661. The *kursī,* worked *à jour,* resembles those of A109 and A110. The surface decorations on the empty spaces between legends on the front, more particularly on the back, are reminiscent of Safavid astrolabes.

COMPONENTS

Body with *kursī* (d. 125, h. 167, t. 4.5), shackle and ring, rete (d. 109) for 40 stars, 4 plates, alidade (114 x 10) and pin. The horse is missing.

FRONT

The *kursī* and the limb are cast in one piece to which the back plate has been joined by rivets along the circumference. Inside the limb the plug has been added and hammered in. At the back there is a faint impression of the rectangular plug. The *kursī* is pierced, producing an unimpressive pattern with a small cartouche in the middle, on which is engraved *allāhu akbar*. There is a trifoliate finial to which the shackle (also trifoliate in shape) has been attached. Through the shackle passes the ring with a flat hexagonal cross section. In the front the points where the *kursī* is joined to the main body appears to be slightly damaged.

The limb is not perfectly circular, but made up of 60 lobes. Each lobe is designed as an oval cartouche in which the *Abjad* numbers of the degree scale are engraved. Besides the *Abjad* symbols, some decorative lines are also drawn in each oval. The limb is graduated in 1° and 6° and labelled from 6 to 90 separately in each quadrant. However, there are many errors in the *Abjad* numerals (underlined below). The numbers, read clockwise from the south point onwards, are as follows:

26	12	75	24	30	36	42	48	54	60	66	72	78	84	90;
96	12	18	24	30	36	42	48	54	60	66	72	78	84	90;
6	22	18	24	29	36	42	48	54	60	66	72	78	84	90;
6	19	18	24	30	36	42	48	54	60	66	72	75	84	25.

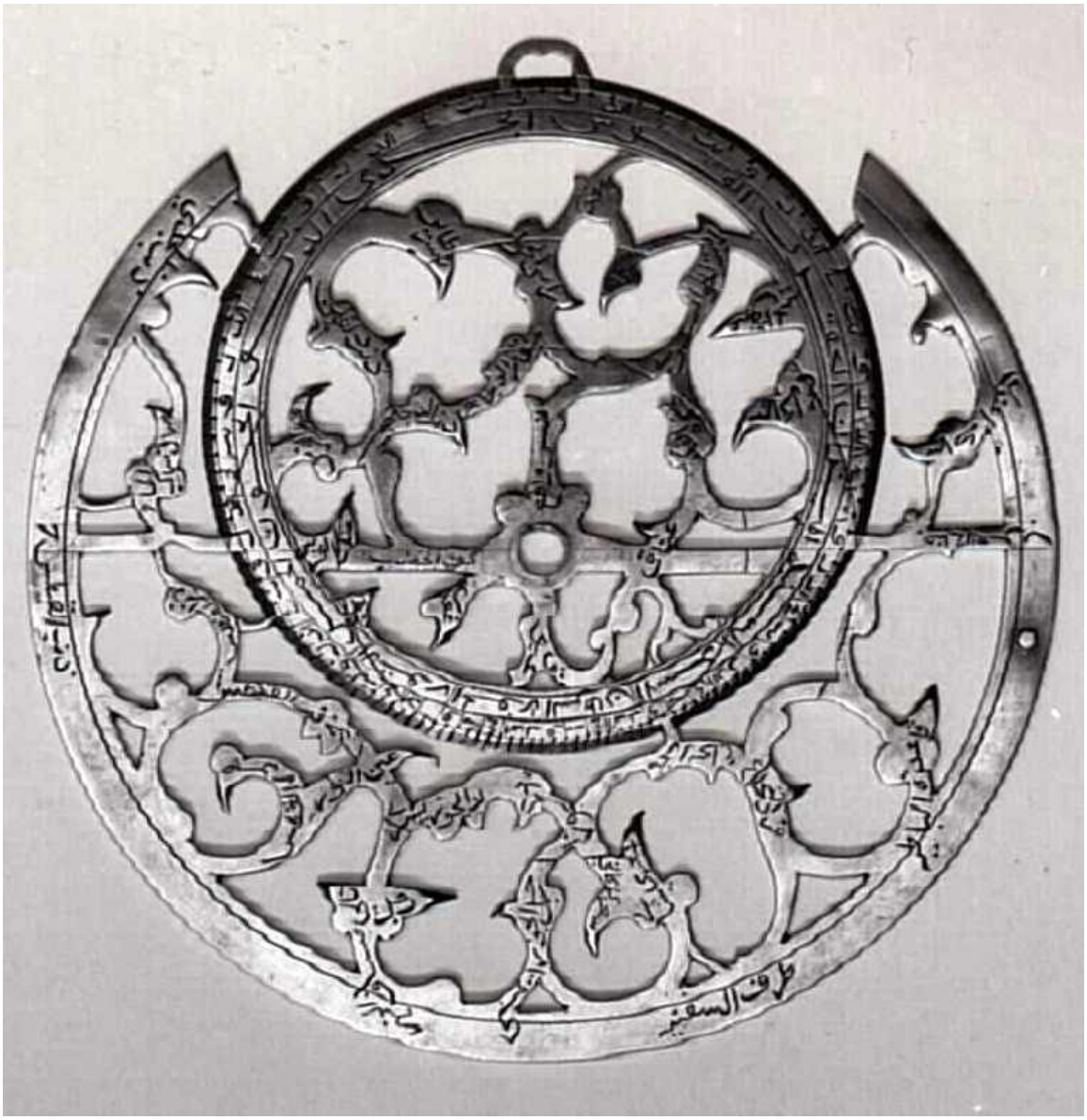


Figure A106.3 – Rete of the astrolabe (photo courtesy Professor Owen Gingerich)

RETE

The two rings of the Capricorn and of the ecliptic are held together by the equinoctial bar which has counter changes at its two intersections with the ecliptic ring. The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names.

Each sign is divided into units of 6° and numbered 6, 12, 18, 24, 30; here the division marks are not clearly engraved; one sees just the numbers. The sloped edge of the ecliptic ring is divided into units of 3°. The *mūrī* is shaped like a thin arch. In the outer ring, just below the west point, there is a handle to rotate the rete.

The 40 star pointers are generally shaped like tiger's claws. Outside the ecliptic, the star pointers are joined by a spiral band, of no particular ornamental value. Inside the ecliptic, the pointers are joined in an asymmetric pattern.

Table A106-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus J[anūbī]*	β Ceti
2	*Dhanab al-Qayṭus Sha[mālī]* ι Ceti	
3	*Baṭn [al-Ḥūt]*	β Andromedae
4	*Fam al-Qayṭus*	γ Ceti
5	*Ṣadr al-Qayṭus*	π Ceti
6	*Ghūl*	β Persei
7	*Jadhmā'*	α Ceti
8	*Tālī Masāfat al-Nahr*	γ Eridani
9	*ᶜAyn al-Thawr*	α Tauri
10	*ᶜAyyūq*	α Aurigae
11	*Rijl [al-Jawzā' al-Yusrā]*	β Orionis
12	*Yad al-Jawzā' Yusrā*	γ Orionis
13	*Yad al- Jawzā' [al-Yumnā]*	α Orionis
14	*Rijl al-Jawzā' Yumnā*	κ Orionis
15	*Shiᶜrā Yamānī*	α Canis Majoris
16	*Shiᶜrā Shāmī*	α Canis Minoris
17	*Ṭarfat Safīna*	ρ Puppis

	Star Name	Identification
18	*Mankhir al-Shujāᶜ*	σ Hydrae
19	*Fard al-Shujāᶜ*	α Hydrae
20	*Qāᶜidat al-Bāṭiya*	α Crateris
21	*ᶜAnāq*	ζ Ursae Majoris
22	*Janāḥ al-Ghurāb*	γ Corvi
23	*Simāk Aᶜzal*	α Virginis
24	*Simāk Rāmiḥ*	α Bootis
25	*Nayyir Fakkah*	α Coronae Borealis
26	*ᶜUnuq al-Ḥayyah*	α Serpentis
27	*Rukbat al-Ḥawwā*	ζ Ophiuchi
28	*Muqaddam*	ρ Ophiuchi
29	*[Rās al-] Jāthī*	α Herculis
30	*Rās al-Ḥawwā*	α Ophiuchi
31	*Nasr Wāqiᶜ*	α Lyrae
32	*Minqār al-Dajājah*	β Cygni
33	*Nasr Ṭā'ir*	α Aquilae
34	*Dhanab Dulfīn*	ε Delphini
35	*Dhanab al-Dajājah*	α Cygni
36	*Fam al-Faras*	ε Pegasi
37	*Dhanab al-Jadī*	δ Capricorni
38	*Sāq Sākib al-Mā' Janūbī*	δ Aquarii
39	*Mankib al-Faras*	β Pegasi
40	*Kaff al-Khaḍīb*	β Cassiopeiae^

PLATES

There are four plates calibrated to the following latitudes.

Table A106-2 Plates

	φ	Longest day
1a	21°	13;16 hours
1b	23°	13;25 hours
2a	27°	13;42 hours
2b	29°	13;51 hours
3a	32°	14;8 hours
3b	36°	14;27 hours
4a	18°+72°	13;5 hours; ---
4b	0°+90°	

Altitude circles are drawn for every 6° and numbered in the usual style on both sides of the meridian. Azimuth circles are drawn for every 10° above and below the horizon on 1a; only below the horizon on 1b. They are not drawn on other plates.

On all plates, under the eastern horizon is written *al-mashriq* and under the western horizon *al-maghrib.*

Plain lines for seasonal hours are drawn on plates 1 to 3 and numbered from the western horizon in *Abjad* symbols. Dotted lines for equal hours are drawn from the western horizon on plates 1 to 3 and these are numbered in common Arabic/Persian numerals from 1 to 12.

On plate 4a, plain lines for seasonal hours are drawn and numbered from the western horizon in *Abjad* symbols; dotted lines for equal hours from the western and eastern horizons are drawn and these too are numbered from the western horizon in common Arabic/Persian numerals.

On plate 4b, at latitude 0° the lines for seasonal and equal hours become the same. These are numbered both in *Abjad* symbols and common Arabic/Persian numerals, both starting from the western horizon and reaching up to the eastern horizon. Below the

horizon is written on the right *lā ᶜarḍ lahu,* on the left *sāᶜāt 12.* This is with reference to the equator. Just above the north point is written *al-ᶜarḍ tisᶜīn* ('the latitude is ninety[degrees]')

There is no plate bearing the plate of ecliptic coordinates and plate of horizons.

GEOGRAPHICAL GAZETTEER

Engraved in two circles with the names, longitudes and latitudes of 38 localities. In the outer circle, the writing is upside-down, i.e. the tops of the letters are towards the centre of the astrolabe; in the inner circle they are the other way round. In the both circles, the outermost unit (in the outer circle, it is the latitude; in the inner circle, it is the place name) is enclosed in an oval cartouche.



Figure A106.4 – Geographical Gazetteer (photo courtesy Professor Owen Gingerich)

Table A106-3 Geographical Gazetteer

	Place Name	L	φ
	Outer Circle		
1	Makka Muᶜaẓẓam	77;10	21;40
2	Madīnat Rasūl[506]	75;20	25;0
3	Jidda	76;0	21;0
4	Bayt al-Maqdis	66;30	31;50
5	Dimashq	70;0	33;0
6	Ḥalab	72;10	35;50
7	Baghdād	82;0	33;25
8	Tabrīz	82;0	38;0
9	Shīrāz	88;0	29;36
10	Qazwīn	85;0	36;45
11	Iṣfahān	87;40	32;40
12	Mashhad	92;30	36;0
13	Harāt	94;20	34;30
14	Balkh	81;0	36;11
15	Bukhārā	94;30	39;50
16	Samarqand	99;36	39;37
17	Kābul	84;40	34;30
18	Kashmīr	88;0	34;0
19	Tubbat	110;0	40;0
20	Qandahār	87;40	33;0
21	Multān	87;25	39;40

[506] In the blank circle above the name is added ᶜAlī[yat] al-Salām.

	Place Name	L	φ
22	Lāhūr	109;20	31;50
23	Tānīsar	112;33	30;10
	Inner Circle		
24	Dihlī	113;28	28;29
25	Akra	115;0	26;43
26	Kawāliyār	114;0	26;29
27	Qannawj	114;50	26;55
28	Banāras	117;20	26;15
29	Aḥmadābād	108;40	23;15
30	Ajmīr	111;5	26;0
31	Aḥmadānakar	105;0	19;0
32	Burhānpūr	103;0	20;30
33	Janīr?	110;0	18;48
34	Bijāpūr	104;20	17;14
35	Kūlkanda	105;19	18;4
36	Dawlatābād	111;0	20;30
37	Ujjayn	110;50	23;30
38	Kanbāyat	109;20	26;20

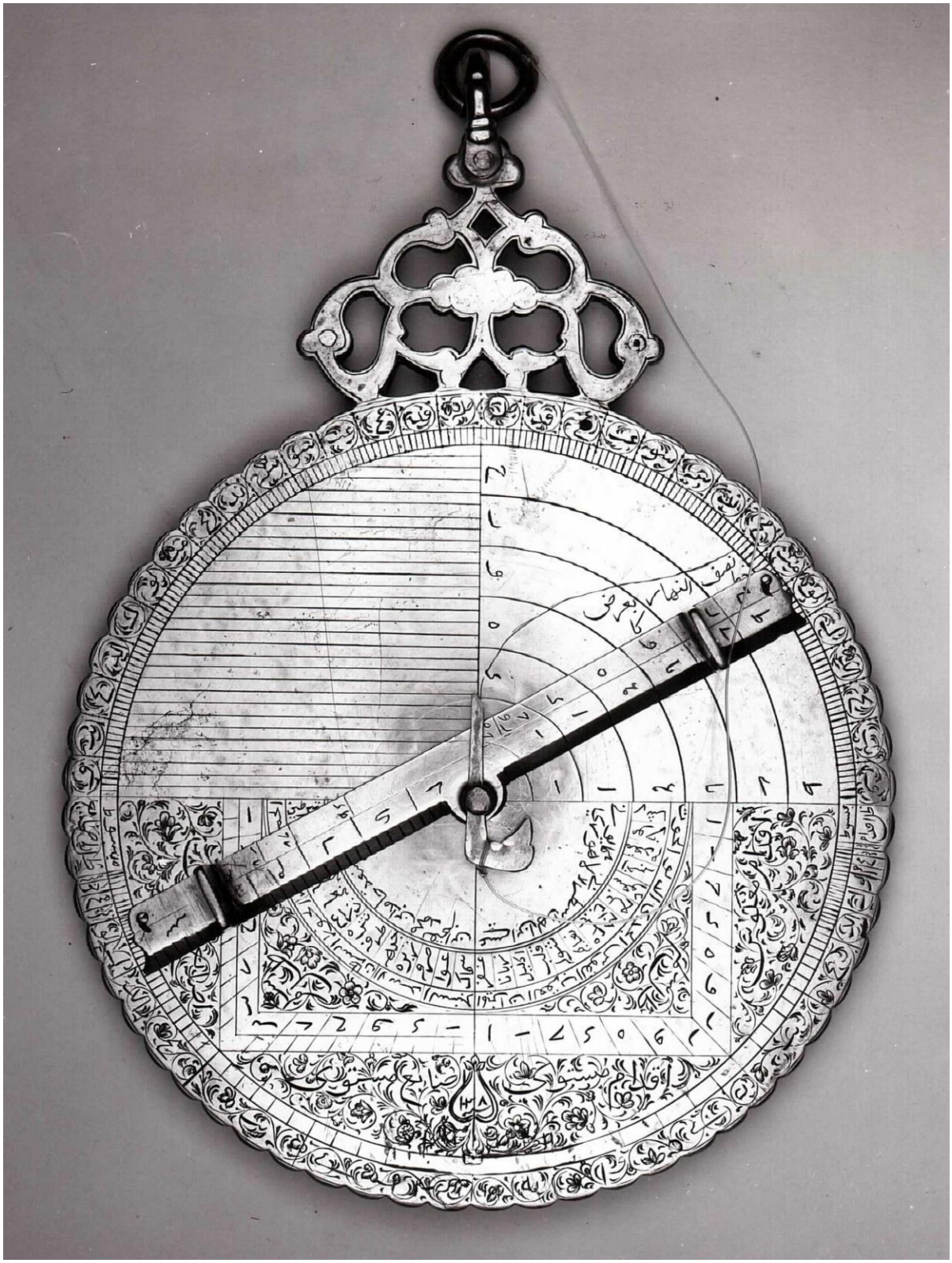


Figure A106.5 – Back of the astrolabe (photo courtesy Professor Owen Gingerich)

Back

On the back, the rim of the upper two quadrants is divided in 1° and 6° and labelled in 6's inside the cartouches as 6—90; 90—6. There are ornamental lines inside these cartouches; these are more on the back than on the front.

In the upper left quadrant 30 (or 29 more exactly) horizontal parallels are drawn. In the upper right quadrant six declination arcs are drawn and the spaces inside (which represent pairs of signs) are labelled with the serial numbers of the signs along the two radii. On this quadrant is plotted a curve of the midday altitude of the sun at the latitude of 21° (i.e. of Mecca) with the label *khaṭṭ niṣf al-nahār bi-ᶜarḍ 21.*

In the lower half, there are shadow squares, on the left for a base of 12 and on the right for a base of 7. The scales are divided and labelled in the usual manner.

Inside the shadow square are semi-circular scales carrying the names of the 12 zodiac signs and the corresponding 28 lunar mansions.

The rim of the lower half carries the cotangent scales. Here also the numbers are written in oval cartouches which are filled with ornate designs to such an extent that the *Abjad* numbers are difficult to read. At the end of the scale on the left is written *ẓill aṣabiᶜ mustawī*; at the end of the scale on the right *ẓill aqdām mustawī.*

The empty spaces between the semi-circular scales and the shadow squares, both inside the shadow squares and outside squares, are filled with floral design with creepers, leaves and flowers.

ALIDADE ETC

The alidade is graduated. On the right into six units and marked from the centre 10, 20, 30, ….60. On the left the divisions correspond to the arcs drawn in the solar quadrant and numbered accordingly with the serial numbers of the zodiac signs.

INSCRIPTION

Inside the two semi-circular scales of lunar mansions and zodiac signs, is engraved upside down the astrolabe maker's signature along its semi-circular outline. Below the shadow squares, in an upside-down heart-shaped cartouche is engraved the year of manufacture *sanah 1038.*

> *aḥqar al-ᶜibād ṣanᶜat ḥāmid ibn muḥammad muqīm ibn ᶜīsā ibn allāhd[ād] asṭurlābī lāhūrī humāyūnī.*
>
> 'The work of the least worthy of servants [of God], Ḥāmid, son of Muḥammad Muqīm, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn.'

The initial *m* in *muqīm* is not correctly formed (it looks like *ya* without diacritics) and the name Allāhdād misspelt.

PROVENANCE

The Library Register has this entry:
Purchased from Persian Antique Gallery, 32 East 57th Street, New York 22, New York. Received 10 January 1956. *552-1 Astrolabe, Persian, 17th Century, Brass instrument with dial and rule on a circular base, diameter 12.7 cm, $ 120 00 Hofer f[un]d.

BIBLIOGRAPHY

Gingerich 1971, no. 67, plate V.

A107⊙ ASTROLABE BY ḤĀMID, 1069 AH (AD 1658)

21 Rabī’ l-awwal 1069 (17 December 1658)

Diameter 112 mm

Hyderabad, Salar Jung Museum (#114/2/xxxv)



Figure A107.1 – Front of the astrolabe (photo by S. R. Sarma)

COMPONENTS

Body with *kursī* (d. 112, h. 141, t. 7), shackle and ring, rete for 28 stars, 5 plates, alidade, pin and horse.

FRONT

The ring and shackle have diamond-shaped cross sections. The *kursī* is high; it is a slightly tapering rectangle with three lobes on either side at the upper corners. The top culminates into a trefoil to which the shackle is attached. The *kursī* is solid and unadorned.

The rim of the mater is graduated into 1° and 6° and labelled clockwise from 6 to 90 separately in each quadrant.



Figure A107.2 – Rete of the astrolabe (photo by S. R. Sarma)

RETE

The rete is very unusual in its design and unlike any of the retes of the Lahore astrolabes. The peripheral Capricorn ring and eccentric ecliptic ring are held together by the equinoctial and solstitial bars, both completely represented. The equinoctial bar is counter-changed at its two intersections with the ecliptic ring. The solstitial ring is interrupted by large oval frames on either end and a small circle in the middle. The equator is represented in two small segments, one inside the ecliptic ring and the other below it.

On the inner edge of the ecliptic ring, there are small protrusions on which the zodiac signs are labelled numerically from 0 to 11 in *Abjad* notation. There are also

protrusions to mark the limits of the signs. Each sign is divided in groups of 6° and labelled. There are 28 star pointers, some of which are set up on triangular arches. The star *al-Wāqiʿ* is shown as the head of a bird with large outstretched wings. There is a prominent handle with a crown-like cross section.

Table A107-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus [Shamālī]*	ι Ceti
2	*Dhanab al-Qayṭus J[anūbī]*	β Ceti
3	*Fam al-Qayṭus*	γ Ceti
4	*Ṣadr al-Qayṭus*	π Ceti
5	*Ghūl*	β Persei
6	*Tālī Masāfat al-Nahr*	γ Eridani
7	*Dabarān*	α Tauri
8	*ʿAyyūq*	α Aurigae
9	*Rijl al-Jawjā'*	β Orionis
10	*Yad al-Jawjā'*	γ Orionis
11	*Yad al-Jawjā'-Yumnā*	α Orionis
12	*Rijl al-Jawjā'-Yumnā*	κ Orionis
13	*Shiʿrā Yamānī*	α Canis Majoris
14	*Shiʿrā [Shāmī]*	α Canis Minoris
15	*Minkhir al-Shujāʿ*	σ Hydrae
16	*Fard al-shujāʿ*	α Hydrae
17	*Qāʿidat al-Bāṭiya*	α Crateris
18	*Simāk Aʿzal*	α Virginis
19	*Simāk Rāmiḥ*	α Bootis

	Star Name	Identification
20	*Nayyir Fakkah*	α Coronae Borealis
21	*ᶜUnuq al-[Ḥayyah]*	α Serpentis
22	*Rās al-Jāthī*	α Herculis
23	*Rās al-Ḥawwā*	α Ophiuchi
24	*Nasr Wāqiᶜ*	α Lyrae
25	*Nasr Ṭā'ir*	α Aquilae
26	*Dhanab al-Dālfīn* (sic!)	ε Delphini
27	*Fam al-Faras*	ε Pegasi
28	*Sāq Sākib al-Mā' J[anūbī]*	δ Aquarii

PLATES

There are five plates with projections for eight different latitudes. On these, the altitude circles are drawn for each 6° and azimuth circles for each 10° below the horizon. There are plain lines for seasonal hours and dotted lines for equal hours from the western horizon. The following latitudes are served by the five plates.

Table A107-2 Plates

	φ	Longest Day
1a	18° + 72°	13;4,36 hours
2a	20°	13;42,56 hours
2b	23°	13;25,4 hours
3a	25°	13;33,36 hours
3b	27°	13;42,46 hours
1b	29°	13;51,36 hours
4a	32°	14;8,0 hours
4b	36°	14;27,10 hours

φ	Longest Day
5a	Plate of ecliptic coordinates
5b	Plate of horizons

On plate 1a, there are combined projections for 18° and 72°. But the latter is not labelled.



Figure A107.3 – Geographical Gazetteer (photo by S. R. Sarma)

GEOGRAPHICAL GAZETTEER

On the inner side of the mater, a gazetteer of 57 localities is engraved in two concentric circles. It is the most carelessly engraved gazetteer in the Lahore astrolabes, both from the point of calligraphy and arrangement. The calligraphy is very poor, and there is no pattern in the arrangement of the localities, Indian and Iranian places are mixed up arbitrarily. Several names and numerical data are indecipherable.

Table A107-3 Geographical Gazetteer

	Place Name	L	φ
	Outer Circle		
1	Makka Muᶜaẓẓam	77;10	21;40
2	Madīnat Mubārak	75;20	24;50
3	Ṭāᶜif	77;30	21;20
4	Hajar Baḥrayn	83;15	25;15
5	Jidda	76;0	21;0
6	Miṣr	63;0	30;20
7	Hajar ?	78;30	28;30
8	Kūfa	79;30	31;30
9	Baghdād	80;15	33;20
10	Shīrāz	88;0	39;30 !
11	Bu[s]ṭ	100;0	33;0
12	Qandahār	107;40	33;0
13	Kābul	104;40	34;30
14	Balkh	101;0	36;41
15	Ṭūs	92;30	36;0
16	Bukhārā	96;30	39;10
17	Samarqand	99;0	40;0

	Place Name	L	φ	
18	Tubbat	110;0	40;0	
19	Kashmīr	105;0	35;0	
20	Lāhūr	109;20	31;50	
21	Dihlī	113;18	28;13	
22	Sulṭānkūt ?	109;0	23;0	
23	Hānsī	112;25	29;45	
24	Tānīsar	112;13	30;10	
25	Kawāliyār	114;0	26;29	
26	Jawnbūr	119;6	26;36	
27	Bānāras	117;20	26;15	
28	Kanbāyat	109;20	22;20	
29	Māhūr	106;0	24;40	(Mathurā ?)
30	Aḥmadnakar	107;40	19;22	
31	Aḥmadābād	108;0	23;0	
32	Sarūnj ?	113;6	24;30	
33	Ujjayn	112;0	22;30	
34	Multān	107;35	29;40	
35	Ajmīr	111;5	26;0	
	Inner Circle			
36	Dawlatābād	101;0	20;30	
37	Janīr ?	110.0	18;48	
38	Bījāpūr	114;20	17;17	
39	Kūlkanda	115;19	18;4	
40	Akra	115;4	26;43	

	Place Name	L	φ
41	Awadh	118;6	27;22
42	Badāwan	114;59	27;32
43	Kūpāmāū	114;33	26;45
44	Kara Mānikpur	118;10	26;49
45	Qannawj	114;50	26;35
46	Lakhnaū	114;53	26;30
47	Kūl Jalālī	114;19	28;4
48	Sawmnāth	106;0	17;0
49	Jamkūt	176;0	5;0
50	Sulṭankūt	115;0	28;30
51	Nahrawara ?	78;20	28;30
52	Samarkand	96;30	39;30
53	Badakhshān	104;25	36;10
54	Khujand	100;35	41;15
55	Tūn	92;30	34;30
56	Nishābūr	92;30	36;21
57	Qazwīn	85;0	36;35



Figure A107.4 – Back of the astrolabe (photo by S. R. Sarma)

BACK

The rim of the upper half carries the scales of altitude, divided in 1° and 6° and labelled as 6—90; 90—6. The rim of the lower half is engraved with the cotangent scales.

The upper left quadrant bears 30 horizontal parallels. The solar quadrant on the right is divided into six segments, each representing a pair of zodiac signs, which are marked by their serial numbers 0 to 11 along the two radii. Here is plotted a curve for the midday altitude of the sun at 20° latitude, presumably for Mecca. In the lower half is engraved a double shadow square, on the left for a base of 7 and on the right for a base of 12 with the usual divisions and labels.

Inside the shadow squares is engraved a table of correspondence between the signs of the zodiac (marked by their serial numbers 0-11) and the lunar mansions (marked by their names in full).

Alidade etc

The alidade is straight and plain without any graduations or any other writing on it. It appears to be original, but a cylindrical sighting tube was attached to it later on. The pin and the wedge also appear to be original. The wedge combines the forms of a serpent and a horse, with a slit for the mouth and a hole for the eye at the back of the head.

Inscription

The maker's inscription is engraved partly above the semi-circular table of zodiac signs and lunar mansions (in two semicircles) and partly below the shadow squares (in one straight line) and reads thus:

> *ṣanᶜat aqall al-ᶜibād ḥāmid ibn muḥammad muqīm ibn ᶜīsā ibn allāhdād asṭurlābī lāhūrī humāyūnī*
>
> *fī al-ta'rīkh 21 rab[ī]' l-awwal sanah 1069.*
>
> 'Made by the least of the servants [of God] Ḥāmid, son of Muḥammad Muqīm, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, on the date 21 of the month Rab[ī]' l-Awwal of the year 1069 [Hijrī]'

The date corresponds to 17 December 1658.

Bibliography

Sarma 1996a, pp. 20-22, pl. 9.

A108⊙ ASTROLABE BY ḤĀMID, 1071 AH (AD 1661)

9 Jumādā al-Awwal 1071 (9 January 1661)

Diameter 112 mm

Paris, Institut du Monde Arabe (AI 86-27)

CCA 3538; Répertoire 3



Figure A108.1 – Mater with the geographical gazetteer (photo courtesy Institut du Monde Arabe)

Components

Only the mater is extant with *kursī* (d. 112, h.148, t. 6) and shackle.

Front

The ring is missing. The shackle is trifoliate. The *kursī* is lobed and has a trifoliate finial. The *kursī* is pierced symmetrically, producing at the centre a cartouche with three lobes on each side. The limb, the back plate and the *kursī* are cast separately and joined together with several rivets. The ends of the circular ring meet at the south point at the top centre; the ends have not been joined properly. The limb is divided in 1° and 6° and labelled clockwise in 6s from 6 to 90, separately in each quadrant.

Geographical Gazetteer

The gazetteer is engraved in two concentric circles separated by an empty circle. In the outer circle, the tops of the letters are towards the centre; in the inner circle towards the outer periphery. The writing is uneven and clumsy; in some places over-written. Unlike his father Muqīm, Ḥāmid has difficulty in engraving the place names within the space of one cell. In one case (no. 2) the name is continued into the empty circle above; in another case (no. 56) the name occupies two cells. There are 57 place names with their longitudes and latitudes.

Table A108-1 Geographical Gazetteer

	Place Name	L	φ
	Outer Circle		
1	Makka Mu^{c}aẓẓam	77;10	21;40
2	Madīnat Rasūl ^{c}Alīyat al-Salām	75;20	24;50
3	Jidda	76;0	21;0
4	Ṭā^{c}if	77;30	21;20
5	Bahrayn	83;15	25;15
6	Bayt al-Maqdis	66;30	31;50

	Place Name	L	φ
7	Miṣr	63;0	30;20
8	Dimashq	70;20	33;20
9	Kūfa	79;30	31;30
10	Baghdād	80;15	33;20
11	Madā’in	80;20	33;0
12	Iṣfahān	86;40	34;0
13	Shīrāz	88;0	29;30
14	Yazd	89;0	35;20
15	Bust	100;0	33;0
16	Qandahār	107;40	33;0
17	Tabrīz	82;0	36;20
18	Qazwīn	85;0	36;15
19	Tūn	92;30	36;0
20	Badakhshān	104;25	36;10
21	Kābul	104;40	34;30
22	Kashmīr	105;0	35;0
23	Ṭūs	92;30	36;0
24	Balkh	101;0	36;41
25	Bukhārā	96;30	39;10
26	Samarqand	99;0	40;0
27	Tubbat	110;0	40;0
28	Kāshghar	106;30	44;0
29	Multān	107;35	29;40
30	Lāhūr	109;20	31;50

	Place Name	L	φ	
31	Dihlī	113;18	28;13	
32	Akra	115;4	26;43	
33	Ajmīr	111;5	26;0	
34	Aḥmadābād	108;0	23;0	
35	Sarūnj	113;6	24;30	
	Inner Circle			
36	Dawlatābād	111;0	20;30	
37	Aḥmadnakar	illegible	19;22	
38	Janīr ?	110;0	18;48	
39	Pījāpūr	114;20	17;17	
40	Kūlkand	115;9	18;4	
41	Burhānpūr	112;0	21;21	place name barely legible
42	Ujjayn	112;0	22;30	
43	Bānāras	117;20	26;15	
44	Lakhnaw	114;13	26;30	
45	Jawnbūr	119;6	26;36	
46	Qannawj	114;50	36;30 !	
47	Kawāliyār	114;0	26;29	
48	Awadh	118;6	27;22	
49	Badāwan	114;59	27;32	
50	Kūl Jalālī	114;19	28;4	
51	Tānīsar	112;33	30;10	
52	Hānsī	112;25	29;45	
53	Sālkūt	109;0	33;0	

	Place Name	L	φ	
54	Sunnām	112;25	30;30	
55	Kūpāmaū’	116;33	26;15	
56	Kara Mānikpūr	118;10	26;19	written in two cells
57	Kanbāyat	109;20	22;20	

BACK

The rim of the two upper quadrants is divided in 1° and 6° and labelled as 6—90; 90—6. The rim of the lower half carries the cotangent scales; the left half bears uneven cells marked with the numbers 6, 12, 18, 24, 30, 36, 42, 48, 54; 60 followed by the label *ẓill aṣābiᶜ;* the right half bears uneven cells marked with the numbers 6, 12, 18, 24, 30, 36, 42, 48, 54; 60 followed by the label *ẓill aqdām.* In the inner circle, each of these cells on the left and right are divided into 6 parts.

The upper left quadrant carries 30 horizontal parallels. In the upper right quadrant are drawn 6 declination arcs. These are labelled with the serial numbers 0 to 11 of the corresponding signs along the vertical and horizontal radii. Above these is drawn a graph of the meridian altitude of the sun for the latitude 20° (roughly for Mecca) with the label *khaṭṭ niṣf al-nahār bi-ᶜarḍ 20.*

In the lower half are engraved the shadow squares, on the left for a gnomon of 12 digits and on the right for a gnomon of 7 digits. The scales are divided and labelled in the usual manner.



Figure A108.2 – Back of the Astrolabe (photo courtesy Institut du Monde Arabe

Inside the shadow squares are two semi-circular scales; the outer one is engraved with the serial numbers of the zodiac signs from 0 to 11; the inner scale carries the names of the corresponding 28 lunar mansions.

INSCRIPTION

In the space between the horizontal diameter of the astrolabe and the semi-circular scales of signs and lunar mansions is engraved the astrolabe maker's signature in four lines thus:

ṣanᶜah qalīl al-ᶜibād ḥāmid ibn muḥammad muqīm
ibn ᶜisā ibn allāhdād lāhūrī asṭurlābī
humāyūnī taḥrīr fī al-tārīkh 9
shahr jumādā al-awwal

below the table of shadows is added *sanah 1071*.

'Made by the least of the servants [of God], Ḥāmid, son of Muḥammad Muqīm, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn. Completed (*taḥrīr*) on the date 9 of the month Jumādā I of the year 1071 [Hijrī].

The date translates to 9 January 1661.

PROVENANCE

Formerly in the collection of Georges Prin, Paris, and in the collection of M. Destombes, Paris.

BIBLIOGRAPHY

Mouliérac 1989, pp. 105-106.

A109 ASTROLABE BY ḤĀMID, 1071 AH (AD 1660-61)

Diameter 103 mm

Cologne, PC

Répertoire 9



Figure A109.1 – Front of the astrolabe (photo by the owner)

This astrolabe didplays better workmanship as compared to the others with the well-crafted *kursī* and rete. The design of the rete, however, shows close similarities with the design of the rete which occurs in many astrolabes made by the Safavid astrolabe-maker ʿAbd al-A'imma, who is Ḥāmid's contemporary.[507]

COMPONENTS

Mater with *kursī* (d. 103, h. 142), ring and shackle, rete for 34 stars, 4 plates, alidade, pin and wedge. The pin and wedge appear to be replacements.



Figure A109.2 – All the components of the astrolabe (photo by the owner)

FRONT

The *kursī* is reticulated with a symmetrical pattern; the two profiles are formed by ogees at the base and top with a lobe in between; the finial is trifoliate. The shackle is also trifoliate; the ring is plain and large.

The limb is divided in 1°, 3° and 6° and numbered in 6s from 6 to 180 and again from 6 to 180. The single degree divisions are rather uneven.

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507 Cf. Y009 and the rete in Figure Y009.2.



Figure A109.3 – Rete of the astrolabe (detail of Figure A109.2)

RETE

The slender peripheral Capricorn ring and the broader ecliptic ring are held together by the tracery that joins the various star pointers. The east-west equinoctial bar and the south-north solstitial bar are not represented at all. The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names. Each sign is divided into 5 parts on the edge of the ecliptic ring, but not numbered. There is no handle to turn the ecliptic ring; the Capricorn index is not well defined.

There are 34 named star pointers which are joined by a tracery of tendrils. These are not listed here because no good photo of the rete is available.

PLATES

There are four plates, each with a projecting tooth at the south point which would fit into the slot at the corresponding place in the rim of the mater. The first three plates serve the latitudes from 20° to 36°. On these plates, altitude circles are drawn for every 6° and numbered on both sides of the meridian. Azimuth arcs are drawn only on the plate for 20° for every 10° above and below the horizon. Those for every 30° are dotted.

In the lower half of the plates, there are plain lines for seasonal hours and dotted lines for equal hours drawn from the western horizon. Both sets are jointly numbered from 1 to 12 along the circle of equator.

It is not known which two sides belong to which plate; therefore, the sides are numbered serially from 1 to 8 below.

Table A109-1 Plates

	φ	Longest Day
1	20°	13;42,16 hours!
2	23°	13;25,4 hours
3	27°	13;42,46 hours
4	29°	13;51,36 hours
5	32°	14;8,0 hours
6	36°	14;27,10 hours
7	Plate of ecliptic coordinates with the label *ṣafīḥat mīzān al-ᶜankabūt*	
8	Plate of horizons with the label *ṣafīḥa āfāqī*	



Figure A109.4 – Geographical gazetteer (photo by the owner)

Geographical Gazetteer

On the inner side of the mater is engraved the geographical gazetteer in two circles with the names, longitudes and latitudes of 34 localities, mostly Indian.

Table A109-2 Geographical Gazetteer

	Place Name	L	φ
	Outer Circle		
1	Makka Muᶜaẓẓam	76;10	21;40

	Place Name	L	φ
2	Madīnat Rasūl ᶜAlīyah al-Salām	75;20	24;50
3	Jadda	76;0	21;0
4	Kūfa	79;30	31;30
5	Baghdād	80;15	33;20
6	Iṣfahān	86;40	34;25
7	Shīrāz	88;0	29;15
8	Qandahār	107;40	33;0
9	Multān	107;35	29;40
10	Lāhūr	109;20	31;50
11	Dihlī	113;18	28;13
12	Akbarābād	115;4	26;43
13	Ajmīr	111;5	26;0
14	Aḥmadābād	108;0	23;0
15	Surūnj	113;6	24;10
16	Ujjayn	112;0	22;30
17	Burhānbūr	112;0	21;21
18	Dawlatābād	111;0	20;30
19	Aḥmadnakar	107;40	19;22
20	Junīr	110;0	18;48
21	Bījāpūr	114;20	17;17
22	Kū[l]kanda	115;19	18;4
23	Mahūra	116;0	24;40

	Place Name	L	φ
	Inner Circle		
24	Bānāras	117;20	26;15
25	Qannawj	114;50	26;35
26	Lakhnaw	114;53	26;30
27	Kawāliyar	114;0	26;29
28	Tānīsar	112;25	30;10
29	Sunnām	112;25	30;30
30	Hānsī	112;25	29;45
31	Sālkūt	109;0	33;0
32	Kābul	104;40	34;30
33	Kashmīr	105;0	35;0
34	Tubbat	110;0	40;0

BACK

The rim of the two upper quadrants is divided in 1°, 3° and 6° and labelled as 6—90; 90—6.

The upper left quadrant carries 30 horizontal parallels. In the upper right quadrant are drawn 6 declination arcs. These are labelled with the serial numbers 0 to 11 of the corresponding signs along the vertical and horizontal radii. Above these is drawn a graph of the meridian altitude of the sun for the latitude 20° (roughly for Mecca) with the label *khaṭṭ niṣf al-nahār bi-ʿarḍ 20.*

In the lower half are engraved the shadow squares, on the left for a gnomon of 12 digits and on the right for a gnomon of 7 digits. The scales are divided and labelled in the usual manner. A table of triplicities is engraved inside the shadow squares with the heading *jadwal muthallathāt laylī wa nahārī.*

The rim of the lower half carries the cotangent scales; the left half bears unequal cells marked with the numbers 6, 12, 18, 24, 30, 36, 42, 48, 60 followed by the label *ẓill*

aṣābiʿ mabsūṭ; the right half bears unequal cells marked with the numbers 6, 12, 18, 24, 30, 36, 42, 48, 60 followed by the label *ẓill aqdām mabsūṭ.* In the inner circle, each of these cells on the left and right are divided into 6 parts.

Inside these cotangent scales, there are two semi-circular rows carrying the names of the 12 signs of the zodiac and those of the 28 lunar mansions.



Figure A109.5 – Back of the astrolabe (photo by the owner)

Alidade

The alidade has ornate ends with two decorative holes on each side and an ornate centre-piece, but it is not graduated.

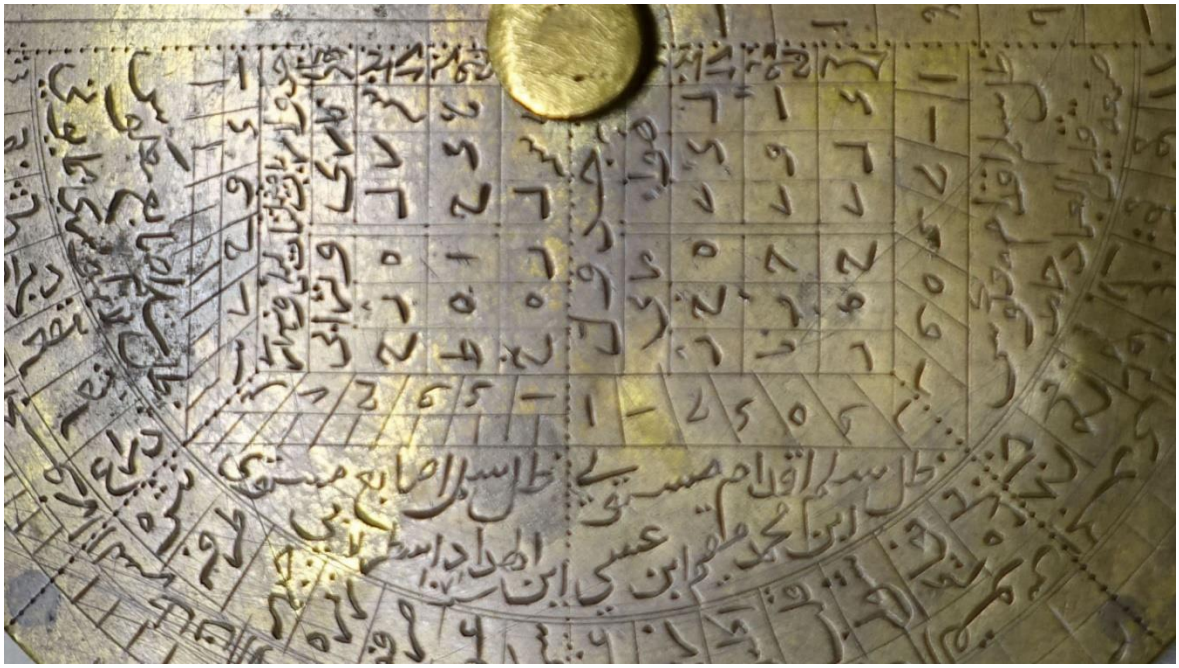


Figure A109.6 – Maker's signature (detail of Figure A109.4)

Inscription

The maker's signature is engraved above the semi-circular row carrying the names of the 28 lunar mansions. It reads as follows:

> *ṣanᶜat qalīl al-ᶜibād ḥāmid*
>
> *ibn muḥammad muqīm ibn ᶜīsā ibn allāhdād asṭurlābī*
>
> *lāhūrī humāyūnī*
>
> *sanah 1071*
>
> 'Made by the least of the servants [of God], Ḥāmid, son of Muḥammad Muqīm, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn. Year 1071[Hijrī].'

Provenance

Damms Antikvariat, Oslo, Catalogue no. 100, 1968, Lot 254, with photo on the frontpage.

A110 ASTROLABE BY ḤĀMID, 1086 AH (AD 1676) [508]

6 Dhū-l-qa‘da 1086 (22 January 1676)

Diameter 141 mm

Qatar, Doha, Museum of Islamic Art (# MW.349.2007), ex-London, Sotheby’s

CCA 3822; Répertoire 4



Figure A110.1 – Front of the astrolabe (© Sotheby’s, London)

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[508] Entry based on the description in Sotheby’s, Cataloguing Preview, *Arts of the Islamic World* (L05221), London 10/12/2005. The photos are kindly provided by Sotheby’s.

COMPONENTS

Body with *kursī* (d. 141), shackle and ring, rete for 39 stars, 5 plates, alidade, pin and horse. The limb and the *kursī* are cast as one piece and riveted to the back plate.

FRONT

The shackle is trifoliate to which a flattish ring is attached. To this is attached a second ring (a bent wire the two ends of which are not joined), which is probably a modern one. The *kursī* is worked *à jour* with a small cartouche in the middle. Whether the *kursī* has a trifoliate finial or not cannot be seen from the photos. The limb divided in 1°, 2° and 6° and labelled in 6's from 6 to 90, separately for each quadrant.



Figure A110.2 – Rete of the astrolabe (© Sotheby's)

RETE

The peripheral Capricorn ring is unusually wide; the ecliptic ring is slightly narrower. The two rings are held together by the equinoctial and solstitial bars; the former has a counter change at its intersection with the ecliptic ring on the left.

The ecliptic ring is divided into the 12 zodiac signs and labelled with their names. Each sign is divided into units of 6° and numbered accordingly. The tracery supporting the star pointers resembles the same in A105. The Capricorn index is arch-shaped.

Table A110-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus Sh[amālī]*	ι Ceti
2	*Dhanab al-Qayṭus J[anubī]*	β Ceti
3	*Janb al-Musalsala*	β Andromedae (= *Baṭn al-Ḥūt*)
4	*Ghūl*	β Persei
5	*Ṣadr al-Qayṭus*	π Ceti
6	*Tālī Masāfat al-Nahar*	γ Eridani
7	*Dabarān*	α Tauri
8	*ᶜAyyūq*	α Aurigae
9	*Rijl al-Jawzā' Yusrā*	β Orionis
10	*Yad al-Jawzā' Yusra*	γ Orionis
11	*Yad al-Jawjā'*	α Orionis
12	*Rijl al-Jawzā'*	κ Orionis
13	*ᶜAbūr*[509]	α Canis Majoris
14	*Ghumayṣā'*	α Canis Minoris

[509] Here and in the next row, Ḥāmid employs other names for *Shiᶜrā Yamānī* and *Shiᶜrā Shāmī,* as his father Muqīm does in his astrolabe A025. On these two new terms, see Kunitzsch 1959, pp. 73-74.

	Star Name	Identification
15	*Minkhir al-Shujāᶜ*	σ Hydrae
16	*Fard al-Shujāᶜ*	α Hydrae
17	*Qalb al-Asad*	α Leonis
18	*Ẓahr Dubb Akbar*	α Ursae Majoris
19	*Qāᶜidat al-Bāṭiya*	α Crateris
20	*Janāḥ al-Ghurāb*	γ Corvi
21	*Simāk Aᶜzal*	α Virginis
22	*Simāk Rāmiḥ*	α Bootis
23	*ᶜAnāq*	ζ Ursae Majoris
24	*Fakkah*	α Coronae Borealis
25	*ᶜUnuq al-Ḥayyah*	α Serpentis
26	*Rās al-Jāthī*	α Herculis
27	*Qalb al-ᶜAqrab*	α Scorpii
28	*ᶜAyn al-Tinnīn*	γ Draco
29	*Rās al-Ḥawwā*	α Ophiuchi
30	*Waqiᶜ*	α Lyrae
31	*Muqaddim*	δ Ophiuchi
32	*Minqār al-Dajājah*	β Cygni
33	*Ṭā'ir*	α Aquilae
34	*Dhanab al-Jadī*	δ Capricorni
35	*Dulfīn*	ε Delphini
36	*Fam al-faras*	ε Pegasi
37	*Sāq Sākib al-Mā'*	δ Aquarii
38	*Kaff al-Khaḍīb*	β Cassiopeiae

	Star Name	Identification
39	*Surrat al-Faras*	δ Pegasi

PLATES

There are five plates with the following specifications:

Table A110-2 Plates

	φ	Longest Day
1a	20°	13;20 hours
1b	29;36°	13;56 hours
2a	32;25°	14;12 hours
2b	38;40°	14;48 hours
3a	40;50°	14;58 hours
3b	18°+72°	13;7 and 21;0 hours
4a	36°	14;32 hours
4b	38°	14;40 hours
5a	Plate of ecliptic coordinates	
5b	Plate of horizons	

It is strange that there are no plates for the three Mughal imperial cities Agra (27°), Delhi (29°) and Lahore (32°). On plates 1 to 4, altitude circles are drawn for each 6° and azimuth arcs for each 15° below the horizon. There are lines for seasonal hours and equal hours. Only two of the five plates have a peg at the bottom to fit into the hole at the exact place in the limb of the mater. It is not clear why the other three are not provided with such a peg.

Geographical Gazetteer

On the inner side of the mater is engraved a gazetteer with the longitudes and latitudes of 42 localities in two concentric circles. The data is arranged in curved segments; the curves in the two circles tilt in opposite directions; this is one of the few ornate features which Ḥāmid borrowed from his father. However, the letters are incised here with a blunt burin and therefore are not sharp. The contrast between the letters here and on the limb is striking. The localities in the inner circle are from the Indian subcontinent, otherwise there is no logic in their sequence.



Figure A110.3 – Geographical gazetteer (© Sotheby's)

Table A110-3 Geographical Gazetteer

	Place Name	L	φ
	Outer Circle[510]		
1	Makka … Musharraf	77;10	21;40
2	Madinat Ṭayyiba	75;20	25;00
3	Tā'if	77;10	21;20
4	Bayt al-Maqdis	63;30	31-30
5	Miṣr	63;20	30;20
6	Baṣra	84;0	30;0
7	Kūfa	79;30	31;30
8	Baghdād	82;0	38;15
9	Iṣfahān	87;17	32;25
10	Shīrāz	88;0	29;39
11	Mashhad Maqdis	92;30	36;0
12	Yazd	89;0	32;0
13	Tabrīz	82;0	38;0
14	Nakhjawān	81;15	38;40
15	Shamākhī	84;30	40;50
16	Qazwīn	85;0	36;0
17	Qandahār	107;40	33;0
18	Samarqand	99;36	36;39
19	Balkh	101;0	36
20	Bukhārā	92;30	29;50

[510] Sotheby's catalogue reads the names in the outer circle from right to left, but those in the inner circle from left to right. Here the names are read from right to left in both cases.

	Place Name	L	φ
21	Kābul	104;0	35;0
22	Kashmīr	105;0	35;0
23	Kirmān	91;30	30;0
	Inner Circle		
24	Tanīsar	112;30	30;0
25	Siyalkut	109;0	33;0
26	Kawāliyār	112;0	26
27	Ujjayn	110;50	23;30
28	Jawnpūr	119;6	26;36
29	Qannawj	114;50	26;20
30	Ajmīr	115;5	26;0
31	Banāras	117;20	26;15
32	Akra	115;4?	26;43 ?
33	Dihlī	113;18	28;13
34	Lahāwar	109;20	31;30
35	Multān	107;25	29;50
36	Aḥmadābād	108;40	23;0
37	Bandar Sūrat	110;0	22
38	Burhānpūr	112;0	21;21
39	Kūlkanda	115;19	18;4
40	Bījāpūr	114;40	17;17
41	Aḥmadnakar	115;0	19;0
42	Dawlatābād	111;0	20;0

BACK

The rim of the two upper quadrants carries the altitude scales, which are divided in 1°, 2° and 6° and labelled as 6—90; 90—6. In the upper left is the trigonometric quadrant with 60 horizontal and 60 vertical parallels, with each fifth dotted. Semi-circles are drawn with the vertical and horizontal radii as diameters.

On the upper right is the solar quadrant, with 15 declination arcs drawn at non-uniform intervals. The names of the signs and the values of the decans (10, 20, 30) are engraved along the vertical and horizontal radii. Three graphs (not sigmoid as in other Lahore astrolabes) are drawn for the latitudes 20°, 36° and 38°, accompanied by labels *khaṭṭ niṣf al-nahār bi-ᶜarḍ 20, khaṭṭ niṣf al-nahār bi-ᶜarḍ 36* and *khaṭṭ niṣf al-nahār bi-ᶜarḍ 38.* Close to the centre is engraved the signature of the maker in three lines (for which see below).

In the lower half, there are shadow squares, on the left for a base of 6 (12) digits and on the right for a base of 7 feet. The four scales are accompanied by the following labels:

Vertical scale on the left: *ẓill sullam aṣābiᶜ maᶜkūs*

Horizontal scale on the left: *ẓill sullam aṣābiᶜ mustawī*

Horizontal scale on the right: *ẓill sullam aqdām mustawī*

Vertical scale on the right: *ẓill sullam aqdām maᶜkūs.*

Inside the shadow squares is inscribed the table of ‘excess of revolution’ (*al-jadwal faḍl al-dawr*).

The lower rim bears the cotangent scales and their subdivisions. The scale on the left is labelled as *ẓill aṣābiᶜ mabsūt* and the scale on the right as *ẓill aqdām mabsūt.*



Figure A110.4 – Back of the astrolabe, alidade, pin and horse (© Sotheby's)

Between the lower rim and the shadow squares is engraved a scale. On this David King writes as follows in the Sotheby's catalogue preview:

> Around this is a most unusual scale labelled *jadwal al-mayl*, 'table of solar declination', in which the solar declination is given to degrees, minutes and seconds for each 6° of the elongation of the sun from the equinoxes. Entries are given for the pairs of zodiacal signs from Aries and Libra to Virgo and Pisces, the outer ones labelled (unusually) *sh-h* for *shamaliyyah*, 'northern' and the inner ones *j-h* for *janubiyyah*, 'southern', with variations *sh-sad-h* and *j-sad-h* where the declination is increasing, the letter *sad* standing for the word *sa'id*, 'increasing'. Corresponding entries on either side of the table should be identical since the function is symmetrical about the equinoxes and the solstices, but this is not the case. The maximum value at the solstices is 23°30'0''. The inclusion of this table in this form does not reflect well on the technical knowledge of the maker. The values were doubtless extracted from some more extensive table and merit further investigation.

ALIDADE

The alidade bears a sexagesimal scale for use with the trigonometric quadrant in the upper register on the right hand side. On the lower register are markings for a universal sundial when the sighting plate on this side is used as a gnomon. The left hand side of the alidade carries a solar scale with the zodiac signs marked by their serial numbers.



Figure A110.5 – Astrolabe maker's signature (detail of Figure A110.4)

INSCRIPTION

The maker's signature is engraved in three lines at the apex of the upper right quadrant and reads thus:

ṣanᶜat aḍᶜaf al-ᶜibād ḥāmid ibn muḥammad muqīm ibn
ᶜīsā ibn allāhdād asṭurlābī humāyūnī. Taḥrīrā fī al-tārīkh
6 fī shahr dhu al-qaᶜida sanah 1086.

'The work of the least of the slaves [of God], Ḥāmid, son Muḥammad Muqīm, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn. Accomplished on the date 6 in the month of Dhu' l-Qa'd[a] in the year 1086 [of the Hijra].'

The date translates to 21 January 1676.

PROVENANCE

Sold Christie's, 10 November 1964, lot 4b

Sold Sotheby's, 19 December 1966, lot 73

Collection Nicolas Landau, Paris

Sold Hôtel Drouot Rive Gauche, Paris, 28 April 1977.

BIBLIOGRAPHY

Sotheby's, London, auction catalogue of 19 December 1966, lot 73.

C. Boisgirard & A. de Heeckeren, *Instruments Scientifiques Anciens,* auction catalogue of 28 April 1977, Paris, no. 671, where the year is wrongly mentioned as '1084 de l'hégire, 1673/74 de l'ère chrétienne'.

A111 ASTROLABE BY ḤĀMID, 1087 AH (AD 1677)[511]

4 Dhu'l Ḥijja 1087 (6 Feb 1677)

Diameter 140 mm

Kolkata, Asiatic Society

Répertoire 5

This astrolabe was with the Asiatic Society, Kolkata, in 1890. Whether it is still there or not could not be ascertained in spite of repeated letters to the Asiatic Society.

COMPONENTS

Mater with *kursī* (d. 140), rete, probably 5 plates; alidade, pin and wedge are missing. The *kursī* is worked *à jour.* On it is engraved the name Muḥammad Saʿīd, presumably the owner.

GEOGRAPHICAL GAZETTEER

In two circles; outer circle: Mecca, Medinah, Ṭāʾif, Jidda, … Lahāwar, Dehlī, Agra, Benares: inner circle: Aḥmadnagar … Sonārgām Bangālah, Pānīpath.

INSCRIPTION

> *ʿamal aqall al-ʿibād ḥāmid ibn muḥammad muqīm ibn ʿīsā ibn allāhdād asṭurlābī lāhūrī taḥrīr fī al-tārīkh 4 shahar ẓi-l ḥjjah sanah 1087.*
>
> 'The work of the lowest of the servants [of God], Ḥāmid, son of Muḥammad Muqím, son of ʿĪsa, son of Allāhdād, the astrolabist of Lahore, completed on the 4th day of the month Zi-l-Ḥijjah, in the year 1087 (= 1677 A.D.).

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[511] This entry is based on a brief description given by Hoernle at that meeting of the Asiatic Society, Calcutta, ca. 1890, when this and another astrolabe were exhibited; these two astrolabes were purchased by Maheśchandra Nyáyaratna at Allahabad for Rs. 9 for the Society; cf. Hoernle 1890.

A112⊙ ASTROLABE AND QIBLA INDICATOR BY ḤĀMID, 1098 AH (AD 1686)

21 Muharram 1098 (7 December 1686)

Diameter 300 mm

London, Nasser D. Khalili Collection of Islamic Art (# SCI 5)



Figure A112.1 – The top of the lid (left) and the inner side of the main plate with slots for compass mountings (right) (photos by S. R. Sarma)



Figure A112.2 – Trifoliate shackle (photo by S. R. Sarma)

This is a massive and complex instrument which combines the features of the astrolabe and *qibla* indicator. It is constructed as a circular casket with a lid which can be screwed to the main plate that constitutes the mater. The reverse side of this main plate is designed as in other astrolabes, but the obverse side is different. Here there is no limb with a degree scale. Instead, an uneven lip which is added all around and a high boss is affixed at the centre. The plates and the rete rest on this lip and on the boss without touching the inner surface of the mater. On this surface are soldered a pair of projecting slots on either side of the boss. These slots may have contained the mounting for a compass, but it is now missing. The seven plates have large holes a little above the centre through which the compass may have become visible for use. Since there is no degree scale on the mater, it is now engraved on all latitude plates. The geographical gazetteer which is normally engraved on the inner surface of the main plate is here engraved on the inner side of the lid.

The gazetteer contains many Indian names for the first time. There are also many new place names of on the plates. Moreover, on the back there are some new astrological tables. I could not, regretfully, decipher all the engravings because of the limited time I had and because of the very small script.

Components

Body with *kursī* (d. 300, h. 350, t. 40), shackle and ring, rete (d. 284) for 32 stars, 7 plates (d. 284) and lid. Alidade, pin and horse are missing.

Front

The ring and shackle are massive; the latter has a perfectly trifoliate form. The solid *kursī* is rather small for this large instrument. Its profiles are lobed; there is no trifoliate finial. A crude decoration is engraved on the back; on the front an inscription, probably the name of an owner, is erased.



Figure A112.3 – Front of the astrolabe (photo by S. R. Sarma)

RETE

The rete is framed by a narrow ring leaving a recess between it and the ring of Capricorn, so that the degree scale on the rim of the latitude plates becomes visible through this recess. The Capricorn ring and ecliptic ring are held together by the

complete equinoctial bar and the solstitial bar which is represented in parts. The equinoctial bar and the ecliptic ring have counter changes at their points of their intersection. The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names. Each sign is further subdivided into 5 parts of 6° each and numbered accordingly. The Capricorn index is large and shaped like an arch. There is no handle to rotate the rete. The 32 named star-pointers are joined by a floral tracery.



Figure A112.4 – Rete of the astrolabe (photo by S. R. Sarma)

Table A112-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus*	β Ceti

	Star Name	Identification
2	*Fam al-Qayṭus*	γ Ceti
3	*Ṣadr al-Qayṭus*	π Ceti
4	*Tālī Masāfat al-Nahr*	γ Eridani
5	*ᶜAyyūq*	α Aurigae
6	*Rijl al-Jawzā' Yusrā*	β Orionis
7	*Yad al-Jawzā' [Yusrā]*	γ Orionis
8	*Rijl al-Jawzā' [Yumnā]*	κ Orionis
9	*Shiᶜrā Yamānī*	α Canis Minoris
10	*Shiᶜrā Shāmī*	α Canis Majoris
11	*Mankhar al-Shujāᶜ*	σ Hydrae
12	*Fard al-Shujāᶜ*	α Hydrae
13	*Qā'idat al-Bāṭiyah*	α Crateris
14	*Janāḥ al-Ghurāb*	γ Corvi
15	*Simāk Aᶜzal*	α Lyrae
16	*Simāk Rāmiḥ*	α Bootis
17	*Nayyir al-Fakkah*	α Corona Borealis
18	*ᶜUnuq al-Ḥayyah*	α Serpentis
19	*Qalb al-ᶜAqrab*	α Scorpii
20	*Rās al-Jāthī*	α Herculis
21	*Rās al-Ḥawwā*	α Ophiuchi
22	*Yad al-Ḥawwā al-Muqaddam*	δ Ophiuchi
23	*Nasr Wāqiᶜ*	α Lyrae
24	*Nasr Ṭā'ir*	α Aquilae
25	*Dhanab al-Dulfīn*	ε Delphini

	Star Name	Identification
26	*Fam al-Faras*	ε Pegasi
27	*Dhanab al-Jadī*	δ Capricorni
28	*Sāq Sākib al-Mā'[Janūbī]*	δ Aquarii
29	*Janāḥ al-Faras*	γ Pegasi
30	*Dhanab al-Qayṭus Sh[amālī]*	ι Ceti
31	*Surrat al-Faras*	δ Pegasi
32	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are seven plates; they all have a large hole above the centre through which the compass projects outside and become visible. Plates 1 to 5a serve different latitudes while 5b is engraved with multiple horizons. The rims on both sides of these 5 plates carry degree scales which are divided in 0;20°, 1°, 6° and numbered clockwise from 1 to 90, separately on each quadrant. Moreover, on these scales the four cardinal points are named: *janūb* (south), *maghrib* (west), *shamāl* (north), *mashriq* (east).

On these plates altitude circles are drawn for each 1° and numbered on both sides of the meridian. Azimuth arcs are drawn below the horizon for each 6°.

The Khalili catalogue says that the plates are engraved below the horizon with lines for Babylonian hours, but there are no hour lines on these plates. Instead there are two sets of lines for *ghaṭīs*; one of equal *ghaṭīs* drawn from the western horizon and numbered from 1 to 32; the other of unequal *ghaṭīs* drawn from both the horizons up to the meridian and numbered 1—15; 15—1.

Near the east point is written *mashriq* and near the west point *maghrib.* The specification of the plate, viz., the latitude and the maximum duration of daylight are engraved below the eastern and western ends of the oblique horizon. On the east given the maximum number of hours (*sāᶜāt*) and on the west the latitude (*al-ᶜarḍ*) and the maximum number of *ghaṭīs* (spelt *karī-hā*). It is surprising that in this astrolabe, where

all other details are meticulously engraved, the same amount of care is not shown in mentioning the duration of the longest days in exact numbers of hours and minutes and exact numbers of *ghaṭīs* and *palas.* What are engraved are gross approximations.

Finally, in these astrolabe plates, the space inside the circle of Cancer is kept free of altitude circles, azimuth arcs and hour lines. In this space are drawn lines radiating from the centre, indicating the azimuths of *qibla* of certain places with their names. Unfortunately, the names are too close together and several are filled with patina; therefore, they cannot be easily deciphered.

Table A112-2 Plates

S.No.	φ	Longest Day in Hours	in *ghaṭīs*
1a	17°	---	---
1b	18°	13;20	32!
2a	20°	13;18!	32!
2b	21°	13;18!	32!
3b	23°	13!	33!
3a	25°	13!	33!
4a	27°	13;43	34!
4b	29°	13;52	34!
5a	32°	14;8	35
5b	Plate of horizons		
6a	*Qibla* directions from various localities		
6b	*Qibla* directions from various localities		
7a	*Qibla* directions from various localities		
7b	*Qibla* directions from various localities		



Figure A112.5 – Plate 5a for Lahore at latitude 32° (photo by S. R. Sarma)

Plate 5 is cut out of a thicker sheet and is heavier than the others. On the obverse side, it carries the projections for Lahore at latitude 32°. In the middle of the plate are the lines of azimuth of *qibla* of as many as 17 places: Qulzūm az Kanār Daryā; Madinat al-Ḥikmā, Baᶜalbak, Ḥalab, (?), Qazwīn, Astarābād, Ṭūs, Siyālkūt, (?). Sunām, Hindūn, Banāras, Dabūl, Barūdah and Nahrawar.

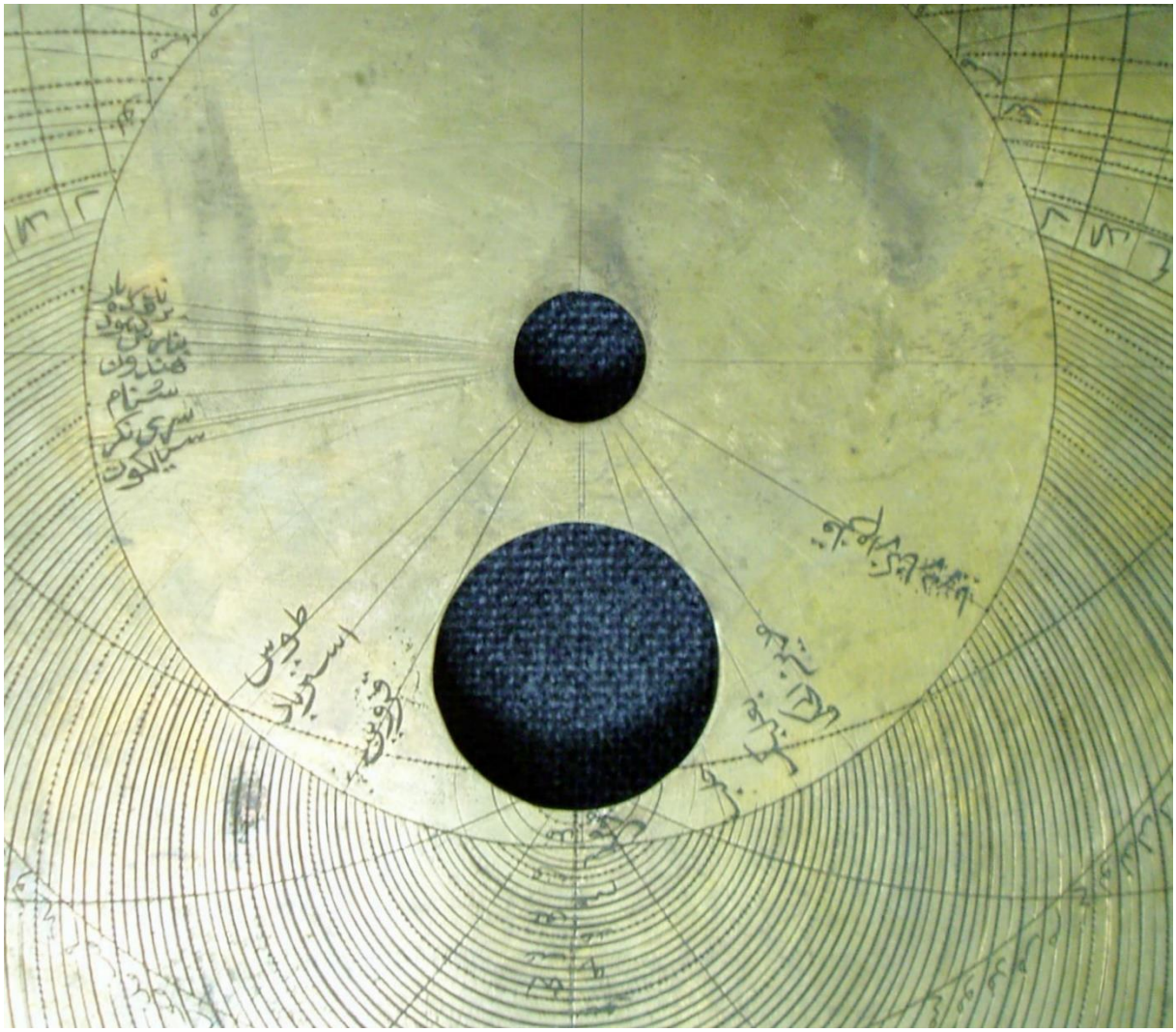


Figure A112.6 – Detail of Figure A112.5, placed here upside down, i.e. north upwards, to facilitate the reading of the place names.

Plate 5b is engraved with the plate of horizons with the label *ṣafīha āfāqī*. It carries half horizons for every degree from 4° to 66°, arranged in 4 sets with intervals of 4°. There are declination scales along the diameters between the equator and the tropics; these are divided in 1° and 6° and marked 6, 12, 18, 23;30. Those outside the equator carry the label *al-maghrib* (west) and those inside *al-sharq* (east). One of the latter is written, by mistake, *al-gharb*. Here also the space inside the circle of Cancer is kept free; here are also drawn lines of the azimuth of *qibla* of 7 localities, one of them being Jawnpur.

There is no plate devoted to the ecliptic coordinates.

Plates 6ab and 7ab carry lines radiating from the centre to indicate the azimuth of *qibla* from various localities.[512] Like the other plates, these too are engraved with the equator and the tropics and with the vertical and horizontal diameters. The cardinal points are labelled *janūb* (south), *maghrib* (west), *shamāl* (north) and *sharq* (east). Along the circle of Capricorn are written the names of the localities and lines connecting these with the centre are drawn. Inside the circle of equator, the azimuth of *qibla* is engraved. For example, 11 *darja* 28 *daqīqa* (11 degrees, 28 minutes).



Figure A112.7 – Detail of plate 6b (photo by S. R. Sarma)

On plate 6a, 30 localities are inscribed in this manner; these include Kalkanda, Burhānpūr, Mandū, Kanbāyat, Ahmadābād, Jawnpūr, Kawāliyār, Amroha, Peshāwar, Qandahār, Badakhshān, Khutan, Kāshghar, Shīrāz, Sabzwar, Iṣfahān, Baṣra, Kāshān, Qumm. Bulghār, Wāsit, Kūfa, Ardbill, ᶜAdan.

Plate 6b carries the data of 24 localities which include Sarandīp, Bījāpūr, Aḥmadnagar, Bandar Sūrat, Narwar, Akbarābād, Dihlī, Tattah, Sarhind, Siyālkūt,

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512 King 1999b, p. 156: ‘On a small number of Lahore instruments, however, gazetteers with qibla values do occur … on one of these (#4223), made by Ḥāmid ibn Muḥammad Muqīm Lāhūrī in 1098 H (=1686), the qiblas are represented graphically on some of the plates by a series of radial lines from the centre.’

Kashmīr, Ghaznī, Kirmān, Iṣṭakhr, Nīshābūr, Astarābād, Rayy, Tāliqān, Baghdād, Madīnat Ṭayyiba and Bayt al-Maqdis.

On plate 7a are engraved 20 localities such as Rahtās, Awrankābād, Ujjayn, Bahrūj, Banāras, Hindūn, Badā'ūn, Hansī Ḥiṣṣār, Kābul, Balkh, Samarqand, Bukhārā, Tūn, Jarjān, Hamadān, Mawṣil and Baʿalbak.

Plate 7b also carries 20 localities which include Dhāka, Rājmahal, Patna, Qannawz, Multān, Lāhūr, Jalālābād, Tubbat, Harat, Ṭūs, Qazwīn, Ḥalab, Dimashq and Iskandariya.

Geographical Gazetteer

The geographical gazetteer is engraved on the inner side of the lid. It provides the names, longitude, latitude, the *inḥiraf* or the azimuth of qibla, and *jihat* for 142 localities, arranged in two circles. Since both circles carry the same number of entries, the writing in the inner circle is much smaller and more difficult to decipher. The locality Tūn is listed twice, under 29 and also under 137, with the same coordinates. Rājmahal (112) and Gaur (113) in Bengal are mentioned here for the first time.



Figure A112.8 – Geographical Gazetteer (photo by S. R. Sarma)

Table A112-3 Geographical Gazetteer

	Place Name	L	φ	*al-qibla samt*	*jihat*
	Outer Circle				
1	Madīnat Rasūl …	75;20	25;20	13;34	SE
2	Bayt al-Maqdis	66;30	32;15	45;18	SE
3	Qayrawan	41;0	21;40	8;9	SE
4	Jarmī Dar al-Mulk Habasha	65;0	9;30	90;28	NE

	Place Name	L	φ	*al-qibla samt*	*jihat*
5	ᶜAdan	76;0	11;0	104;10	NE
6	Ṣanᶜā‘ Dar al-Mulk Yaman	97;0	14;30	48;48	NE
7	Miṣr	43;20	30;20	31;46	SE
8	Iskandariyya	61;54	25;30	30;39	SE
9	Qulzum az Kanār Daryā	64;0	25;30	30;39	SE
10	Sāwa	85;0	35;0	60;38	SW
11	Qazwīn	45;0	36;0	62;22	SW
12	Iṣfahān	86;40	32;25	49;40	SW
13	Kāshān	86;0	34;0	55;29	SW
14	Qumm	85;40	34;45	48;1	SW
15	Rayy	86;20	35;0	56;32	SW
16	Ṭāliqān	85;45	36;10	60;23	SW
17	Astarābād	89;35	36;50	11;17	SW
18	Janjān	90;0	36;50	50;10	SW
19	Dāmghān	88;55	36;20	50;7	SW
20	Shīrwān	91;30	36;5	45;21	SW
21	Pishāwar	92;30	36;20	43;30	SW
22	Ḥalab	72;10	35;50	71;30	SE
23	Madīnat al-Hikmā	65;40	32;20	55;11	SE
24	Mawṣul	77;0	34;30	89;19	SE
25	Dimashq	70;0	33;15	59;33	SE
26	Baᶜlbak	70;45	38;15	62;16	SE

	Place Name	L	φ	*al-qibla samt*	*jihat*
27	Anṭakiya	71;22	35;30	68;35	SE
28	Laḥā	43;30	24;0	21;40	?
29	Ṭūs	92;30	37;0	45;51	SW
30	Tūn	92;30	34;30	49;49	SW
31	Harat	94;20	34;30	36;51	SW
32	Balkh	101;0	36;41	39;27	SW
33	Badakhshān	104;24	37;0	25;21	SW
34	Kirmān	61;40	35;0	22;30	SW
35	?	77;20	34;0	89;22	SW
36	Bulgār	90;0	29;30!	65;18	SW
37	Kūfa	79;30	31;30	77;31	SW
38	Baghdād	80;0	33;25	77;15	SW
39	Wāsiṭ	81;30	32;20	69;11	SW
40	Baṣra	84;0	30;0	52;8	SW
41	Kāzrūn	87;0	29;15	38;21	SW
42	Shīrāz	88;0	29;6	36;15	SW
43	Iṣṭakhr	88;30	30;0	36;27	SW
44	Jūnahkar (Junagadh)	106;20	22;20	2;30	NW
45	Khanbāyat	107;55	22;20	4;30	NW
46	Barūdah (Baroda)	108;35	22;20	4;55	NW
47	Bharūj	108;25	21;40	5;6	NW
48	Sūrat Bandar	108;10	21;25	0;97	NW

	Place Name	L	φ	*al-qibla samt*	*jihat*
49	Yatar (?) Kujarāt	107;25	28;35	1;45	NW
50	Nadarwār ?	109;40	21;0	7;29	NW
51	?	109;40	20;40	7;43	NW
52	Burhānpūr	102;20	21;21	8;28	NW
53	Awrankābād Dawlatābād[513]	111;0	19;47	10;50	NW
54	Aḥmadnakar	109;25	18;40	11;10	NW
55	?	110;13	18;33	11;?	NW
56	Kalkanda	112;19	18;35	11;15	NW
57	Bījāpūr	113;26	17;17	14;56	NW
58	Mandū	111;36	22;10	5;6	NW
59	Ujjayn	11230	22;15	5;47	NW
60	Sarūj	114;12	24;48	8;18	NW
61	Narwar	114;55	25;30	?;11	NW
62	Rahtas	118;0	35;0	29;36	NW
63	?	100.55	24;12	2;19	NW
64	Lakhnawtī	116;15	27;30	0;0	SW
65	?	118;20	33;5	14;37	SW
66	?	118;35	32;30	13;17	SW
67	Siyālkūt	108;55	32;25	12;58	SW
68	?	108;0	31;40	12;28	SW
69	Lāhūr	109;20	31;50	11;28	SW

[513] Two localities in one entry.

	Place Name	L	φ	*al-qibla samt*	*jihat*
70	Lūdhyānā	110;40	31;10	9;32	SW
71	Sirhind	111;30	30;30	30;56	SW
	Inner Circle				
72	Hamadān	83;0	35;10	66;43	SW
73	Bukhārā	97;39	39;36	40;3	SW
74	Samarqand	99;36	39;31	?;?	SW
75	Kāshghar	106;36	44;?	33;2	SW
76	Khutan	103;42	?;?	29;50	SW
77	Hurmūz	92;0	25;0	10;18	SW
78	Qandahār	107;40	33;?	20;10	SW
79	?	82;30	25;10	3;13	SW
80	?	83;30	25;9	1;12	SW
81	Sūstān ?	104;25	26;40	5;34	SW
82	?	105;0	27;40	…	SW
83	Sarī Bakū	112;52	33;10	10;19	SW
84	Kānkara	111;35	33;35	14;3	SW
85	Kīrān	113;20	29;40	4;45	SW
86	Akbarābād	115;0	26;43	00	…
87	Kūl Jalālī	114;50	27;12	00	…
88	Sunām	111;30	29;30	6;10	SW
89	Thānīsar	112;30	30;10	6;36	SW
90	?	112;0	30;0	6;12	SW
91	Hardwar	113;0	30;15	6;20	SW
92	Haḍrat Dihlī	113;35	28;39	3;35	SW

	Place Name	L	φ	*al-qibla samt*	*jihat*
93	Hānsī Hiṣār	112;?	29;45	6;9	SW
94	Mīwāt …	112;25	27;45	?;11	SW
95	?	114;45	28;40	3;0	SW
96	Badāūn	114;55	27;30	0;57	SW
97	Sanbhal	114;40	18;30	?;19	SW
98	Hindūn	114;20	26;35	0;51	SW
99	Ajmīr	111;5	26;50	0;35	SW
100	Dhūl Dahūl	110;20	28;0	4;14	SW
101	Aḥmadābād Kujrāt	108;20	23;0	3;37	SW
102	Kawāliyar	114;56	25;16	0;03	SW
103	Kālpī	116;0	26;35	0;15	SW
104	Qannawj	116;15	36;55!	0;55	SW
105	Bahraij	116;30	28;0	0;35	…
106	Alhābād	116;6	26;?	0;05	NW?
107	Banāras	114;20	27;0	37;35	NW
108	Jawnpūr	117;6	26;30	1;48	NW
109	Rahtās …	118;15	26;30	1;48	NW
110	?	119;2	26;40	1;45	NW
111	Munkīr	120;0	26;6	1;6	NW
112	Rājmahal	121;5	25;15	4;10	NW
113	Kawr (Gaur) Bankāla	121;12	25;0	4;30	NW
114	?	120;0	18;0	12;27	NW
115	Dhāka	126;12	24;0	7;8	NW

	Place Name	L	φ	*al-qibla samt*	*jihat*
116	Baradwān	122;0	28;35	7;22	NW
117	Multān	107;35	29;40	9;6	SW
118	… Makrān	99;0	28;0	12;59	SW
119	Ghaznī	104;5	34;20	21;7	SW
120	Kābul	105;0	34;30	20;27	SW
121	Jalālābād	105;40	34;10	18;30	SW
122	Pashāwar	106;40	33;50	12;30	SW
123	?	107;0	33;24	16;12	SW
124	?	105;15	33;18	12;49	SW
125	Kashmīr	108;0	35;0	29;36	SW
126	Tubbat	110;0	40;0	23;30	SW
127	Basṭām	89;30	35;10	50;2	SW
128	Tabrīz[514]	82;0	38;0		
129	Nakhjawāb	81;15	38;40		
130	Shamākhī	84;30	40;50		
131	Bāb Abwāb	85;0	43;0		
132	Hawsam Kīlān	85;10	37;0		
133	Sarakhs	94;30	37;0		
134	Marw	97;0	37;0		
135	Qā'īn	93;20	33;40		
136	?	95;30	37;0		

[514] From here onwards, the *qibla samt* and the *jihat* are not given.

	Place Name	L	φ	*al-qibla samt*	*jihat*
137	Tūn	92;30	34;30		
138	?	85;37	36;31		
139	?	87;20	35;40		
140	Pānīpat	113;9	28;37		
141	Sarāndīb	130;0	10;0		
142	Jadda	76;0	21;0		

BACK

On the back, the rim of the upper half carries altitude scales which are divided in 0.20°, 1°, 6° and numbered in 6s as 6---90; 90---6°. In the upper left quadrant, 60 horizontal and 60 vertical parallel lines; semi-circles are drawn on both the radii. In the solar quadrant on the right, 30 declination arcs are projected stereographically so that the intervals between the lines become gradually smaller as they approach the centre. Such unequal intervals are rare in Lahore astrolabes, but common in Safavid astrolabes. Four curves of the midday altitude of the sun are drawn for latitudes 20°, 21°, 27° and 32°. The first one is accompanied by the full label *khaṭṭ niṣf al-nahār bi-ᶜarḍ 20*; at the other curves, only the latitude is given.

In the lower part of the quadrant, below the last of the declination arcs, is an inscription *Mālik Qādirdād Khān Mūhandis 1186 hijrī* (owner: Qādirdād Khān, Engineer/ Architect, 1186 Hijrī = AD 1772-73).



Figure A112.9 – Back of the astrolabe (photo by S. R. Sarma)

In the lower half are the shadow squares, on the left for a gnomon of 12 digits and on the right for a gnomon of 7 feet with the usual labels.

The lower half of the rim carries scales of cotangents and their subdivisions. Below these scales, is a semi-circular row. The right half contains the name of the maker

(which is given below) and the left half the names of the astrological scales inscribed below.

Below this row are 14 semi-circular rows containing an elaborate set of astrological tables such as the correspondence between the 28 lunar mansions and 12 zodiac signs, duodenaries, novenaries, triplicities, limits, faces and so on. This is perhaps the most elaborate collection of astrological tables to be found on any Lahore astrolabe.



Figure A112.10 – Signature of the astrolabe maker (photo S. R. Sarma)

INSCRIPTION

> *ᶜamal aqall al-ᶜibād ḥāmid ibn muḥammad muqīm ibn ᶜīsā ibn allāhdād asṭurlābī lāhūrī humāynī taḥrīr fī al-tārīkh 21 shahar muharram al-harām sanah 1098.*
>
> 'The work of the lowest of the servants [of God], Ḥāmid, son of Muḥammad Muqīm, son of ᶜĪsa, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, completed on the date 21 of the holy month Muharram in the year 1098.'

The date translates to 7 December 1686.

BIBLIOGRAPHY

Maddison & Savage-Smith 1997, I, pp. 228-230, item 131 with photos of the front of the astrolabe and of the gazetteer.

A113⊙ ASTROLABE BY ḤĀMID, 1099 AH (AD 1688)

12 Rabīʿ al-Awwal 1099 (17 January 1688)

Diameter 89 mm

London, Guildhall, the Hon'ble Clockmaker's Company Museum

CCA 1115; Répertoire 6



Figure A113.1 – Front of the astrolabe (photo by S. R. Sarma)

COMPONENTS

Body with *kursī* (d. 89, h. 108, t. 6), shackle and ring, rete (d. 69) for about 20 stars, 3 plates, alidade, pin and horse.

FRONT

High solid *kursī* with a trifoliate finial to which are attached a trifoliate shackle and a large ring. On the front and back lines are drawn parallel to the edge of the *kursī.* On the front, inside the line drawn parallel to the edge, the space is excavated and here is written in large letters in relief *Allāhu Akbar.* The empty space around the letters is filled with black colour.

The limb is divided in 1° and 6° and labelled clockwise from 6 to 90, separately for each quadrant.

RETE

The two rings of the Capricorn and ecliptic are held together by an almost complete equinoctial bar (with counter changes at its intersection with the ecliptic ring on the left and at the centre) and by an almost complete solstitial bar. The two are not straight bars, but rather mixed with the tracery that joins the various star pointers.

The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names. Each sign is divided into groups of 6° and numbered accordingly from 6 to 30.

The solstitial bar projects out of the ecliptic ring at the top and touches the degree scale; this is the Capricorn index (*al-mūrī*). There is a handle at the west point on the Capricorn ring for rotating the rete.

There are about 20 star pointers, which are joined by an indifferent tracery.

PLATES

There are only 3 plates extant, although there is space for one or two which are lost.

Table A113-1 Plates

S.No.	φ	Longest Day
1a	21°	13;18 hours
1b	24°	13;53 hours !

S.No.	φ	Longest Day
2a	27°	13;43 hours
2b	29°	13;52 hours !
3a	32°	14;8 hours
3b	36°	14;22 hours !

Altitude circles are drawn for every 6°, azimuths for every 30° above the horizon and for every 15° below the horizon. There are lines for seasonal and equal hours.

GEOGRAPHICAL GAZETTEER

On the inner side of the mater is engraved a geographical gazetteer with the longitudes, latitudes, *inḥiraf* and *jihat* of 23 localities, engraved counter-clockwise from Mecca to Banaras. On the surface can be seen two holes on the meridian at equal distances on either side of the centre which are plugged or filled. But these are not visible on the back. These marks can be seen on the three plates also.



Figure A113.2 – Geographical Gazetteer (photo by S. R. Sarma)

Table A113-2 Geographical Gazetteer

	Place Name	L	φ	*inḥirāf*	*jihat*
1	Makka Muᶜẓẓam	77;10	21;40	74 !	SE !
2	Madīnat Ṭayyiba	74;20	25;0	63;34	SE
3	Bayt al-Maqdis	66;30	32;15	45;18	SE
4	Qayrawān	41;0	21;40	10;9	SE
5	Miṣr	63;30	30;20	8;9	SE

	Place Name	L	φ	*inḥirāf*	*jihat*
6	Iṣfahān	86;40	32;25	49;40	SW
7	Kāshān	86;0	34;0	14;19	SW
8	Qum	84;40	34;45	18;1	SW
9	Mashhad Maqdis	92;30	36;0	44;51	SW
10	Balkh	101;0	36;41	29;17	SW
11	Kābul	105;0	34;30	20;27	SW
12	Awrankābād	111;5	19;47	10;27	NW
13	Aḥmadnakar	109;25	18;40	11;10	NW
14	Qalᶜahbadar (Gulburga?)	110;13	18;38	11;27	NW
15	Kalkanda	115;19	18;35	11;4	NW
16	Bījāpūr	113;26	17;17	14;56	NW
17	Burhānpūr	112;20	21;21	8;28	NW
18	Lāhūr	109;20	31;50	11;28	SW
19	Dihlī	113;1	28;30	3;35	SW
20	Ajmīr	111;5	25;50	11;25	SW
21	Bandar Sūrat	108;10	21;25	5;17	NW
22	Aḥmadābād	108;20	23;0	3;37	NW
23	Banāras	117;20	27;0	1;35	NW

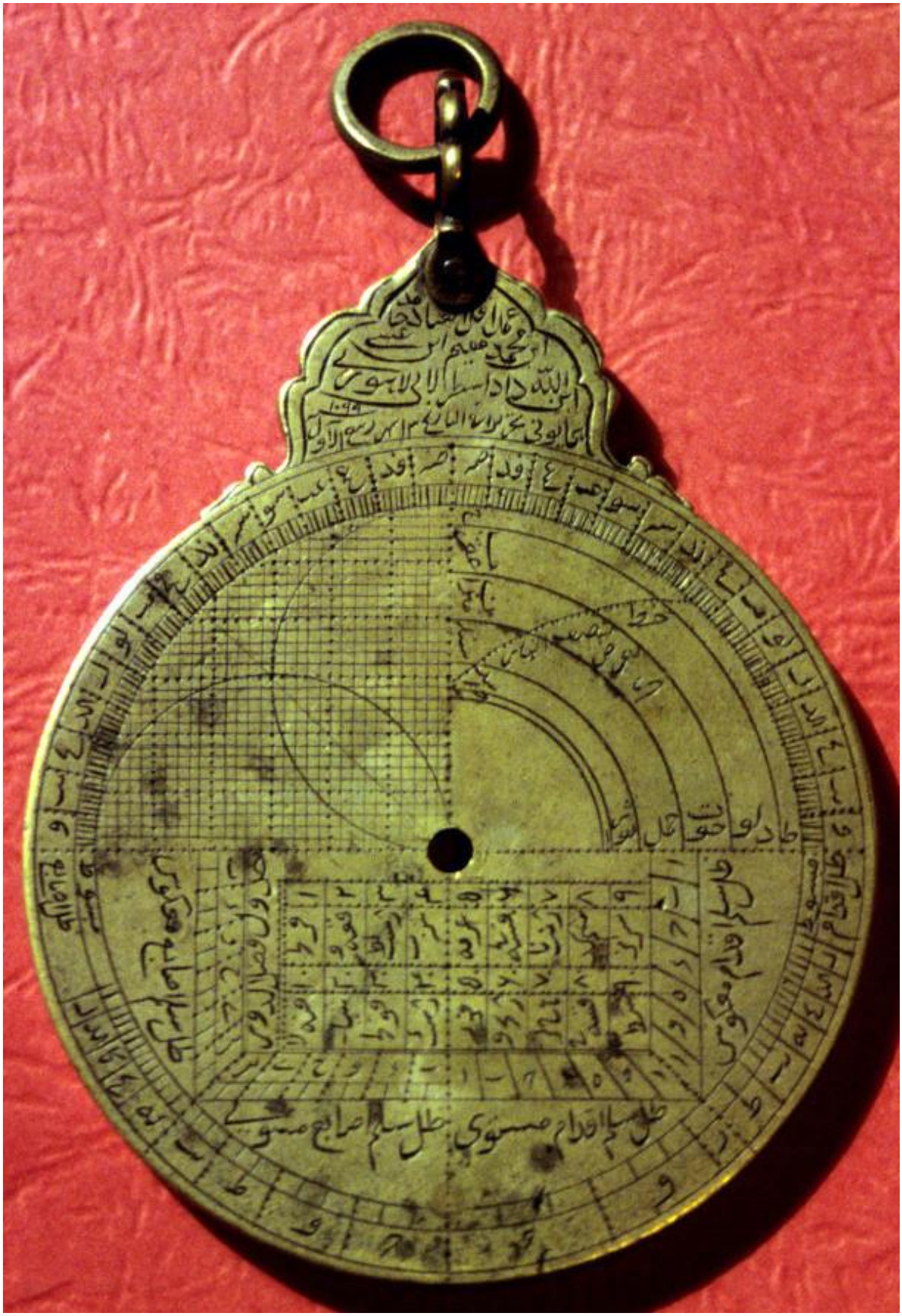


Figure A113.3 – Back of the astrolabe (photo by S. R. Sarma)

BACK

The rim of the upper half carries the altitude scales, divided in 1° and labelled in 6's as 6—90;90—6. In the upper left is a trigonometric quadrant with 30 horizontal and 30 vertical parallels, with every fifth line highlighted with dots. Semicircles are drawn on both the radii and a radial line is drawn to 45° on the arc. In the upper right is a solar quadrant with declination arcs drawn at non-uniform intervals. The related pairs of signs are marked along the two radii by their serial numbers. There is a dotted curve showing the solar altitude at midday for latitude 20° with the label *khaṭṭ niṣf al-nahār bi-ᶜarḍ* 20.

In the lower half are drawn shadow squares, on the left for a base of 6 (12) dgits and on the right for a base of 7 feet. The four scales are accompanied by the following labels:

Vertical scale on the left: *ẓill sullam aṣābiᶜ maᶜkūs*

Horizontal scale on the left: *ẓill sullam aṣābiᶜ mustawī*

Horizontal scale on the right: *ẓill sullam aqdām mustawī*

Vertical scale on the right: *ẓill sullam aqdām maᶜkūs*

The lower rim bears the corresponding cotangent scales and their subdivisions. The scale on the left is labelled as *ẓill aṣābiᶜ mabsūt* and the scale on the right as *ẓill aqdām mabsūt.* Inside the shadow squares is inscribed the table of the 'excess of revolution' (*jadwal faḍl al-dawr*). There are no other astrological tables.

INSCRIPTION

On the back of the *kursī* is the astrolabe maker's signature:

> *ᶜamal aqall al-ᶜibād ḥāmid*
> *ibn muḥammad muqīm ibn ᶜīsā*
> *[ibn] allāhdād asṭurlābī lāhūrī*
> *humāyūnī taḥrīrā fī al-tārīkh 13 shahr rabīᶜ al-awwal sanah 1099*
> 'Made by the least of the slaves [of God] Ḥāmid, son of Muḥammad Muqīm, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, completed on the date 24 in the month Rabīᶜ I of the year 1099.'

The date corresponds to 17 January 1688.

PROVENANCE

Ex- coll. Nethropp.

A114 ASTROLABE BY ḤĀMID, 1102 AH (AD 1691)

24 Jumādā al-Awwal 1102 (22 Feb 1691)[515]

Diameter 116 mm

PLU, ex-Paris, Brieux

CCA 3517; Répertoire 7

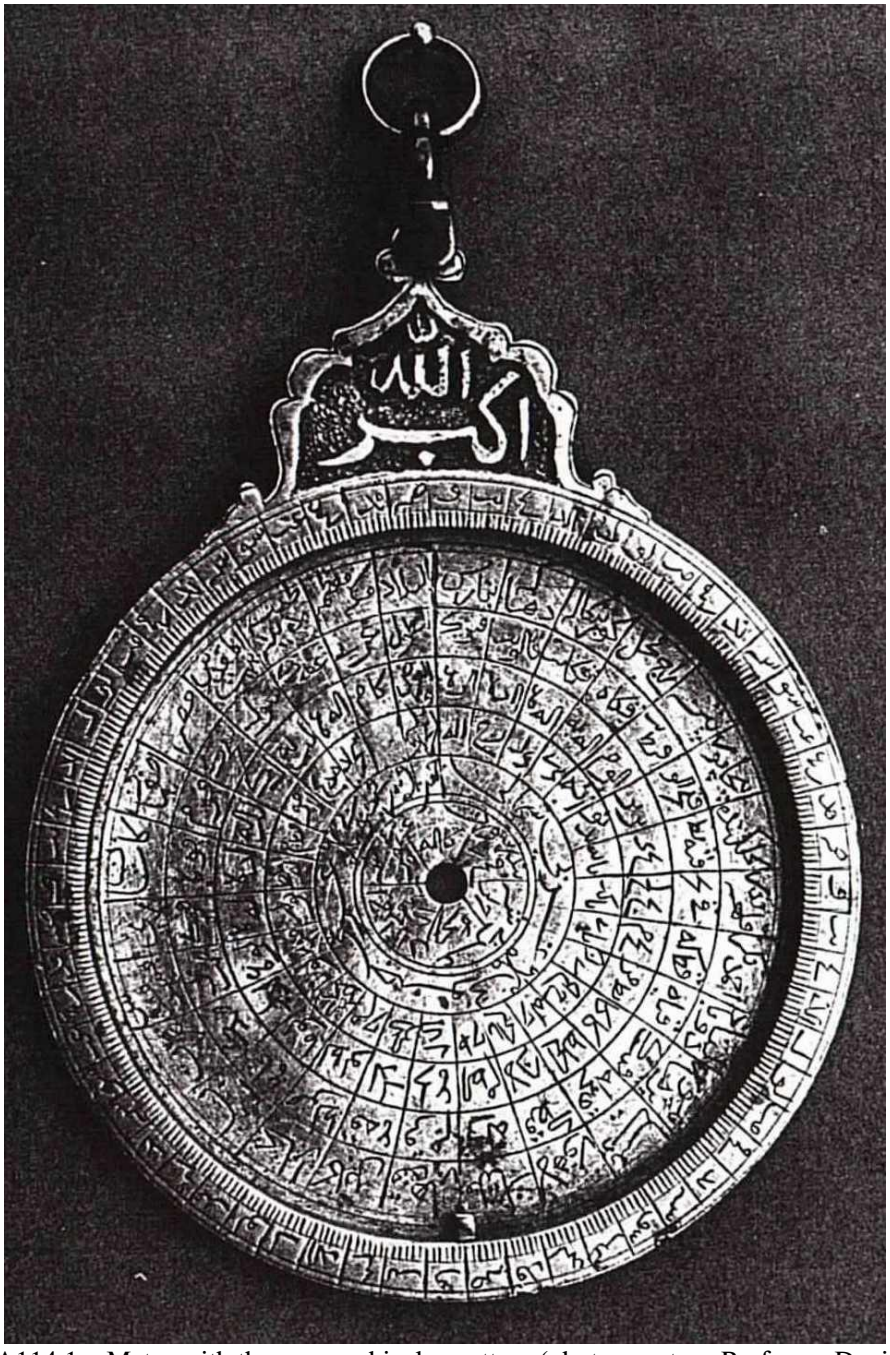


Figure A114.1 – Mater with the geographical gazetteer (photo courtesy Professor David King)

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[515] The entry is based on the photographs and notes kindly provided by Professor David King.

COMPONENTS

Only the mater (d. 116, t. 8) is extant.

FRONT

High solid *kursī* with a trifoliate finial to which are attached a trifoliate shackle and a large ring. On the front and back decorative lines are drawn parallel to the edge of the *kursī.* On the front, inside the line drawn parallel to the edge, the space is excavated and filled with *Allāhu Akbar* in large letters in relief.

The limb is divided in 1° and 6° and labelled clockwise from 6 to 90, separately for each quadrant.

GEOGRAPHICAL GAZETTEER

On the inner side of the mater is engraved a geographical gazetteer with the longitudes, latitudes, *qiblah samt* and *jihat* of 27 localities, engraved counter-clockwise from Mecca to Banaras. Because of the poor quality of the photograph, several items could not be deciphered.

Table A114-1 Geographical Gazetteer

	Place Name	L	φ	*qiblah samt*	*jihat*
1	Makka Muᶜaẓẓam	77;10	21;40		
2	Madīnat Ṭayyiba	75;20	25;0	63;34	SE[516]
3	Bayt al-Maqdis	66;30	32;15	45;18	SE
4	Miṣr	63;20	30;20	31;46	SE
5	Iṣfahān	86;40	32;25	49;40	SW[517]
6	Kāshān	86;0	34;0	15;19	SW
7	Rayy	86;20	35;0	36;37	SW

[516] Nos. 2-4 have *sharqī janūbī,* ES.

[517] Nos. 5-16 have *gharbī janūbī,* SW. Although all these localities have higher latitudes than that of Mecca and thus are to the north, some of these are to the west and some to the east of Mecca. So common designation SW to all these is clearly inappropriate.

	Place Name	L	φ	*qiblah samt*	*jihat*
8	Mashhad Maqdis	92;30	36;0	?	SW
9	Harat ?	104: 20?	?	?	SW
10	?	111;0	36;9		SW
11	Bukhārā	97;39	39;36	40;3	SW
12	Kābul	105;0	34;30	20;27	SW
13	Qandahār	107;40	33;0	20;10	SW
14	Multān	107;35	29;40	9;3	SW
15	Lāhūr	109;20	31;50	11;28	SW
16	Dihlī	113;35	28;39	3;35	SW
17	Burhānpūr	112;20	21;21	8;28	NW[518]
18	Dawlatābād	111;5	19;47	10;50	NW
19	Aḥmadnakar	109;25	18;40	11;10	NW
20	Qal^{c}ahbadar (Gulburga?)	110;13	18;38	11;27	NW
21	Kalkanda	115;19	18;4	11;14	NW
22	Bījāpūr	113;26	17;17	14;56	NW
23	Patnah	119;12	26;40	1;15	NW
24	Rājmahal	121;5	25;15	4;10	NW
25	Kawr (Gaur) Bankāla	121;12	25;0	4;30	NW
26	Dhāka	127;12	24;0	7;8	NW
27	Banāras	117;20	27;0	1;35	NW

518 Nos. 7-27 have *gharbī shamālī,* north-west. All these localities are in India and therefore Mecca is to the west in all cases. But some, like nos. 23-27, have higher latitudes; here Mecca would be to the SW and NW.

	Place Name	L	φ	*qiblah samt*	*jihat*
28	Bandar Sūrat[519]	108;30	21;25	?	
29	ᶜAdan	?	?	?	
30	Ajmīr	?	?	?	
31	?	?	?	?	

[519] This and the next three places are inscribed inside the inner circle. The last place name and the coordinates are illegible.

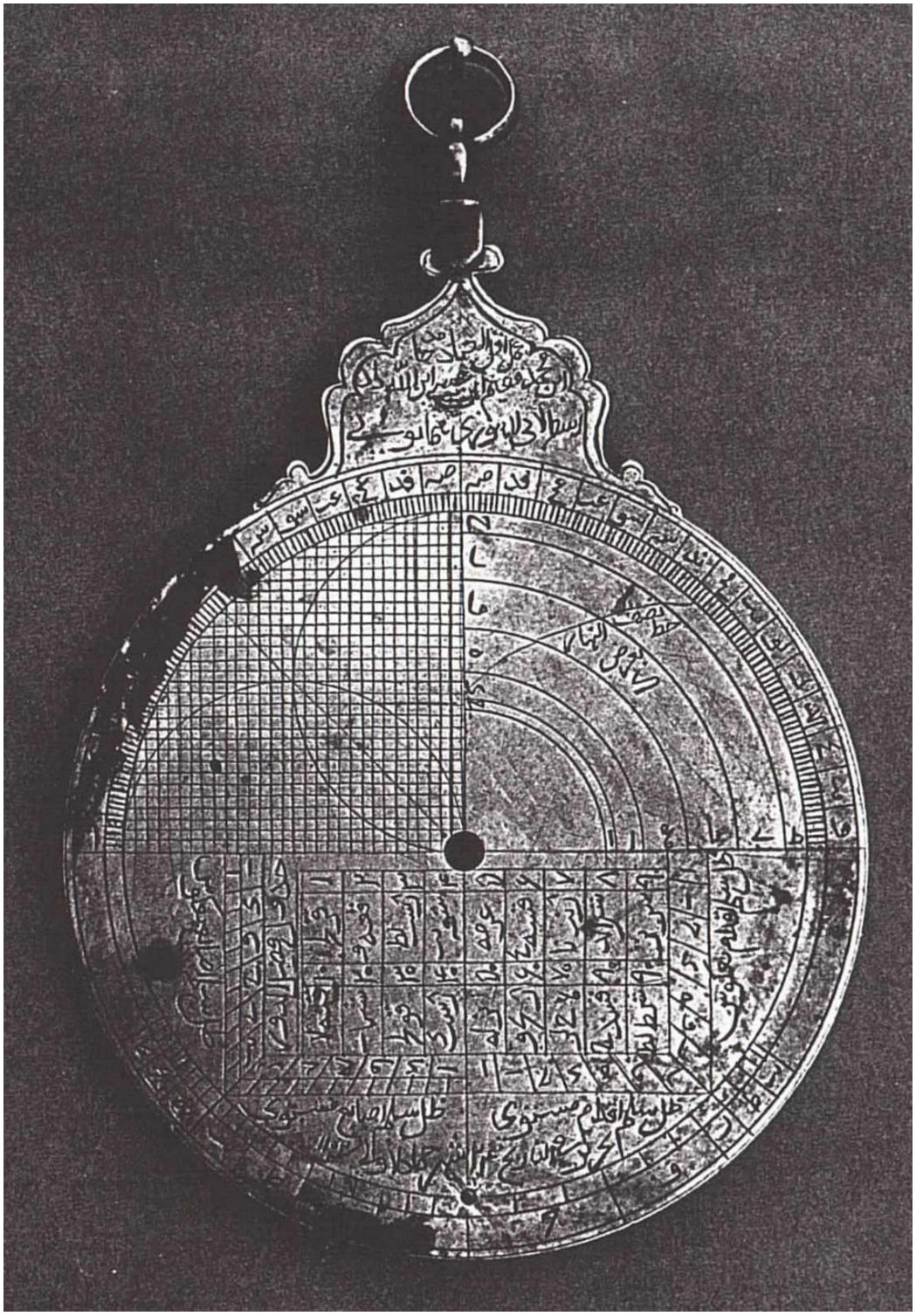


Figure A114.2 – Back of the astrolabe (photo courtesy Professor David King)

BACK

The upper rim carries the altitude scales, which are divided into 1° and 6° and labelled as 6—90; 90—6. The lower rim bears the cotangent scales, but without any labels. In the upper left quadrant are drawn 30 vertical and 30 horizontal parallels with arcs of sine and versed sine and a radial line to 45° which bisects the quadrant. In the

upper right is a solar quadrant with declination arcs at non-uniform intervals, with the serial numbers of the related zodiac signs marked along the two radii. There is a curve showing the solar altitude at midday at latitude 20 with the label *khaṭṭ niṣf al-nahār bi-ᶜarḍ 20.*

In the lower half are drawn two shadow squares, on the left for a base 6 (12) and on the right for a bsse of 7, with the usual labels. Inside the shadow squares is engraved the table of 'excess of revolution' (*faḍl al-dawr*).'

Inscription

The maker's signature is engraved on the back of the *kursī*; the date is added below the shadow squares:

> *ᶜamal aqall al-ᶜibād ḥāmid*
> *ibn muḥammad muqīm ibn ᶜīsā ibn allāhdād*
> *asṭurlābī lāhūrī humāyūnī*
> *taḥrīr fī al-tārīkh 24 shahar jumādā al-awwal sanah 1102.*
> 'Made by the least of the slaves [of God] Ḥāmid, son of Muḥammad Muqīm, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn,
> Completed on the date 24 in the month Jumādā I of the year 1102.'

The date corresponds to 22 February 1691.

Provenance

Formerly with Mme. Dominique Brieux until 1992.

A115 ASTROLABE BY ḤĀMID, 1102 AH (AD 1691)

24 Ramadan 1102 (20 June 1691)[520]

Diameter 126 mm

London, PC? ; ex-Milan

Répertoire 8



Figure A115.1 – Front of the astrolabe (photo courtesy Professor Gerard L'E. Turner)

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[520] The entry is based on Linton 1980, no. 168, pp. 100-101, and on the colour photos of the front and back, and the black-and-white photos of all the plates kindly provided by the late Professor Gerard L'E. Turner when the astrolabe was in Milan.

Components

Body with *kursī* (d. 126), shackle and ring, rete for 36 stars, 6 plates; alidade, pin and horse are missing.

Front

The *kursī* is high and solid; it terminates in a trefoil-shaped finial to which the shackle and a very large ring are attached. The shackle also, when seen from the side, has a trefoil shape. On the front side of the *kursī* is engraved, in rather large letters, *Allāhu Akbar*. On the reverse is engraved a poem which is followed by Ḥāmid's signature; the latter is continued below the shadow squares.

The limb is divided into 1° and 6° and labelled in 6s from 6° to 90°, separately for each quadrant.

Rete

The two rings of the Capricorn and ecliptic are held together by the complete equinoctial bar and an almost complete solstitial bar. The former has counter changes at its intersection with the ecliptic circle on the left and at the centre. While the equinoctial bar is partly covered by the star pointers and the tracery that joins them, the solstitial bar is completely covered by these. The ecliptic circle is divided into the 12 signs of the zodiac and labelled with their names. On the edge of ecliptic ring there are unnumbered marks, dividing each sign into groups of 6°.

There are 36 named star pointers, which are shaped like the flared petals of tulip flowers, as in the retes by Ḥāmid's father Muqīm. These are joined by a floral pattern. There is a handle at the west point on the Capricorn circle. A pin projecting out of the ecliptic circle and touching the degree scale is the Capricorn index (*al-mūrī*).

Plates

There are 6 plates of which 5 are calibrated for latitudes ranging from 18° to 40°. These plates are engraved with equal altitude lines for each 6°, azimuth arcs for each 15° below the horizon, and plain lines for seasonal hours and dotted lines for equal hours drawn from both the western and eastern horizons .

Table A115-1 Plates

	φ	Longest Day
1a	18°	13;3 hours
1b	20°	13;20 hours
2a	25°	13;36 hours
2b	27°	13;47 hours
3a	29°	13;52 hours
3b	32°	14; 8 hours
4a	34°	14;12 hours
4b	36°	14;22 hours
5a	38°	14;40 hours
5b	40°	14;48 hours
6a	Plate of ecliptic coordinates	
6b	Plate of horizons	

GEOGRAPHICAL GAZETTEER

On the inner side of the mater, a geographical gazetteer is said to have been engraved with the longitude, latitude, *inḥirāf* and *jihat* for 36 localities. It could not by reproduced here as no photo was available.

BACK

The rim of the upper half carries the altitude scales, divided in 1° and 6° and labelled as 6—90; 90—6. The rim of the lower half bears the scales of cotangents. The upper left quadrant contains 30 vertical and 30 horizontal parallels with every fifth line highlighted with dots. There are arcs of sine and versed sine and a radial line to 45° which bisects the two arcs.

In the upper right quadrant there are 6 unevenly spaced arcs of the signs of the zodiac; the signs are numbered along the two radii. There is also a graph of the meridian altitude of the sun for latitude 20° with the label *khaṭṭ niṣf al-nahār bi-ᶜarḍ 20*.



Figure A115.2 – Back of the astrolabe (photo courtesy Professor Gerard L'E. Turner)

In the lower half there are shadow squares, on the left for a base of 12 and on the right for a base of 7 with the usual labels. Inside the shadow squares is engraved a table of 'excess of revolution' (*faḍl al-dawr*).

ALIDADE ETC

The alidade, horse and pin are missing. In the available photos, the components are held together by a pin with a peculiar handle which must a replacement.

INSCRIPTION

On the back of the *kursī* is engraved first a poem:

natash dahān waqad tawāyī ḥakīm naqaṭ mūhūm wakhṭ mustaqīm

'The trace of thy mouth and of thy height, Oh wise man! The imaginary point and the straight line.'

This is followed by Ḥāmid's signature which is continued below the shadows:

ᶜamal aqall al-ᶜibād ibn muḥammad muqīm ḥāmid
bi tārīkh 24 ramaḍān al-mubārak sanah 1102.

'The work of the least of men, the son of Muḥammad Muqīm, Ḥāmid. On the date of the 24th Ramaḍān in the blessed year 1102 [Hijrī].'

The date translates to 21 June 1691. Here Ḥāmid mentions only his father by name and not the other ancestors.

PROVENANCE

Formerly in the collection Jean Tetreau, Paris; of Ferrari, Paris; and of Leonard Linton, Point Lookout. Linton's collection including this astrolabe was auctioned in 1980. This astrolabe was acquired by a private collector in Milan. Around 2010, the Milan collection is said to have been was acquired by Ahuan Art Gallery, London.

BIBLIOGRAPHY

Linton 1980, no. 68, pp. 100-101.

A116 ASTROLABE ATTRIBUTABLE TO ḤĀMID

Not dated

Diameter 132 mm

Hyderabad, Salar Jung Museum (#112/1/xxxv)



Figure A116.1 – Front of the astrolabe (photo by S. R. Sarma)

This and the next astrolabe are remarkably alike in many respects: in the design of the rete, in having a plate where one side is calibrated for multiple horizons and the other side with projections for the latitude of 72° and in having the table of 'the excess of revolution' within the shadow squares. Moreover, in both astrolabes α Canis Majoris is named *ʿAbūr* as is done in A110 by Ḥāmid. The *kursīs* in both have the same outline, but in the present astrolabe the surface in the front is embellished with a floral design. In both the geographical gazetteer is engraved in two circles and the argument is given only at the beginning of the first circle and not at beginning of the second circle. At the same time, these two have many features in common with the astrolabes signed by Ḥāmid such as the outlines of the *kursī* and the design of the rete. Therefore, these two unsigned astrolabes can be attributed to Ḥāmid.

COMPONENTS

Body with *kursī* (d. 132, t. 6.5) with shackle and ring, rete for 30 stars, 3 plates. Original alidade, pin and wedge are missing. These are replaced by a crude alidade with a sighting tube, a bolt and nut. There are two washers; the larger one has a crown-like projection, probably original.

FRONT

The ring is plain and shackle trifoliate. The *kursī* is solid and shaped like the *kursīs* in several of the astrolabes by Ḥāmid (A105, A111, A112, A113 and A115). On the surface in the front is a pattern engraved in low relief, showing three tulip-like flowers. The limb is graduated in 1° and 6° and numbered clockwise in 6s, from 6 to 180 from the south point up to the north point, and again from 6 to 180 from the north point up to the south point. This is a very unusual method and does not occur anywhere else.

RETE

The rete closely resembles the retes in many of the astrolabes by Ḥāmid in the manner the equinoctial and solstitial bars are shaped and in the tracery that joins the star pointers is designed. The ecliptic ring is divided into 12 signs of the zodiac and labelled with their names. Each sign is further divided in groups of 6° and numbered accordingly as 6, 12, 18, 24, 30. These units are halved to 3° on the edge of the ecliptic ring. The Capricorn index is shaped like thin rectangular stub. A handle was attached near the west point on the peripheral ring. Its top is broken and there remains now only a stub.

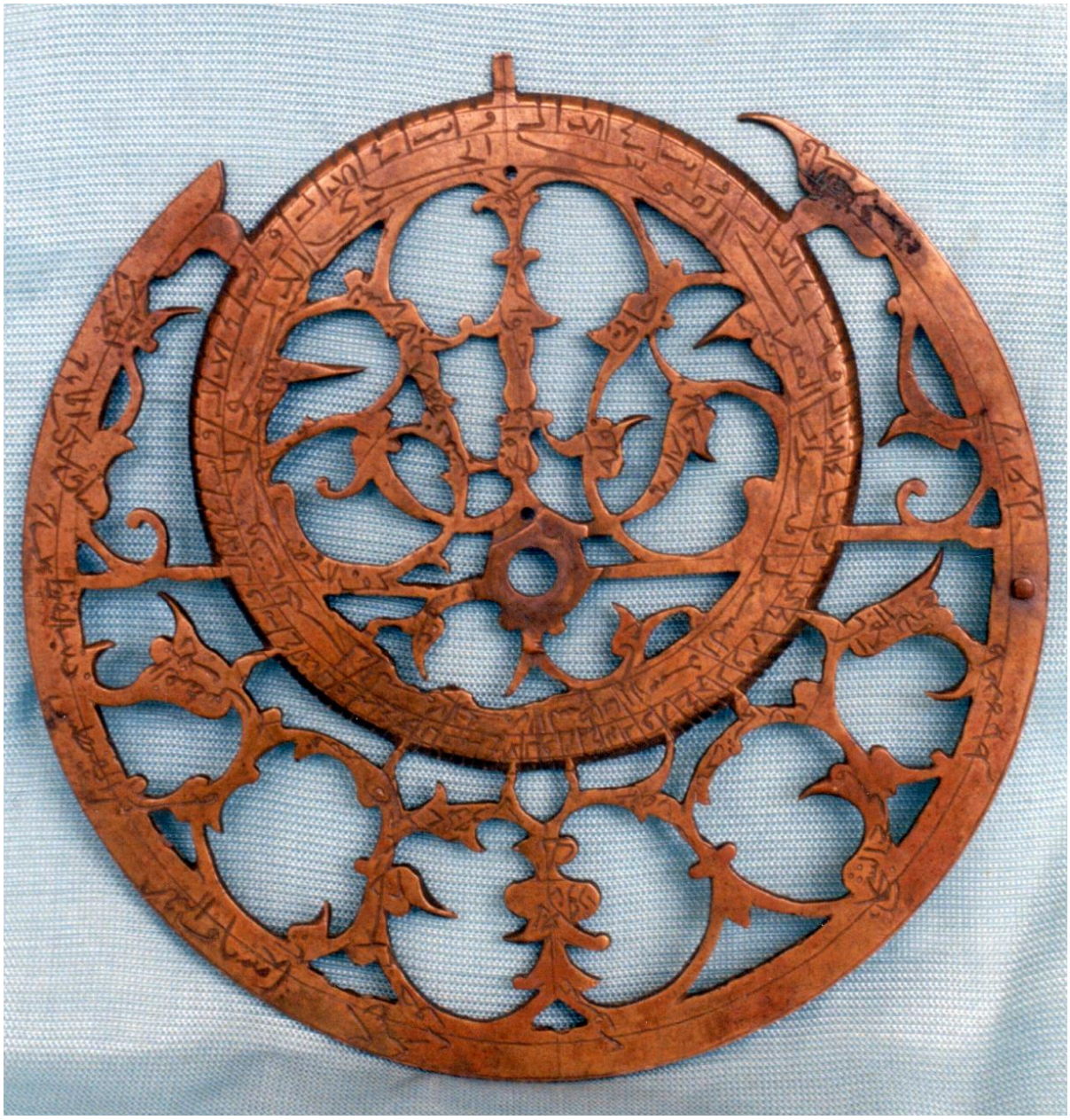


Figure A116.2 – Rete of the astrolabe (photo by S. R. Sarma)

There are some 30 star pointers carrying star names which are often drastically shortened.

Table A116-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus [Shamālī]*	ι Ceti

	Star Name	Identification
2	*Dhanab al-Qayṭus J[anūbī]*	β Ceti
3	*Fam [al-Qayṭus]*	γ Ceti
4	*Ṣadr al-Qayṭus*	π Ceti
5	*Ghūl*	β Persei
6	*Tālī Masāfat al-Nahr*	γ Eridani
7	*Rijl al-Jawzā' al-Yusrā*	β Orionis
8	*Yad al-Jawzā' [al-Yusrā]*	γ Orionis
9	*Rijl al-Jawzā' [al-Yumnā]*	κ Orionis
10	*ᶜAbūr*	α Canis Majoris
11	?	α Canis Minoris
12	*Fard al-Shujāᶜ*	α Hydrae
13	*[Ẓahr al-] Dubb [al-Akbar]*	α Ursae Majoris
14	*Mankhar al-Shujāᶜ*	σ Hydrae
15	*Qā'idat al-Bāṭiya*	α Crateris
16	*Janāḥ al-Ghurāb*	γ Corvi
17	*Simāk Aᶜzal*	α Virginis
18	*Simāk Rāmiḥ*	α Bootis
19	*[Nayyir al-] Fakkah*	α Coronae Borealis
20	*Qalb al-ᶜAqrab*	α Scorpii
21	*[Rās al-] Jāthī*	α Herculis
22	*[Rās al-] Ḥawwā*	α Ophiuchi
23	*[Yad al-Ḥawwā al-] Muqaddam*	δ Ophiuchi
24	*[Nasr] Wāqiᶜ*	α Lyrae

	Star Name	Identification
25	*Nasr Ṭā'ir*	α Aquilae
26	?	
27	*[Dhanab al-] Dulfīn*	ε Delphini
28	*Dhanab [al-Dajājah]*	α Cygni
29	*Fam [al-Faras]*	ε Pegasi
30	*Dhanab al-Jadī*	δ Capricorni
31	*Sāq Sākib al-Mā' J[anūbī]*	δ Aquarii
32	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are three plates. On plates 1 and 2, altitude circles are drawn for each 6°. Azimuth arcs are drawn for each 15° below the horizon. There are lines for seasonal hours and dotted lines for equal hours drawn from the western horizon. Strangely there is no plate for 32°, the latitude of Lahore. It is possible that there were originally five plates in this astrolabe, and two of which are now missing.

Table A116-2 Plates

	φ	Longest Day
1a	18°	13;18 hours
1b	20°	13;20 hours
2a	27°	13;49 hours
2b	29°	13;52 hours
3a	72°	
3b	Plate of horizons	

Geographical Gazetteer

The gazetteer is engraved in two circles providing the names, longitudes, latitudes and *inhirāf* for 40 places. The argument is engraved at the beginning of the outer circle, but not at the beginning of the inner circle. The zero symbol looks sometimes like the *Abjad* symbol for 31.



Figure A116.3 – Geographical Gazetteer (photo by S. R. Sarma)

Table A116-3

	Place Name ***al-bilād***	**L** ***al-ṭūl***	**φ** ***al-ᶜarḍ***	***Inḥirāf*** ***qiblah samt***
	Outer Circle			
1	Makka Muᶜaẓẓam	77;10	21;40	------
2	Madīnat Ṭayyiba	75;20	25;0	63;34 ?
3	Bayt al-Maqdis	66;30	32;15	45;18
4	Qayrawān	41;0	21;40	62;22
5	Jarmī Ḥabash	65;0	9;30	42;28
6	Miṣr	63;20	30;20	31;46
7	Iskandariyya	61;54	30;18	28;18
8	Quljum Kanār Darya	64;0	30;39	30;39!
9	ᶜAdan	76;0	11;0	84;10
10	Sanaᶜān	74;0	14;30	88;48
11	Sāwa	85;0	35;0	60;38
12	Qazwīn	85;0	36;0	62;22
13	Iṣfahān	86;40	32;25	49;40
14	Kāshān	86;0	34;0	55;29
15	Shīrāz	83;0	29;36	36;14
16	Ṭūs	92;30	36;0	84;51
17	Tūn	92;30	34;30	39;39
18	Harāt	94;20	34;30	36;51
19	Balkh	101;0	36;41	29;24
20	Bukhārā	97;39	39;36	40;3
21	Samarqand	99;16	39;31	16;57

	Place Name *al-bilād*	**L** *al-ṭūl*	**φ** *al-ᶜarḍ*	*Inḥirāf qiblah samt*
22	Qandahār	104;40	33;0	20;10
23	Kābul	105;0	34;30	20;28
	Inner Circle			
24	Dihlī	113;35	18;39 !	3;35
25	Akbarābād	115;0	26;43	0;0 !
26	Ajmīr	111;5	25;50	0;35
27	Aḥmadābād	110;20	23;0	3;37
28	Burhānbūr	112;20	21;21	8;40
29	Qalᶜahndar (Gulbarga?)	110;13	18;18	52;21
30	Dawlatābād	111;5	19;47	10;50
31	Aḥmadnakar	109;25	18;40	11;10
32	Bījābūr	113;26	17;17	15;0
33	Kalkandah	115;19	18;35	12;15
34	Rājmahal	121;5	25;15	4;10
35	Yabat ?	109;12	26;40	1;45
36	Gaur Bankāla	121;12	25;0	53;30
37	Banāras	114;20	27;0	1;35
38	Lāhūr	109;20	31;50	11;18
39	Multān	104;35	29;40	9;?
40	Bandar Sūrat	108;10	21;35	?;5

BACK

The rim of the upper half carries altitudes scales, divided in 1° and 6° and labelled as 6—90; 90—6. In the upper left quadrant are drawn 30 horizontal and 30 vertical

parallels, with each fifth highlighted by dots. A radial line is drawn from the centre to 45° on the arc. The upper right quadrant is divided by declination arcs into six unequal segments and the names of the related segments are engraved along the horizontal and vertical radii. Two curves are traced for the midday latitude of the sun at the latitudes 20° (roughly for Mecca) and 32° (for Lahore) with the labels *khaṭṭ niṣf al-nahār bi-ᶜarḍ 20* and *khaṭṭ niṣf al-nahār bi-ᶜarḍ 32*.

In the lower half are drawn shadow squares, for a base of 6 and 12 on the left and for a base of 7 on the right. The four scales are accompanied by the usual labels.



Figure A116.4 – Back of the astrolabe (photo by S. R. Sarma)

Inside the shadow squares is inscribed the table entitled *jadwal faḍl al-dawr* (excess of revolution).

The rim of the lower half is engraved with the scales of cotangents. These are followed by four semi-circular rows. The innermost row carries the names of the 28 lunar mansions. The next row is filled with the names of the 12 zodiac signs. In the following row, each sign is divided in 5 parts and numbered as 6, 12, 18, 24 and 30. In the last row each of these parts is divided thrice into units of 2°.

A117⊙ ASTROLABE ATTRIBUTABLE TO ḤĀMID

Not dated

Diameter 117 mm

Edinburgh, National Museum of Scotland (#1962.13)

CCA 89



Figure A117.1 – Front of the astrolabe (photo by S. R. Sarma)

COMPONENTS

Body with *kursī* (d. 117, h. 147, t. 7), shackle and ring, rete, 5 plates, alidade, pin and horse. The horse appears to be a modern replacement.

FRONT

The ring is plain and the shackle trifoliate. The *kursī* is solid and the profiles are made up of a lobe between two ogees. The finial is trifoliate, but the two horizontal petals are slightly extended and curved downwards. The surface is plain without any ornamentation. The limb is graduated in 1° and 6° and numbered clockwise in 6s from 6 to 90, separately in each quadrant.



Figure A117.2 – Rete of the astrolabe (photo by S. R. Sarma)

RETE

The peripheral Capricorn ring and the ecliptic ring are held together by the tracery that joins the various star pointers. Unlike in other astrolabes, the equinoctial bar is not represented here; the solstitial bar appears only in interrupted segments to which are attached some star pointers. The tracery which joins the star pointers is very symmetrical, but strangely not all the star pointers are engraved with their names. There is a small handle below the west point.

Table A117-1 Stars on the Rete

	Star Name	Identification
1	*Ṣadr al-Qayṭus*	π Ceti
2	*Ghūl*	β Persei
3	*ᶜAyn al Thawr* ?	α Tauri
4	*ᶜAyyūq*	α Aurigae
5	*Riǰl [al-Jawzā' al-] Yusrā*	β Orionis
6	*Yad [al-] Jaw[zā' al-Yusrā]*	γ Orionis
7	*ᶜAbūr*	α Canis Majoris
8	*Shiᶜrā Shāmī*	α Canis Minoris
9	*Fard [al-Shujāᶜ]*	α Hydrae
10	*Qalb al-Asad*	α Leonis
11	*[Janāḥ al-] Ghurāb*	γ Corvi
12	*Simāk Aᶜzal*	α Virginis
13	*Simāk Rāmiḥ*	α Bootis
14	*Nayyir al-Fakkah*	α Coronae Borealis
15	*Rās al-Hawwā*	α Ophiuchi
16	*Nasr Ṭā'ir*	α Aquilae
17	*?*	α Cygni

	Star Name	Identification
18	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are 5 plates, all with notches at the north point.

Table A117-2 Plates

	φ	Longest Day
1a	17°	12;38 hours
1b	18°	13;4 hours
2a	27°	13;43 hours
2b	29°	13;52 hours
3a	32°	14;8 hours
3b	36°	14;22 hours
4a	34°	14;14 hours
4b	38°	14;40 hours
5a	72°	
5b	Plate of horizons	

On the first four plates, altitudes circles are drawn for each 6° and azimuth arcs for each 15° below the horizon. There are lines for seasonal hours and dotted lines for equal hours. On 1a, 1b, 2a and 2b, dotted lines for equal hours are drawn from the western horizon; on 3a, 3b, 4a and 4b, they are from both the horizons.

GEOGRAPHICAL GAZETTEER

Gazetteer is engraved in two circles, providing the names, longitudes and latitudes of 47 places roughly in the order of increasing longitudes. The argument occurs at the beginning of the first circle, but not at the beginning of the second circle. It is interesting

that Golconda is referred to here (no. 46) as Ḥaydarābād for the first time on an astrolabe.



Figure A117.3 – Geographical Gazetteer (photo by S. R. Sarma)

Table A117-3 Geographical Gazetteer

	Place Name	L	φ
	Outer Circle		
1	Makka Mu^{c}aẓẓam	77;10	21;40
2	Madīnat Ṭayyiba	75;20	25;0
3	Bayt al-Maqdis	66;30	31;50

	Place Name	L	φ
4	Kūfa	79;30	31;30
5	Baghdād	82;0	38;55
6	Miṣr	63;20	30;20
7	Dimashq	70;44	33;35
8	Ḥalab	72;10	35;50
9	Baṣra	84;0	30;0
10	Marāgha	82;0	37;20
11	Tabrīz	82;0	38;0
12	Ardabīl	82;30	38;0
13	Shamākhī	84;30	40;50
14	Nakhjawān	81;15	38;40
15	Shūshtar	84;30	31;30
16	Shīrāz	88;0	29;36
17	Yazd	89;0	32;0
18	Nahāwand	83;55	34;20
19	Hamadān	83;0	35;0
20	Qazwīn	85;0	36;45
21	Jurbāzqān	85;35	34;15
22	Iṣfahān	86;40	32;25
23	Kāshān	86;0	34;0
24	Qumm	85;40	34;?
25	Rayy	86;0	35;0
26	Damāwand	87;20	36;10
27	Astarābād	89;35	37;50

	Place Name	L	φ
	Inner Circle		
28	Samnān	88;0	36;0
29	Sabzawār	91;30	36;5
30	Nishābūr	92;30	36;21
31	Ṭūs	92;30	37;0
32	Tūn	92;30	34;30
33	Qā'īn	93;20	33;40
34	Harat	94;20	34;30
35	Marw	97;0	34;40
36	Tālūn ?	104;50	34;10
37	Badakhshān	104;24	34;?
38	Balkh	101;0	36;0
39	Bukhārā	97;30	39;50
40	Samarqand	99;16	39; 31
41	Qandahār	104;40	33;0
42	Kashmīr	108;0	35;0
43	Kābul	104;40	34;30
44	Lāhūr	109;20	31;50
45	Bandar Sūrat	110;31	27;0
46	Ḥaydarābād	115;39	18;0
47	Bīchābūr	114;40	17;17

Back

On the back, the rim of the upper half carries altitude scales divided in 1° and 6° and numbered as 6—90; 90—6. The rim of the lower half bears the cotangent scales and their subdivisions.

The upper left quadrant is filled with 60 horizontal and 60 vertical parallels; attempt was made to emphasis ever fifth line with dots, but this has not been carried out uniformly. Semi-circles are drawn on both the radii and 3 quarter circles around the centre at 24 units (the arc of the obliquity of the ecliptic), 12 units (?) and 8 units (?). There is a radial line joining the centre to 45° on the arc and another line joining the inner terminals of the arc. The upper right quadrant is divided by 6 declination arcs and the related signs are marked by their serial numbers along the two radii. Two graphs are plotted to show the midday altitude of the sun throughout the year at latitudes 20° and 38°. The latter is accompanied by the label *khaṭṭ niṣf al-nahār bi-ᶜarḍ 38;* the former by *bi-ᶜ20.* While 20° can be the approximate latitude of Mecca (its traditional value is 21;40°), it is not clear which locality is represented by the latitude 38°.

In the lower half are engraved shadow squares, on the left for a base of 6 and 12 and on the right for 7 with the usual division of the scales and accompanied by the usual labels. Within these shadow squares is inserted the table of ‘the excess of revolution’ (*jadwal faḍl al-dawr*).

Alidade

The alidade is not graduated and sights are rather large.

Provenance

Formerly of the Sir John Findley Collection.



Figure A117.4 – Back of the astrolabe (photo by S. R. Sarma)

BIBLIOGRAPHY

Gunther 1932, no. 89, pp. 217-18;

Sotheby & co, *Sir John Findlay Collection: Catalogue of an Important Collection of Scientific Instruments* (the second and final part), Monday, 26 February 1962, lot 265, p. 67, plate XXV with the photos of the front and back.

A118⊙ ASTROLABE ATTRIBUTABLE TO ḤĀMID

Not dated, 17th Century

Diameter 77 mm

London, Science Museum (1938-437)



Figure A118.1 – Front of the astrolabe (photo by S. R. Sarma)

With a diameter of 77 mm, this is one of the smallest astrolabes; the workmanship is quite good, but the calligraphy is rather poor, especially in the geographical gazetteer. A graph for meridian altitude of the sun at Lahore's latitude of 32° is plotted on the back, but strangely no plate is made for this latitude. The solid *kursī* resembles the same in the astrolabe at Edinburgh (A117) and the rete displays similarities with the retes in many preceding astrolabes. It is therefore attributable to Ḥāmid.

Components

Body with the *kursī* (d. 77, h. 102, t. 7.5), ring, shackle, rete (d. 64.5), 5 plates (d. 64.5), alidade (length 7.8), pin and horse.

Front

The ring has a diamond cross-section; shackle trifoliate; *kursī* is solid with lobed profiles and a trifoliate finial. The limb is divided in 2° and 10° and numbered clockwise in 10s from 10 to 360.

Rete

The slender Capricorn ring and the broader ecliptic ring are held together by the equinoctial bar which is counter-changed at the centre. The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names. Each sign is divided into 5 units, but not numbered. Parts of the circles of equator and Cancer can be seen on the surface. Eighteen star-pointers are engraved with starkly abridged star names; several pointers are not named. There is a large round handle on the equinoctial bar close to the west point; the Capricorn index is well formed.

Plates

There are five plates. On the latitude plates, altitude circles are drawn for every 6°; azimuth arcs are for 10° sometimes above the horizons and sometimes below. Plain lines for seasonal hours; dotted lines drawn from the western horizon for equal hours. The duration of the longest day is not mentioned on two plates; rough approximation in the rest.

Table A118-1 Plates

	φ	Longest Day
1a	34°	---
1b	36°	14 hours
2a	22°	13 hours
2b	40°	15 hours
3a	42°	15 hours
3b	Double projection	
4a	27°	---
4b	Plate of ecliptic coordinates	
5a	Plate of horizons	
5b	Plate of horizons	

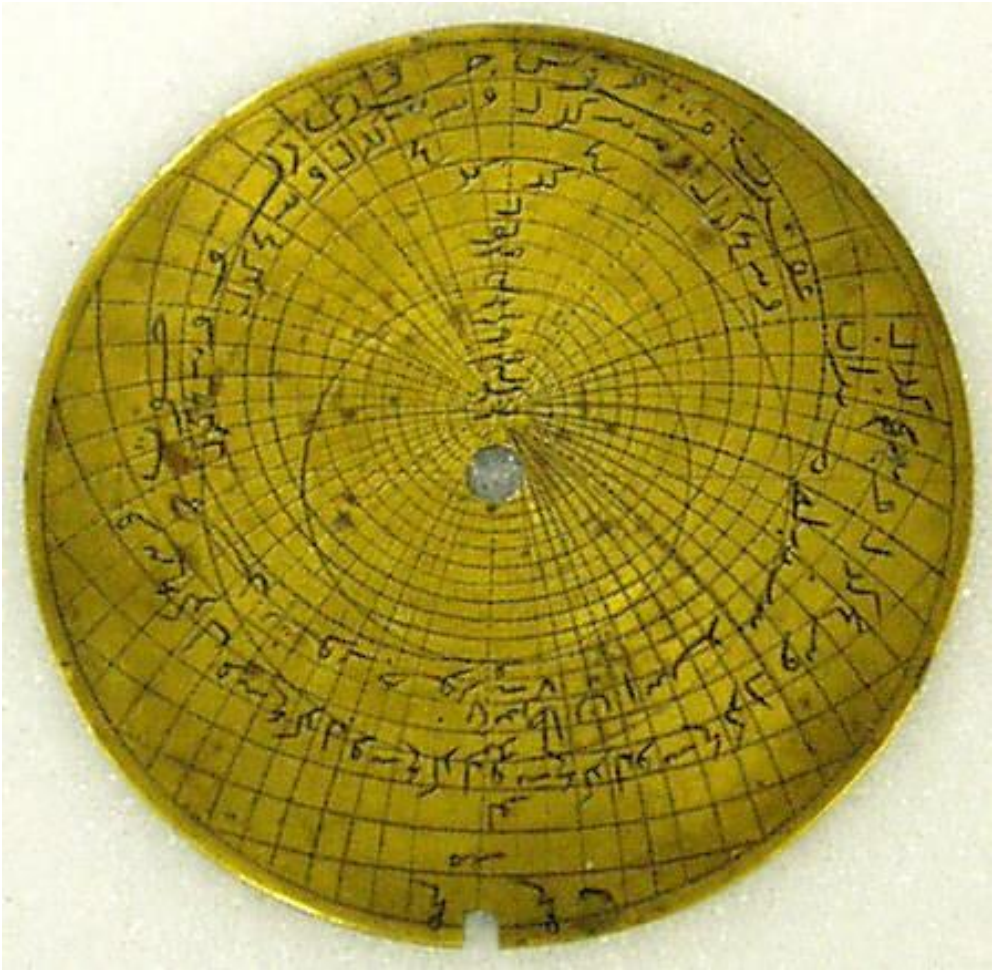


Figure A118.2 – Plate of ecliptic coordinates (photo by S. R. Sarma)

Plate 5 is engraved with multiple horizons on both sides. In spite of its small size with a diameter of 64.5 mm, the plate of ecliptic coordinates is engraved with latitude circles and longitude circles for each 6° and numbered very meticulously.



Figure A118.3 – Geographical gazetteer (photo by S. R. Sarma)

GEOGRAPHICAL GAZETTEER

The geographical gazetteer is engraved in two circles with the names (*bilād*), longitudes (*ṭūl*) and latitudes (*ʿarḍ*) of 42 localities which include several Indian cities.

Table A118-2 Geographical Gazetteer

	Place Name	L	φ
	Outer Circle		
1	Makka	77;10	21;40
2	Madīna	75;20	25;0

	Place Name	L	φ
3	Bayt al-Maqdis	66;30	31;50
4	?	83;0	26;15
5	Miṣr	69;20	30;20
6	ᶜAdan	76;0	11;0
7	Tibirīya	68;0	32;0
8	Dimashq	70;0	33;55
9	Baᶜālbak	70;45	33;15
10	Ḥalab	72;10	32;50
11	Qūniya	66;30	41;0
12	Irbīl	77;20	35;0
13	?	105;55	37;59
14	Kūfa	79;30	31;30
15	Baṣra	86;0	30;0
16	Shīrāz	88;0	30;0
17	Yazd	89;0	32;30
18	Ṭūs	92;30	36;0
19	Tūn	97;30	34;30
20	Balkh	100;0	36;41
21	Bukhārā	97;30	39;50
22	Samarqand	99;36	39;57
23	Badakhshān	104;24	37;10
24	Khutan	87;0	47;30
25	Tubbat	108;0	40;0
26	Kashmīr	108	35;0

	Place Name	L	φ
27	Kābul	104;40	35;0
	Inner Circle		
28	Qandahār	106;40	33;0
29	Multān	106;35	29;40
30	Lāhūr	109;20	31;50
31	Dihlī	110;45!	28;47
32	Akra	114;0	27;13
33	Jawnbūr	119;40	36;36! it should be 26;26
34	Kawāliyar	115;0	26;29
35	Ajmīr	110;0	24;0
36	Mīwāt	117;10	32;50
37	Bānārasī	117;20	26;55
38	Qannawj	115;50	26;35
39	Māndū	117;4	22;4
40	Burhā[n]būr	109;0	20;31
41	Aḥmad[ā]bād	111;9	19;0
42	Dawlatābād	111;0	20;30



Figure A118.4 – Back of the astrolabe (photo by S. R. Sarma)

BACK

The rim of the upper half carries altitude scales graduated in 1° and 5° and labelled 5---90; 90---5. The trigonometric quadrant in the upper right is engraved with 30

horizontal parallel lines with every fifth highlighted. The solar quadrant in the upper right is divided by the declination arcs into 18 zones, one for each 10°. The corresponding signs are marked by their serial numbers along the two radii. A graph for the meridian altitude of the sun in all seasons is drawn for the latitude 32° with the label *khaṭṭ niṣf al-nahār ᶜarḍ 32*.

Shadow squares are drawn in the lower half, on the left for the base of 12 and on the right for the base of 7; the scales are divided accordingly and accompanied by the usual labels.

The rim on the lower half carries cotangent scales and their subdivisions. These scales are followed by four semi-circular rows. The first two are engraved with the names of the first 6 zodiac signs from *al-Ḥamal* to *al-Sunbula* and the 14 corresponding lunar mansions; rows 3 and 4 contain the names of the signs from *al-Mīzān* to *al-Ḥūt* and the 14 corresponding lunar mansions.

ALIDADE

Alidade is plain and not graduated. The pin is original, but the wedge is a replacement.

A119 ASTROLABE ATTRIBUTABLE TO ḤĀMID[521]

Diameter 132 mm

PLU: ex-Sir John Findlay Collection

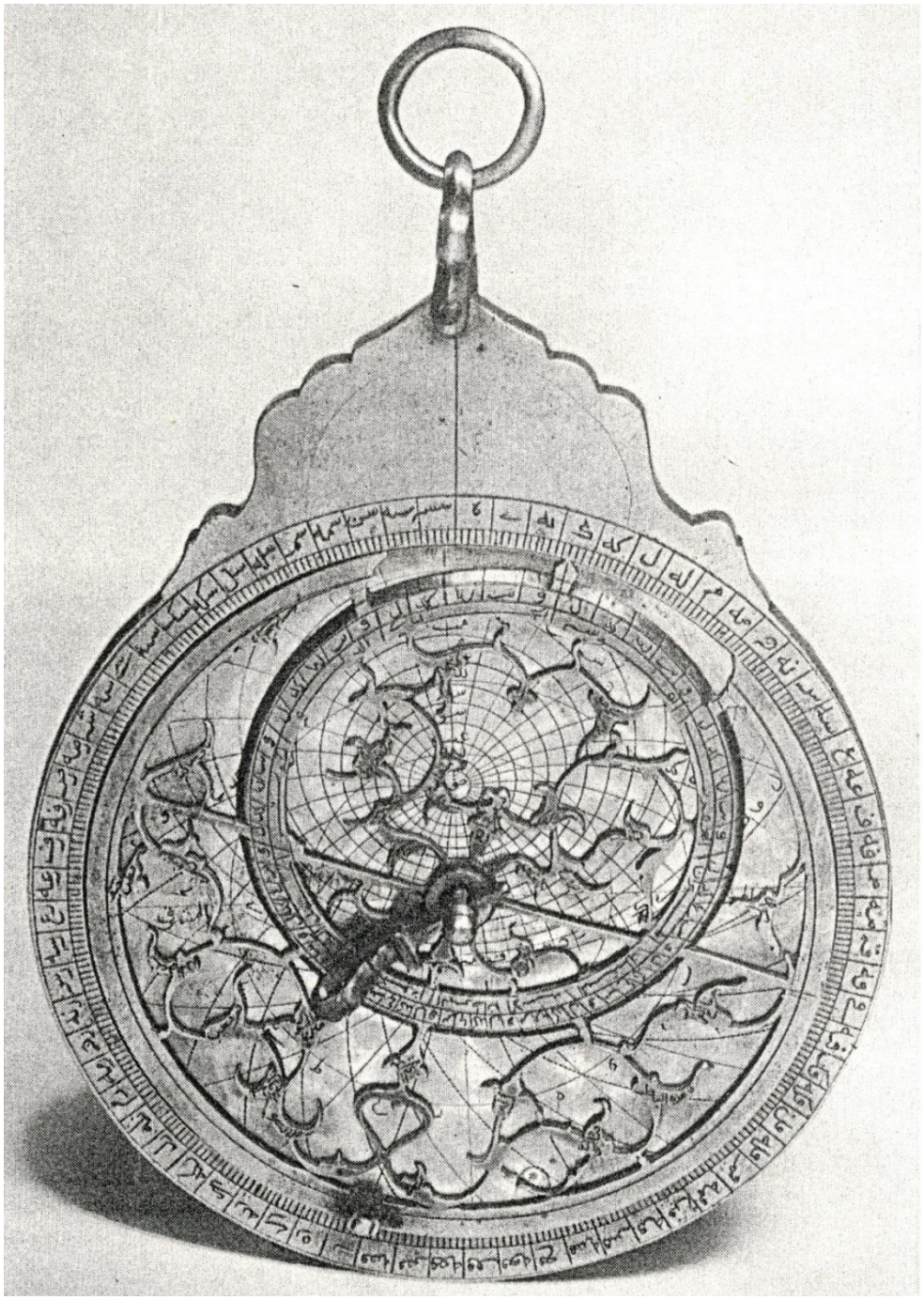


Figure A119.1 – Front of the astrolabe (photo from Sotheby's catalogue)

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[521] Entry based on Sotheby & co, *Sir John Findlay Collection: Catalogue of an Important Collection of Scientific Instruments* (the second and final part), Monday, 26 February 1962, lot 264, p. 66, plate XXIV with the photos of the front and back.

The profiles of the *kursī* and the design of the rete strongly suggest that this astrolabe may have been made by Ḥāmid, even though the two upper quadrants on the back are rather unusual.

Components

Body with *kursī* (d. 132 mm), shackle and ring, rete, 4 plates, alidade, pin, wedge and suspension cord.

Front

The suspension cord is of plaited silk threads. The ring is plain; the shackle also appears to be plain. The solid *kursī* has profiles exactly like those in A111, A112, A113and A115. The surface of the *kursī* is plain in the front: the vertical diameter of the astrolabe is extended on it and also a semicircle is drawn faintly. On the back of the *kursī* is the name Muḥammad Bāqir bin Siddiq al-Dawlah in relief in large letters, presumably of the man for whom the astrolabe was made. The area around the raised letters is painted black. The limb is divided in 1° and 5° and numbered in 5s from 5 to 360.

Rete

The slender Capricorn ring and the wider ecliptic ring are held together by the equinoctial bar which has counter changes at its intersection with the ecliptic ring on the left and at the centre. The 32 named star pointers are joined by an arabesque tracery.

Plates

There are four plates; the first three are calibrated for latitudes 29°, 38°, 32°, 34°, 36°, 37°. The fourth plate carries plates of horizons on both sides. Two of the latitudes, 29° and 32°, belong to Delhi and Lahore respectively. The others fall outside India proper. This is not unusual for Ḥāmid; he has plates for 34°, 36° and 38° in his other astrolabes also. On the plate which is visible under the rete in the photo, altitude circles are drawn for every 6°, azimuth arcs for every 10° above the horizon as also lines for seasonal hours and lines for equal hours drawn from the western horizon.

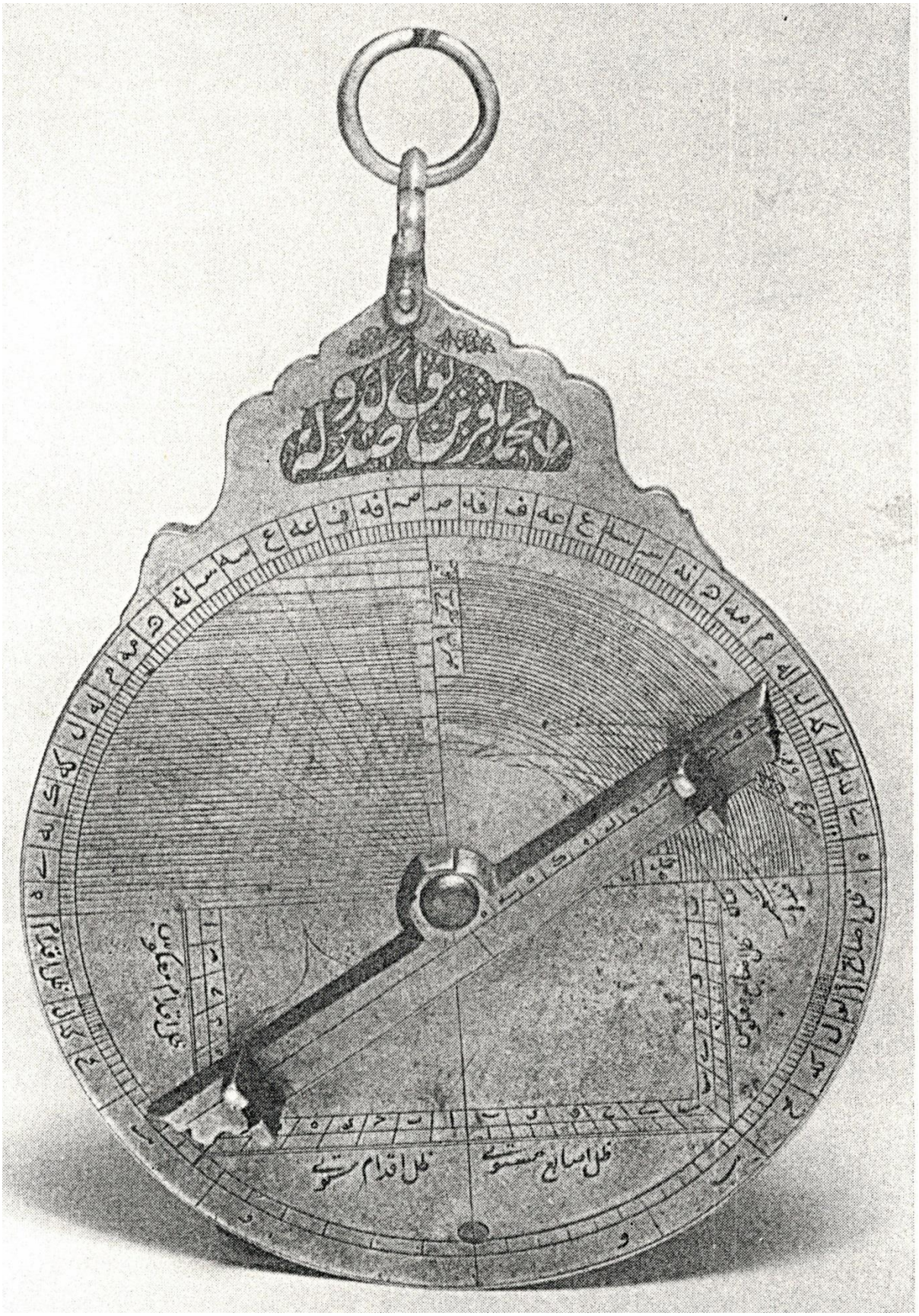


Figure A119.2 – Back of the astrolabe (from Sotheby's catalogue)

Geographical Gazetteer

The catalogue states that the geographical gazetteer on the inner side of the mater provides the names, longitudes, latitudes and *inḥirāf* of 52 towns.

Back

The rim of the upper half carries altitude scales which are divided in 1° and 5° and numbered as 5—90; 90—5. In the upper left quadrant are drawn 60 horizontal lines; which are followed by 4 horizontal lines at unequal intervals. Radian lines are drawn from the centre to every 5° on the arc. In the upper right quadrant are drawn declination arcs for every 6° of solar longitude; the names of the related signs are written in small boxes along the two radii. Upon these are traced the graphs of the azimuths of *qibla* for Multān, Kashmīr, Qandahār, Tūs, Iṣfahān, Baṣra and Madīna.

In the lower half are drawn the shadow squares, on the left for a base of 7 and on the right for 6 (12) with the usual labels. The rim of the lower half carries cotangent scales and their subdivisions with the labels *ẓill aqdām* on the left and *ẓill aṣābiʿ* on the right.

Alidade

The alidade has ornate ends, ornate centre piece and ornate sighting plates; the right hand side carries a sexagesimal scale numbered in 5s as 5, 10, 5, 20 … 5, 60. The wedge is of the usual design; its head and neck are bent backwards to form a loop.

Bibliography

Sotheby & co, Sir John Findlay Collection: Catalogue of an Important Collection of Scientific Instruments (the second and final part), Monday, 26 February 1962.

A120 ASTROLABE ATTRIBUTABLE TO ḤĀMID

Diameter 96 mm

PLU



Figure A120.1 – Front of the astrolabe
(photo courtesy Museum of the History of Science, Oxford)

In the archives of the Museum of the History of Science at Oxford, there are photos of the front and back of this astrolabe, and also somewhat faint photocopies of the gazetteer, and the two sides of the six plates, together with the following note in the handwriting of Francis Maddison:

> Indo Persian astrolabe / Not signed / ? c 1700 / Brass (1 varnished paper plate) / Diameter 96 mm.
>
> Brought to FRM [= Francis R. Maddison] for examination on 29 October 1985 by: / ***[522] Edinburgh / Neg. ref. no. 85 – 46ab 35.S.

There is no doubt that this astrolabe was produced in the Lahore family, but it is difficult to decide by whom. In the solar quadrant on the back, there are two graphs of the solar meridian altitude at latitudes 21° (Mecca) and 32° (Lahore). Ḥāmid drew the graph for Mecca on many of his astrolabes. As many as six of his astrolabes carry just one single graph for Mecca at 20°. On some others, graphs are drawn for the latitude of 21° along with other latitudes like 32° for Lahore. Therefore, it is quite likely that the present astrolabe was made by Ḥāmid.

Components

Body with *kursī* (d. 96), shackle and ring, rete, 6 plates, alidade, pin and horse.

Front

The *kursī* looks like a royal crown in outline, with trifoliate finial. The limb is rather broad; it is divided in 1° and 6° and numbered from 1 to 90, separately in each quadrant.

Rete

The Capricorn ring and the ecliptic ring are held together by the equinoctial bar, which has counter changes at its two intersections with the ecliptic ring. The ecliptic ring is divided into the 12 zodiac signs and labelled with their names; each sign is divided into 5 and 10 divisions and numbered in 6s. Traces of the circles of the equator

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[522] Here are the name and address of a person, but the names of individual owners are not mentioned in this Catalogue as a matter of policy.

and of the Tropic of Cancer are visible on the surface of the ecliptic ring. There are about 30 star pointers.

PLATES

There are 6 plates serving 23° and 25°; 27° and 29°; 32° and 1°+72°+90°; 21° and 18°+30°; plate of ecliptic coordinates and plate of horizons. The values of the hours of the longest day are difficult to read in the faint photocopies. On plates 1-5, altitude circles are drawn for each 3°, azimuth arcs for each 10°, sometimes below the horizon and sometimes both above and below the horizon, and plain lines for seasonal hours and dotted lines for equal hours from the western horizon. The plate of ecliptic coordinates and the plate of horizons are endowed with the usual labels.

GEOGRAPHICAL GAZETTEER

In the geographical gazetteer, arranged in a spiral form, the names, geographical longitudes and latitudes of 30 places starting from Mecca are engraved.

BACK

The rim of the upper half carries the altitude scales which are divided in 1° and 6° and numbered as 6—90; 90—6. The upper left quadrant contains a sine-cosine grid with 30 vertical and 30 horizontal parallels, with each fifth line being dotted. In the upper right quadrant are 18 solar declination arcs, one for each 10° of the solar longitude. Every third of the arcs, which forms the boundary between two signs, is highlighted with dots. The serial numbers of the related signs are marked along the two radii. Two graphs of the solar meridian altitude are drawn across the quadrant for latitudes 21° and 32°, i.e. for Mecca and Lahore. The former is accompanied by the label *ʿarḍ 21* and the latter *ghaṭ* (sic!) *niṣf al-nahār ʿarḍ 32.*

In the lower half are shadow squares on the left for a base of 12 and on the right for a base of 7. The two scales on the left are divided in 6 and 12 units and numbered 2, 4, 6, 10, 12, while the two scales on the right are divided in 7 units and numbered serially from 1 to 7. In the two corners below are the labels *ẓill sullam.* The four scales are accompanied by the usual labels.

The rim of the lower half bears two cotangent scales. The divisions in the scale on the left are numbered 6, 12, …60, followed by the label *ẓill aṣābiʿ*. The divisions in the scale on the right are also numbered in the same manner, but followed by the label *ẓill*

aqdām. Each division in these scales is divided into 5 parts in the following semi-circular row.

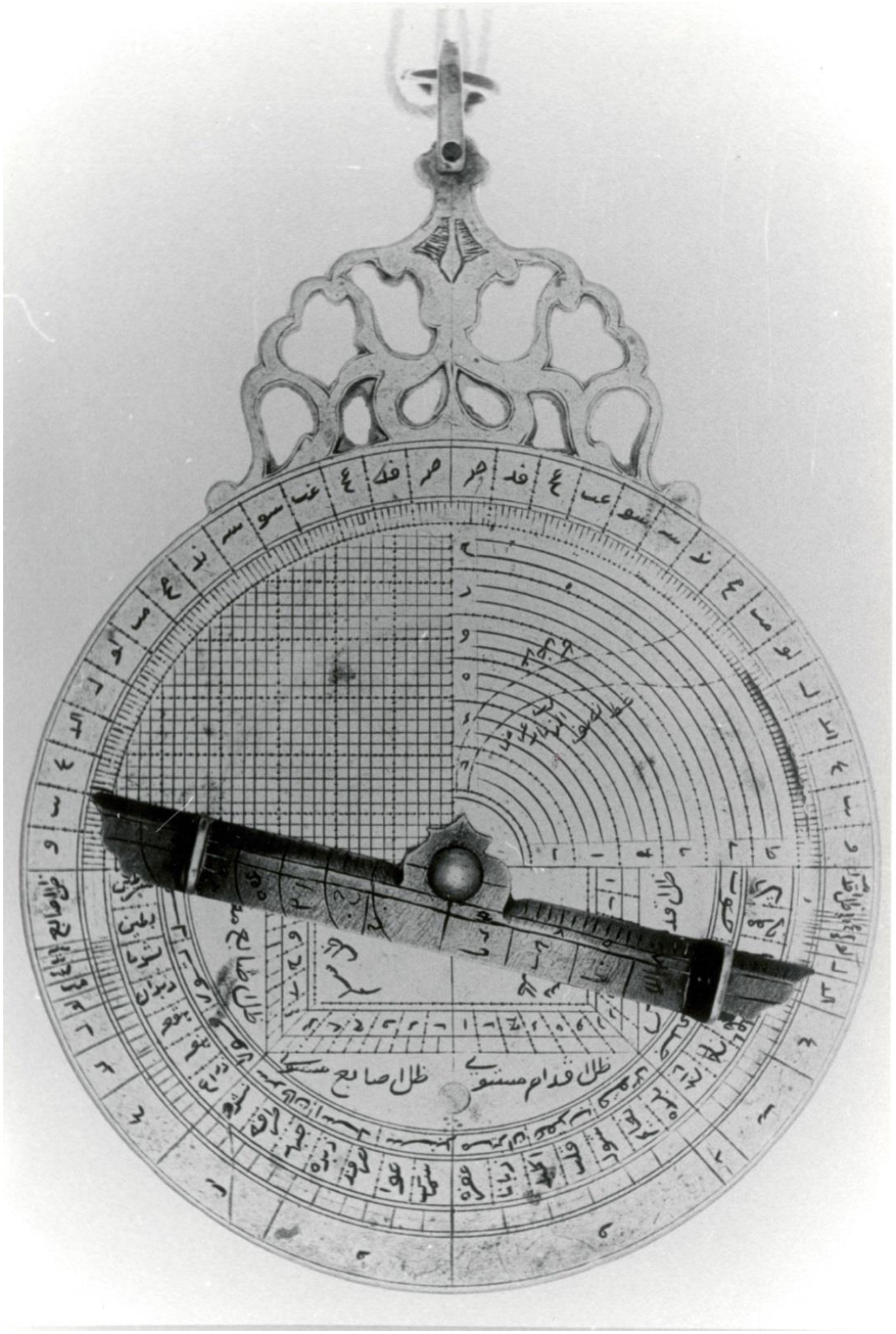


Figure A120.2 – Back of the astrolabe (photo courtesy Museum of the History of Science, Oxford)

Then follow two semi-circular rows engraved with the names of the 28 lunar mansions and the names of the 12 signs respectively.

The semi-circular rows on the back are separated by double lines and the divisions in these rows are often separated by dotted lines.

ALIDADE

The alidade has ornate terminals and an ornate centre-piece. The right hand side carries a sexagesimal scale to match with the divisions in the upper left quadrant. There are also markings for a sundial here. The left hand side is divided by arcs of solar declination and marked with the serial numbers of the signs.

The wedge is quite long, measuring about 50 mm and appears to be shaped like a horse's head with a high neck.

JAMĀL AL-DĪN

Jamāl al-Dīn ibn Muḥammad Muqīm (*fl.* 1666-1691), the last member of the Lahore family, is known from four astrolabes which he produced between 1077/1666-67 and 1103/1691-92. He may have produced more than four astrolabes during this quarter century, but these have not come to light. Even among the four extant astrolabes, the last two are not accessible. Of the remaining two, 0 is an ordinary astrolabe, while A121 is an impressive production with a zoomorphic rete and *qibla*-indicating lines engraved along with the regular gazetteer. Two other astrolabes are attributed to him: a common astrolabe (A126) and a universal astrolabe (A125). The latter is a rare *shakkāziyya* type of universal astrolabe and resembles closely the unique astrolabe made by Ibn al-Sarrāj in Aleppo in 729/1328-29, which David King considers to be 'the most sophisticated [instrument] ever made between Antiquity and 1600'.[523]

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523 King 2005, p. 694.

A121⊙ ZOOMORPHIC ASTROLABE AND QIBLA INDICATOR BY JAMĀL AL-DĪN 1077 AH (AD 1666-67)

Diameter 251 mm

London, Science Museum (#1985-2077)

Répertoire 1



Figure A121.1 – Front of the astrolabe (photo by S. R. Sarma)

In this ambitious astrolabe, Jamāl al-Dīn incorporates a zoomorphic rete following the footsteps of his father Muḥammad Muqīm, a *zawraqī* horizon in emulation of his uncle Ḍiyā' al-Dīn Muḥammad, and a *qibla* indicator which his brother Ḥāmid imitated in a grander scale twenty years later (A112). But the astrolabe lacks the elegance of the astrolabes of Muqīm and Ḍiyā al-Dīn.

Components

Body with *kursī* (d. 251, h. 340, t. 11), shackle and ring, rete (d. 228) for 42 stars, 7 plates (d. 228), alidade (l. 230), pin and horse (replacement).

Front

The ring has a diamond-shaped cross-section; the shackle also has a similar cross-section and a trifoliate form. The *kursī* is reticulated, with tulip-like forms in the profiles and a small rectangular cartouche in the middle; the finial is trifoliate.

The limb is divided in 1° and 6° and labelled in 6s from 6 to 90, separately in each quadrant.

Zoomorphic Rete

The two rings of Capricorn and ecliptic are joined by the complete equinoctial bar, with counter changes at its intersections with the ecliptic circle and by the complete solstitial bar, without any counter change.

The ecliptic circle is divided into 12 signs of the zodiac and labelled with their names; each sign is divided into groups of 6° and numbered, the bevelled edge of the ecliptic ring is divided into 1°. Floral tracery joins the 42 star-pointers, some of which have zoomorphic or anthropomorphic forms.[524] Because of these forms, the exact positions of stars are not always properly shown. In some places, small round holes are made to indicate the exact positions of stars.

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524 The Répertoire mentions 67 star pointers which is clearly an error.



Figure A121.2 – Rete of the astrolabe (photo by S. R. Sarma)

Table A121-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus J[anūbī]*	β Ceti
2	*Baṭn [al-Ḥūt]*	β Andromedae
3	*Rijl al-Musalsala*	γ Andromedae
4	*Fam al-Qayṭus*	γ Ceti

	Star Name	Identification
5	*Ṣadr al-Qayṭus*	π Ceti
6	*Rās al-Ghūl*	β Persei
7	*Tālī Masāfat al-Nahr*	γ Eridani
8	*ᶜAyn al-Thawr*	α Tauri
9	*ᶜAyyūq*	α Aurigae
10	*Rijl al-Jawzā' [al-Yusrā]*	β Orionis
11	*Yad al-Jawzā' [al-Yusrā]*	γ Orionis
12	*Yad al- Jawzā' [al-Yumnā]*	α Orionis
13	*Rijl al-Jawzā' [al-Yumnā]*	κ Orionis
14	*Shiᶜrā Yamānī*	α Canis Majoris
15	*Shiᶜrā Shāmī*	α Canis Minoris
16	*Fard al-Shujāᶜ*	α Hydrae
17	*Qalb al-Asad*	α Leonis
18	*Dubb Akbar*	α Ursae Majoris
19	*Qāᶜidat al-Bāṭiya*	α Crateris
20	*ᶜAnāq*	ζ Ursae Majoris
21	*Janāḥ al-Ghurāb*	γ Corvi
22	*Simāk Aᶜzal*	α Virginis
23	*Simāk Rāmiḥ*	α Bootis
24	*Nayyir al-Fakkah*	α Coronae Borealis
25	*ᶜUnuq al-Ḥayyah*	α Serpentis
26	*Qalb al-ᶜAqrab*	α Scorpii
27	*Rukbat Ḥawwā*	ζ Ophiuchi
28	*Rijl al-Muqaddam*	α Ophiuchi

	Star Name	Identification
29	*Rās al-Jāthī*	α Herculis
30	*Rās al-Ḥawwā*	α Ophiuchi
31	*ᶜAyn al-Tinnīn*	γ Draconis
32	*Nasr Wāqiᶜ*	α Lyrae
33	*Minqār al-Dajājah*	β Cygni
34	*Nasr Ṭā'ir*	α Aquilae
35	*Dhanab al-Dulfīn*	ε Delphini
36	*Dhanab al-Dajājah*	α Cygni
37	*Fam al-Faras*	ε Pegasi
38	*Sāq Sākib al-Mā' J[anūbī]*	δ Aquarii
39	*Dhanab al-Qayṭus Sh[amālī]*	ι Ceti
40	*Mankib al-Faras*	β Pegasi
41	*Surrat al-Faras*	δ Pegasi
42	*Kaff al-Khaḍīb*	β Cassiopeiae

Of these, 26 star pointers are given zoomorphic shape. Here Jamāl al-Dīn follows the example of his father Muḥammad Muqīm who created two splendid zoomorphic astrolabes (A023 and A051) and chooses nearly the same stars for zoomorphic shape, but his forms lack the elegance of his father's work. As in the case of Muqīm's astrolabes, here also we shall describe the zoomorphic shapes and explain their significance, in the same sequence as the stars are listed above. For each star, we shall provide first the Arabic name of the star as engraved on the astrolabe and its literal meaning and show how Jamāl al-Dīn lends a visual form to this meaning.

The first major constellation south of the ecliptic is the sea-monster Cetus, transliterated as *al-qayṭus* in Arabic, which is visualized on Islamic celestial globes with

'a snarling dog's head, bird's feet, and a feathered fish tail'.[525] Muqīm just depicts the fish tail with the two fins (northern and southern) and the dog's head, placing the appropriate stars in these parts. The tips of the tail fins become the pointers to the stars called respectively after these. Jamāl al-Dīn imitates this.

1. *Dhanab al-Qayṭus J[anūbī]* (southern tail of Cetus), shown as the tip of the southern fin of the fish tail.

2. *Baṭn [al-Hūt]* (belly of the fish), head of a fish

4. *Fam al-Qayṭus* (mouth of Cetus) snarling dog's head

7. *Talī Masāfat al-Nahr* (valley or expanse of the river [Eridanus]), the river is shown as an arc, from which projects the thin star pointer.

8. *ᶜAyn al-Thawr* (eye of the bull), bull's head with horns and an engraved eye.

10-11-12-13. The four stars are located in the two hands and the two feet of Orion. Muqīm depicts the hands skillfully with the three last fingers folded, and the index finger outstretched to form the star pointer. He depicts the legs through tapering shoes. Jamāl al-Dīn's figures can be understood only when one knows Muqīm's figures.

14. *Shiᶜrā Yamānī* (the southern Shiᶜra, α Canis Majoris, Sirius), dog's head.

15. *Shiᶜrā Shāmī* (the northern Shiᶜra, α Canis Minoris, Procyon), dog's head.

16. *Fard al-Shujāᶜ* (the isolated one of the serpent), snake's head.

19. *Qā'idat al-Bāṭiya* (bottom of the cup), a bucket with vertical serrations.

20. *Janāḥ al-Ghurāb* (wing of the raven), full body of a crow.

29. *Rās al-Jāthī* (the head of the kneeling man, i.e. Hercules), a stiff bust of a human figure with a crown.

30. *Rās al-Ḥawwā* (the head of the serpent charmer), similar human figure as above, but upside down.

31. *ᶜAyn al-Tinnīn* (the eye of the dragon), a grinning fish.

33, 36. *Minqār al-Dajājah* (the bird's beak) and *Dhanab al-Dajājah* (the bird's tail), both names engraved on a soaring bird.

34. *Nasr Ṭā'ir* (the flying eagle), bird with engraved eye and engraved wing feathers.

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525 Savage-Smith 1985, p. 187.

36. *Dhanab al-Dulfīn* (the dolphin's tail), head of a fish.

37, 40, 41. *Fam al-Faras* (the mouth of the horse), *Mankib al-Faras* (shoulder of the horse) and *Surrat al-Faras* (the navel of the horse) are engraved on the figure representing the shoulder and head of a horse; a longish piece projecting out of the horse's mouth serves as the star pointer.

39. *Dhanab al-Qayṭus Sh[amālī],* (northern tail of Cetus), shown as the tip of the northern fin of the fish tail.

42. *Kaff al-Khaḍīb* (the dyed hand), a female face engraved on the equinoctial bar.

ZAWRAQĪ HORIZON

There is a slender arc of the horizon which passes through the two intersections of the ecliptic and equinoctial bar and reaches up to the circle of Capricorn on both sides. This arc, together with the upper half of the solstitial bar, forms a ship with its mast.

This arc represents the *zawraqī* horizon of presumably latitude 40°. There are four labels related to this horizon. Where it touches the Capricorn ring above the west point, there is a label on the Capricorn ring which reads *ufq mujassam gharbī* (solid horizon western). On the opposite side, where the horizon arc touches the Capricorn ring above the east point, there is another label on the Capricorn ring which is difficult to decipher: it can be either *ufq sharqī mujassam* (solid horizon eastern) or *ufq sharqī ʿarḍ m* (eastern horizon, latitude 40°). On the eastern segment of the horizon which is inside the ecliptic ring is written *ufq sharqī* (eastern horizon) and on the western segment *ufq gharbī* (western horizon).

There is a label on the solstitial bar above the arc and another on the Capricorn ring where the lower part of the solstitial ring touches; I cannot decipher either one completely. This *zawraqī* horizon is to be used with the plate 4b which will be described below.

PLATES

There are seven plates; on the first four altitude circles are drawn for each 1° and azimuth arcs below the horizon for each 6°. There are lines for seasonal hours; lines for equal hours are drawn generally from the western horizon; in a few cases from the western as well as from the eastern horizons. The durations of the longest day at different latitudes are rough approximations, given only in hours.

Table A121-2 Plates

	φ	Longest day
1a	23°	13 hours
1b	27°	13 hours
2a	29°	13 hours
2b	32°	14 hours
3a	34°	14 hours
3b	36°	14 hours
4a	38°	14 hours
4b	40°	14 hours
5a	21°	13 hours
5b	Double projection for 18° and 48°.	
6a	Triple projection for 0°, 72°, 90°.	
6b	Markings for determining the astrological ‘projections of the rays’ at latitudes 32° and 36°with curves for each 6° of latitude.	
7a	Plate of ecliptic coordinates with the label *ṣafīḥat mīzān al-ᶜankabūt*	
7b	Plate of horizons with the label *ṣafīḥa āfāqī*	

Plate 7 is engraved with the plate of ecliptic coordinates on the obverse. Here the latitude circles are drawn for every 2°, but not numbered systematically. The longitude arcs are drawn for every 6° and numbered from 6 to 30, separately in each zodiac sign. But the ecliptic circle with the names of the signs is not drawn. The label reads *ṣafīḥat mīzān al-ᶜankabūt*.

The reverse side of this plate is engraved as the plate of horizons with the label *ṣafīḥa āfāqī.* Here half-horizons for every 1° are drawn in four sets at intervals of 4° in the following manner:

2	6	10	…	58	62	66;30
3	7	11	…	59	63	66;30
4	8	12	…	60	64	66;30
5	9	13	…	61	65	66;30

Declination scales are drawn on either side of the equator between the equator and the tropics; these are divided in 3° and 6°, and numbered 6, 12, 18, 23;30, the last value being the obliquity.

Plate 5b carries the double projections for latitudes 18° and 48° in the two halves.

On plate 6a, one half carries the projections for 0° (label *lā ᶜarḍ lah*) and 72° (*ᶜarḍ 72*), and the other half for latitude 90° (label *ᶜarḍ tisᶜūn*).

Plate 4b appears to have been designed for use along with the *zawraqī* horizon on the rete, although it is somewhat different from similar plates in Ḍiyā'al-Dīn's astrolabes. Besides the concentric circles of Capricorn, equator and Cancer, the ecliptic circle is drawn in two bands. The inner band should have been divided into the 12 signs of the zodiac, but the divisions are not completely marked. The outer band is divided into units of 6°. As on other plates, altitude circles are drawn for each 1° and the azimuth arcs for each 6° below the horizon. Lines for seasonal hours; lines for equal hours are drawn from the western horizon up to the eastern horizon and once again from the eastern horizon to the western.



Figure A121.3 – Plate 4b for latitude 40° (photo by S. R. Sarma)

The names of 19 stars are written at approximately the same places as in the rete when it is at rest, but their exact locations are not marked. The stars are *Dhanab al-Qayṭus* (β Ceti), *Fam al-Qayṭus* (γ Ceti), *ᶜAyn al-Thawr* (α Tauri), *Yamānī* (α Canis Majoris), *Shāmī* (α Canis Minoris), *Mankhar al-Shujāᶜ* (σ Hydrae), *Fard al-Shujāᶜ* (α Hydrae), *Qāᶜidat al-Bāṭiya* (α Crateris), *ᶜAnāq* (ζ Ursae Majoris), *Simāk Aᶜzal* (α Virginis), (?), *Fakkah* (α Coronae Borealis), *Rāmiḥ* (α Bootis), *Wāqiᶜ* (α Lyrae), *Minqār al-Dajājah* (β Cygni), *Nasr Ṭā'ir* (α Aquilae), *Fam al-Faras* (ε Pegasi), *Dhanab al-Jadī* (δ Capricorni), *Kaff al-Khaḍīb* (β Cassiopeiae).

GEOGRAPHICAL GAZETTEER

The inner side of the mater is divided into two halves by the north-south line. On the left half, a gazetteer for 80 localities is engraved in four concentric semi-circles. It

is arranged according to climates. The headings mentioning the climates are written in a circular band above each circle. In the first such band, the boundaries of each climate are marked by a special symbol, but not in other bands. Therefore, in the second, third and fourth circles, it is difficult to know where one climates end and a new one begins. The arguments are in the first cells on the left and the gazetteer has to be read from the left to the right.

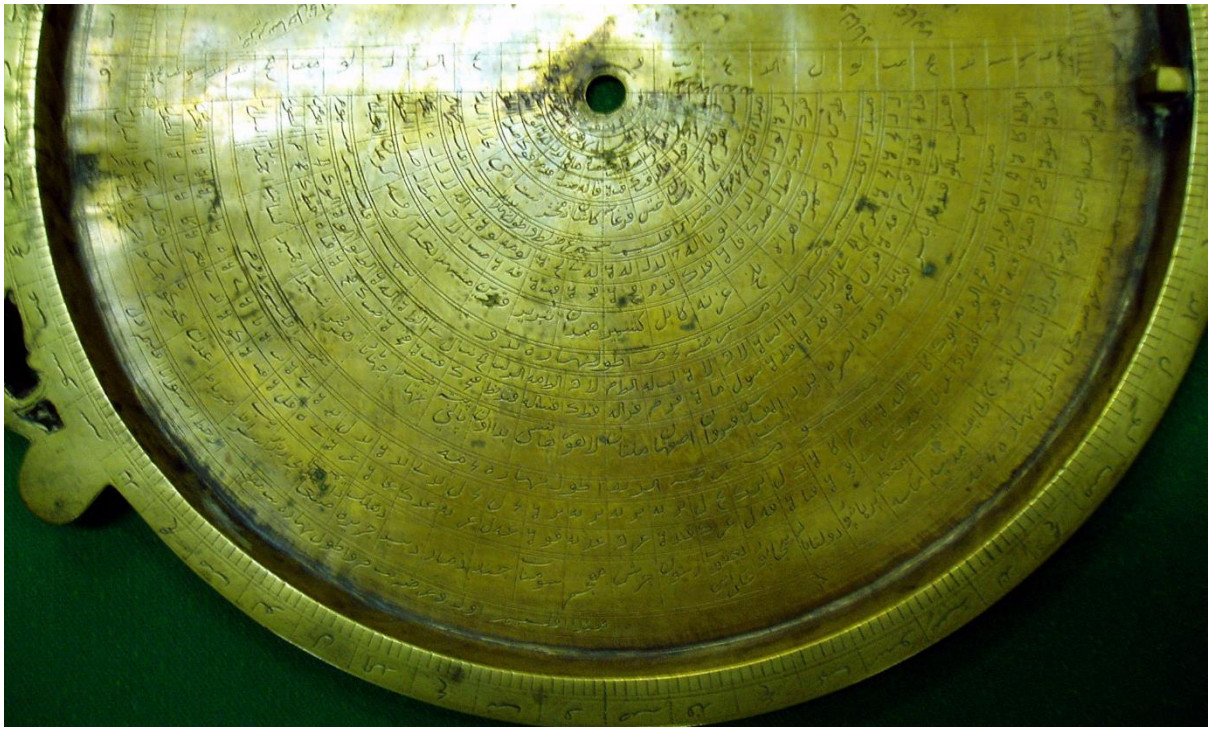


Figure A121.4 – Geographical gazetteer (photo by S. R. Sarma)

Table A121-3 Geographical Gazetteer

	Place Name	L	φ
	First Circle		
[-I] *az khaṭṭ istiwā' tā iqlīm awwal* (from the equator up to the first climate)			
1	Sāḥil Baḥr Awqiyānūs	11;0	0;0
2	Jazīra Qanbala	21;0	3;0
3	Jamkūt	177;0	5;0
4	Kukūh	31;10	10;0

	Place Name	L	φ
5	ᶜAdan	26;0[526]	11;0
6	Marbāṭ?	42;0	14;0
7	Sarāndīb	130;0	10;0
[I] *mabdā' iqlīm awwal wa ᶜarḍ 12;40 wa aṭwal nahār 12;48* (beginning of the first climate and latitude 12;40 and the longest day 12;48 [hours])			
8	Bazza az Barbar	10;5	14;0
9	Sanᶜā' Dār al-Mulk Yaman	77;0	14;30
10	Jazīra Damtab ?	71;0	14;0
11	Dabīl	74;20	14;10
12	Damār	77;15	13;30
13	Janad	75;30	13;30
14	Sawmnāt	106;0	17;0
15	Mujam	74;14	17;15
16	Jurash	77;50	17;15
17	Zaytūn	154;0	17;15
18	Hālī ibn Yaᶜqūb	77;20	18;30
19	Bījāpūr	105;30	17;20
[II] *iqlīm dūyum ᶜarḍ 20;30 aṭwal nahār 13;15* (second climate, latitude 20;30°, longest day 13;15 hours)			
20	Dawlatābād	111;0	20;30
21	Burhānpūr	113;0	21;0
22	Makka Muᶜaẓẓam	77;10	21;40
23	Madīnat Tayyiba	75;20	25;0

[526] Longitude 26;0° is too low; it should be 56;0°.

	Place Name	L	φ
24	Ṭā'īf	77;30	21;20
25	Qannawj	114;50	26;20
26	Banāras	117;20	26;15
27	Akbarābād	115;0	26;43
28	Jawnpūr	119;6	26;26
29	Ujjayn	110;50	23;30
30	Jadda	76;0	21;0
31	Kawāliyar	114;0	26;29
	Second Circle		
[II] *tatimma iqlīm dūyum* (continuation of the second climate)			
32	Aḥmadābād	108;40	23;14
33	Kanbāyat	109;20	26;20
34	Ajmīr	111;5	26;0
35	Shīrāz	88;0	29;36
36	Hurmuz	92;20	25;0
[III] *mabdā' az iqlīm siwum ʿarḍ 27;15 aṭwal nahār 13;45* (beginning of the third climate, latitude 27;15°, longest day 13;45 hours)			
37	Jahānābād	113;0	29;0 for Shāhjahānābād !
38	Thānīsar	112;0	20;10!
39	Pānīpat	113;20	28;52
40	Badāūn	114;59	27;32
41	Hānsī	112;25	29;45
42	Lāhūr	109;20	31;50
43	Multān	107;25	29;40

	Place Name	L	φ
44	Iṣfahān	87;40	32;35
45	Qayrawān	41;0	31;0
46	Bayt al-Maqdis	66;30	31;50
47	Yazd	89;0	32;0
48	Basra	84;0	30;0
49	Awadh	118;6	27;32
50	Fīrūzābād	87;30	28;10
51	Bakar	85;0	27;40
52	Qandahār	107;40	33;0
53	Sālkūt	109;0	33;0
54	Sirhind	111;33	30;30
	Third Circle		
[III] *tatimma iqlīm siwum* (continuation of the third climate)			
55	Kirmān	91;30	30;5
56	Kūfa	79;30	31;30
57	Baghdād	31;30[527]	33;25
[IV] *mabdā' az iqlīm chahārum ʿarḍ 33;40 aṭwal nahār 14;6* (Beginning of the fourth climate, latitude 33;40°, the longest day 14;6 hours)			
58	Mashhad	92;30	36;0
59	Qazwīn	85;0	36;45
60	Tabrīz	82;0	38;0
61	Hamadān	83;0	35;10

[527] An absurdly low value; other gazetteers mention values between 70;0 and 80;0.

	Place Name	L	φ
62	Kashmīr	108;0	35;0
63	Kābul	104;40	34;30
64	Ghazna	104;20	35;3
65	Balkh	101;0	36;11
66	Harat	94;20	34;30
67	Samarqand	99;30	36;30
68	Marw	94;20	36;30
69	Ṭūs	84;20	37;0
	Fourth Circle		
[IV] *tatimma iqlīm chahārum* (continuation of the fourth climate)			
70	Bukhārā	97;30	36;50
71	Rayy	86;20	34;0
72	Tubbat	104;40	34;30
[V] *mabdā' az iqlīm panjum ᶜarḍ 39;6 aṭwal nahār 14;14* (beginning of the fifth climate, latitude 39;6°, longest day 14;14 hours)			
73	?	92;30	41;0
74	Kāshān	81;35	42;0
75	Farghāna	102;0	42;20
76	Khutan	102;20	42;0
77	Badakhshān	84;34	37;10
78	Kashghar	106;30	44;0
[VI] *mabdā'az iqlīm shashum ᶜarḍ 43;30*) (beginning of the sixth climate, latitude 43;30°)			
79	Harqala	67;20	46;30
80	?	?	?

In the last annulus, around the central hole there is some writing, which is partly rubbed off by the alidade and cannot be deciphered.



Figure A121.5 – Qibla map on the mater (photo by S. R. Sarma)

QIBLA MAP

On the right hand side of the mater is engraved a unique map showing the directions of several Indian towns towards Mecca. On this map, David King remarks as follows:

> A grid based on an orthogonal projection would have the parallels of latitude projected as family of parallel lines (whose distance from the equator varies with the sin φ) and the meridians as a family of ellipses (cutting the equator at a radial distance varying with Sin ΔL, where ΔL is the longitude difference from the central meridian). Although I am not aware of any text that proposes such a grid either for a world-map or any kind of map for finding qibla, the method is graphically demonstrated on an instrument, namely an astrolabe dated 1077 J [= 1666/7] by Jamāl al-Dīn ibn Muḥammad Muqīm of Lahore … Longitude differences from the central meridian and latitudes in the northern hemisphere are represented by their sines on the horizontal and vertical axes, and there is an annulus of grid markings around the map but none on the map itself. Mecca is neither at the centre nor on the central meridian, and the qiblas of various localities that are represented by

rectilinear segments joining them to Mecca are based on another approximation, namely $q = \tan^{-1} \{[\sin L – \sin L_M] / [\sin \varphi – \sin \varphi_M]\}$.[528]

Along the vertical diameter of the mater which divides the two halves is drawn a scale; it is labelled in 6s, from the centre up to the periphery on both directions from 6 to 90. Along the rim of the mater, there is a circular scale which is divided in groups of 6° and labelled from the south point onwards from 6 to 90 and once again from 6 to 90. On this grid, several localities are marked with dots enclosed in circles. Lines are drawn from these circles up to the position of Mecca, with labels stating *khaṭṭ samt qibla* … (line of the azimuth of *qibla* from X). The holy city of Mecca is not at the centre of the map, but towards the right. Its position is marked by a large double circle with the label *Makka Muᶜaẓẓam.* We list below the localities and the labels, starting from the left.

Table A121-4 Qibla Map

	Place Name with the Label	Vertical Scale	Circular Scale
1	*khaṭṭ samt qibla Bījāpūr*	30	30
2	*samt qibla Akbarābād*	30	30
3	*samt qibla [Shāh]jahānābād*	28	30
4	*samt qibla Dawlatābād*	24	21
5	*samt qibla Lāhūr*	24	20

528 King 1999b, p. 95; see also Christie's Catalogue, p. 95: David King … writes '[the right] half of the mater is engraved with what is essentially a map. Some 17 localities are marked by means of small circles in the appropriate positions with respect to Mecca. The horizontal diameter of the mater is taken as the equator, and the longitudes from 0° to 180° are measured along this diameter from left to right. The city of Mecca, the physical focus of Muslim worship, is clearly marked and lines are drawn representing the *qiblas* of various localities. For the region of the maker, the towns of Lahore, Akbarābād, Jihānābād and Kabul are represented. Such cartographic procedures for finding the *qibla* were already advocated in the ninth century, but diagrams are rare. Indeed, two are known from manuscript sources, and instruments engraved with such diagrams are also uncommon.' See also King 1992a; King & Lorch 1992.

	Place Name with the Label	Vertical Scale	Circular Scale
6	(No label)	18	18
7	*khaṭṭ Banāras*	18	16
8	*samt qibla Kābul*	18	15
9	*khaṭṭ samt qibla Burhānpūr*	18	14
10	*samt qibla Mashhad*	6	3
	khatt nahār meridian ?		
11	*khaṭṭ Iṣfahān*	12	87
12	*khaṭṭ Bazal* ?	12	84
13	*Makka Muʿaẓẓam*	18	78
14	*samt qibla Madīna Ṣabab*?	18	46
15	*samt qibla Bayt al-Maqdis*	24	36
16	*samt qibla Jazīra Jānz*	44	48
17	*Jazīra* *** (no point)		

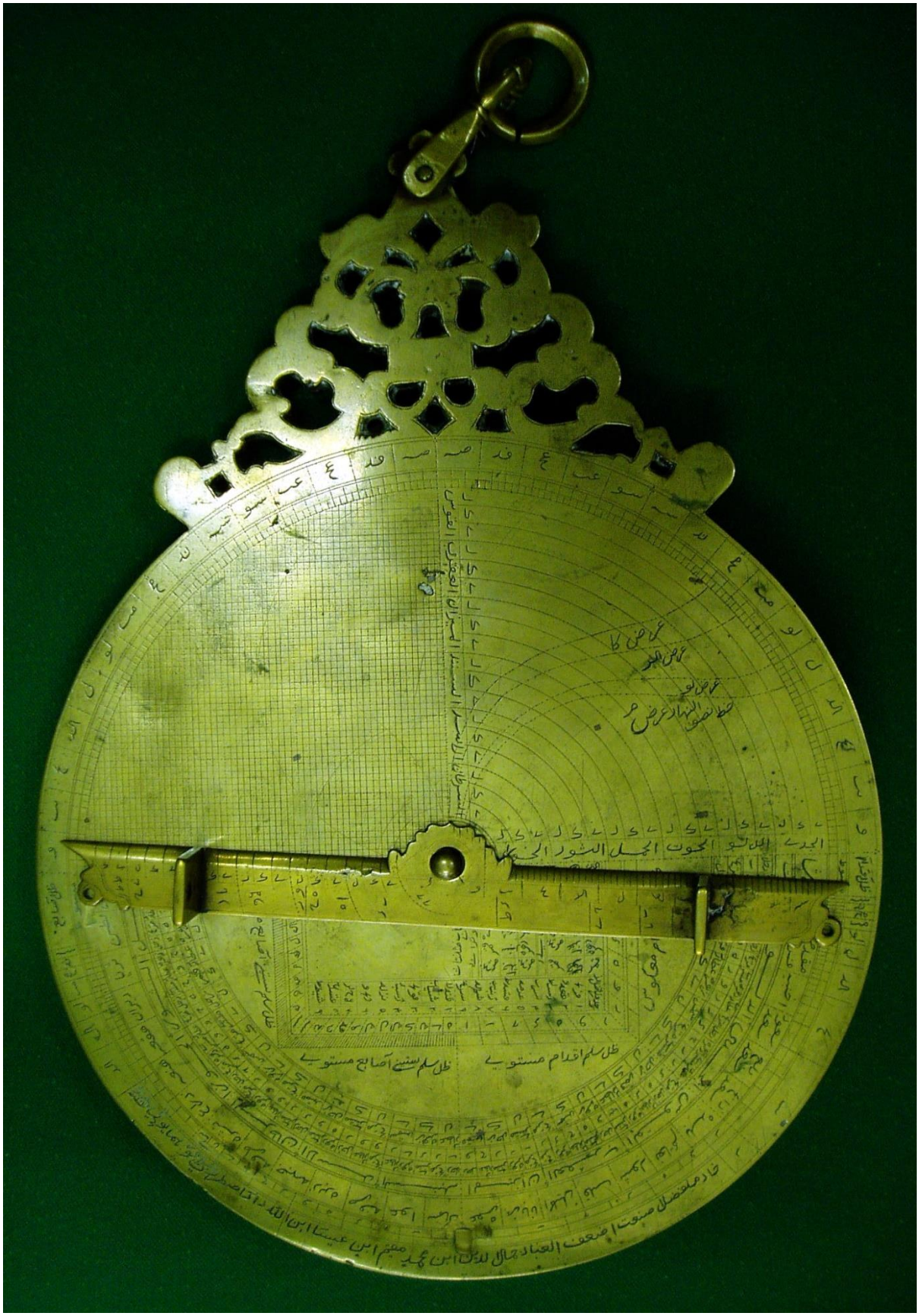


Figure A121.6 – Back of the Astrolabe (photo by S. R. Sarma)

BACK

The altitude scales on the upper half of the rim are graduated in 1°, 2° and 6° and numbered in 6s as 6---90; 90---6. In the upper left is the trigonometric quadrant with 60 horizontal and 60 vertical parallels of which every sixth line is highlighted with dots. Semi-circles are drawn on the vertical and horizontal radii and quarter circles at 8, 10½, 12, 24 units.

In the upper right is the solar quadrant with declination arcs at intervals of 10° of solar longitude. The names of the corresponding signs and their divisions of 10°, 20°, 30° are written along the two radii. On this quadrant are plotted four curves of the meridian altitude of the sun at latitudes 21°, 27°, 36°, 40°; the last curve is accompanied by the full label *khaṭṭ niṣf al-nahār bi-ᶜarḍ 40.* Under the other curves are written just the latitude values.

In the lower half are the double shadow squares, on the left for a gnomon of 12 digits and on the right for a gnomon of 6 feet. The vertical and horizontal scales on the left are divided into 12 parts and each part into 5 units. These are numbered in 5s from 5 to 60. The vertical scale bears the label *ẓill sullam sittaynī āṣābiᶜ maᶜkūs* and the horizontal scale *ẓill sullam sittaynī āṣābiᶜ mustawī.* The horizontal and vertical scales on the right are divided in 7 parts and numbered from 1 to 7; they bear the labels *ẓill sullam aqdām mustawī* and *ẓill sullam aqdām maᶜkūs* respectively.

Inside the shadow squares are the tables of excess of revolution (*faḍl al-dawr*) and of triplicities.

The lower half is framed by cotangent scales and their subdivisions which are engraved on the rim; the one on the left carries the label *ẓill āṣābiᶜ* and that on the right *ẓill aqdām.*

Inside the cotangent scales, there are 6 semi-circular rows. The first two are engraved with the names of the 28 lunar mansions and the 12 zodiac signs; the next two rows contain the table of limits (*al-ḥudūd*) and the last two the table of faces (*al-wujūh*).



Figure A121.7

ALIDADE ETC

The alidade has ornate ends and an ornate centre-piece. The right half carries a sexagesimal scale numbered in 6s from 6 to 60. The left half is engraved with declination arcs and marked with the serial numbers of the signs and their subdivisions of 10°, 20° and 30°. The lower register on the right bears markings of unequal hours when the alidade is used as a sundial with the sighting plate on the right as the gnomon.

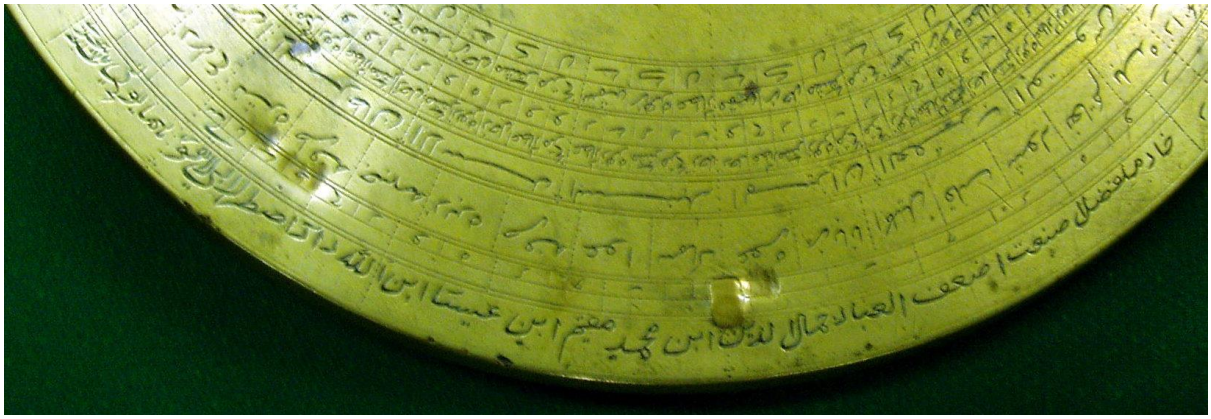


Figure A121.8

INSCRIPTION

The maker's name is engraved on the lower rim in the middle of the cotangent scales and reads as follows:

> *khādim al-fuḍalā' ṣanaᶜt aḍaᶜf al-ᶜibād jamāl al-dīn ibn muḥammad muqīm ibn ᶜīsā ibn allāhdād aṣṭurlābī lāhūrī humāyūnī sanah 1077 hijrī.*
>
> 'The servant of the eminent, the weakest of the servants [of God], Jamāl al-Dīn, son of Muḥammad Muqīm, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, made [this astrolabe in] the year 1077 Hijrī (= AD 1666-67).'

PROVENANCE

Formerly in the collection of David H. H. Felix, Philadelphia.

BIBLIOGRAPHY

Christie's, New York, Catalogue 31.10.1985, lot 331, pp. 94-95.

King 1992a, I, pp. pp.167-171.

King 1999b, pp. 95-96, 145.

King 2005, pp. 808-809.

A122⊙ ASTROLABE BY JAMĀL AL-DĪN, 1092 AH (AD 1681-82)

Diameter 166 mm

London, Victoria & Albert Museum (30-1882 (I.S)[529]

CCA 81; Répertoire 2

In this astrolabe, the alidade is mounted on the front and all the components are joined with a nut and bolt and welded. Consequently, the bolt cannot be unscrewed to open the astrolabe and to examine the plates and the gazetteer.

A geographical gazetteer is engraved on the edge of the astrolabe. At the apex of the *kursī* are engraved the arguments, *al-bilād, al-ṭūl* and *al-arḍ* on both sides, followed by the names of towns, their longitudes and latitudes. Much of this gazetteer is difficult to decipher. Therefore it has not been copied.

COMPONENTS

Body with *kursī* (d. 166, h. 225, t. 7), shackle and ring, rete for 45 stars, ? plates, alidade; the pin and horse are missing.

FRONT

The *kursī* has a very wide base. Its contours are formed by ogees and lobes; the finial is not trifoliate, but with five lobes. The *kursī* is pierced symmetrically, producing in the middle a crude cartouche on which is engraved *Allāhu Akbar* on the front. On the surface in the front decorative lines are drawn parallel to the pierced holes.

The limb is graduated in 1°, 2° and 6° and labelled in 6s from 6° to 90°, separately for each quadrant.

RETE

The rete is very dark and coppery. The equinoctial bar has counter changes at its two intersections with the ecliptic. The solstitial bar is complete, but blended with the tracery that joins the various star pointers. The ecliptic band is rather broad; it is divided into the 12 signs of the zodiac and labelled with their names. Each sign is further subdivided into 6° each which are numbered in *Abjad* symbols from 6 to 30, separately

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[529] Victoria and Albert Museum wrote to me to say that they do not permit publication of private photography of their objects. Therefore, this entry is regretfully without my photos.

for each sign. The sloping edge of the zodiac ring is divided into 3°. The star pointers and the tracery that joins them are indifferently designed with hardly any trace of elegant designs made by the astrolabe maker's father Muqīm or the cousin Ḍiyā' al-Dīn. The tracery looks more like the traceries of his brother Ḥāmid.

There are said to be 45 star pointers, some of which are blocked by the alidade. The following 39 could be deciphered.

Table A122-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus J[anūbī]*	β Ceti
2	*Rijl al-Musalsala*	γ Andromedae
3	*Fam al-Qayṭus*	γ Ceti
4	*Ṣadr al-Qayṭus*	π Ceti
5	*Ghūl*	β Persei
6	*Kaff al-Jadhmā'*	α Ceti
7	*Mirfaq al-Thurayyā*	α Persei
8	*Tālī Masāfat al-Nahr*	γ Eridani
9	*ᶜAyn al-Thawr*	α Tauri
10	*ᶜAyyūq*	α Aurigae
11	*Yad al-Jawzā' al-Yumnā* ?	α Orionis
12	*Rijl al-Jawzā' al-Yumnā*	κ Orionis
13	*Shiᶜrā Yamānī*	α Canis Majoris
14	*Shiᶜrā Shāmī*	α Canis Minoris
15	*Ṭaraf Safīna*	ρ Puppis
16	*Mankhar al-Shujāᶜ*	σ Hydrae
17	*Qalb al-Asad*	α Leonis
18	*Qāᶜidat al-Bāṭiya*	α Crateris

	Star Name	Identification
19	*Ṣarfa*	β Leonis
20	*ᶜAnāq*	ζ Ursae Majoris
21	*Janāḥ al-Ghurāb*	γ Corvi
22	*Simāk Aᶜzal*	α Virginis
23	*Simāk Rāmiḥ*	α Bootis
24	*Nayyir Fakkah*	α Coronae Borealis
25	*ᶜUnuq al-Ḥayyah*	α Serpentis
26	*Rukbat al-Ḥawwā* ?	ζ Ophiuchi
27	*Rās al-Jāthī*	α Herculis
28	*Rās al-Ḥawwā*	α Ophiuchi
29	*Yad Yumnā al-Muqaddam*	δ Ophiuchi
30	*Nasr Wāqiᶜ*	α Lyrae
31	*Minqār al-Dajājah*	β Cygni
32	*Nasr Ṭā'ir*	α Aquilae
33	*Dhanab al-Dulfīn*	ε Delphini
34	*Dhanab al-Dajājah*	α Cygni
35	*Fam al-Faras*	ε Pegasi
36	*Dhanab al-Jadī*	δ Capricorni
37	*Sāq Sākib al-Mā' Janūbī*	δ Aquarii
38	*Dhanab al-Qayṭus Sh[amālī]*	ι Ceti
39	*Mankib al-Faras*	β Pegasi

PLATES

Since the astrolabe cannot be taken apart, the number and other details of the plates cannot be ascertained. Through the interstices of the rete can be seen the topmost plate on which the latitude is engraved as 27° and the duration of the longest day is given as 13 hours; almucantars are drawn for every 3° and azimuths for every 10° below the horizon.

GEOGRAPHICAL GAZETTEER

It is not known whether a gazetteer was engraved on the inner side of the mater. There is one on the edge of the mater, but it is largely undecipherable.

BACK

The rim of the upper half is divided, as in the front, into 1°, 2°, and 6° and labelled as 6—90.90—6. The upper left quadrant is filled with 60 horizontal and 60 vertical parallels; attempt was made to emphasis ever fifth line with dots, but this has not been carried out uniformly. Semi-circles are engraved on both the radii and 3 quarter circles around the centre at 24 units (the arc of the obliquity of the ecliptic), 12 units (?) and 8 units (?). There is a line joining the centre to 45° on the arc and another line joining the inner terminals of the arc.

The upper right quadrant is divided by 18 concentric declination arcs, one for each decan. Every third curve, being the boundary between two signs, is dotted. The names of the related signs and the numerical values of the decans are inscribed along the two radii. Upon these declination arcs are superimposed four curves of solar meridian altitude for the following four latitudes: *ʿarḍ 27; 29; ʿarḍ 32,* and *khaṭṭ niṣf al-nahār ʿarḍ 36*. The first three are the latitudes Agra, Delhi and Lahore respectively. The fourth latitude of 36° represents the middle of the fourth of the seven climates of antiquity and thus the middle of the inhabited world.

In the lower half are drawn two shadows squares, on the left for a base of 6 and 12 and on the right for 7, with the usual division of the respective scales and with the usual labels. Inside the shadow squares is engraved the astrolabe maker's signature which is reproduced below.

The broad rim on the lower half carries the cotangent scales in three concentric bands. The outer band is divided in unequal divisions. Those on the left are numbered,

starting from the vertical diameter, as 6, 12, 18, 24, 30, 36, 42, 48, 54, 60, followed by the words *ẓill aṣābic mustawī*; those on the right are numbered 6, 4 (?), 12, 18, 24, 30, 36, 42, 48, 54, 60 followed by the words *ẓill aqdām mustawī*. In the middle band the units of the outer band are divided into 6 parts each and the first 12 divisions are numbered on both the sides. In the inner band, some of the units on the middle band are halved but not all.

In the space between the cotangent scales on the rim and the shadow squares are drawn six semi-circular rows. Starting from the outside, these contain the names of the 28 lunar mansions, the names of the 12 signs of the zodiac, the table of limits and the table of faces.

Alidade

The alidade is graduated with the declination arcs and the names of pairs of signs on the right hand side and with a sexagesimal scale and a scale of unequal hours on the left. There are three holes of different magnitudes in the two sights.

Inscription

Engraved inside the shadow square:

khādim al-fuḍalā' aḍᶜaf al-ᶜibād jamāl al-dīn
ibn muḥammad muqīm ibn ᶜīsā ibn allāhdād asṭurlābī
humāyūnī lāhūrī sanah 1092 hijrī.

'The servant of the eminent, the weakest of the servants [of God], Jamāl al-Dīn, son of Muḥammad Muqīm, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, [made] [in] the year 1092 Hijrī (= AD 1681-82).'

Bibliography

Gunther 1932, no. 81, p. 213 (just a short entry of 6 lines).

A123 ASTROLABE BY JAMĀL AL-DĪN, 1094 AH (AD 1682-83)[530]

Diameter 160 mm

Kuwait, PC; ex-collection Alain Brieux

Répertoire 3

Not much information is available on this and the next astrolabe except the short entries in the Répertoire. It is said that in the rete of these two astrolabes there are *zawraqī* arcs designed for a southern astrolabe. On one of the plates of this astrolabe, names of 21 stars are engraved. Unless images of the rete and the plate with the 21 stars are available, it is difficult to visualize how they would have functioned.

RETE

The zodiac ring carries the names of the 12 signs; 42 star pointers; 'line of horizon for a southern astrolabe in contradistinction to A121 where the horizon is northern.'

PLATES

Five plates, including one on which the names of 21 stars are engraved.

BACK

Altitude scales on the upper half of the rim divided in 2°; trigonometric quadrant in the upper left; in the upper right declination arcs and curves for the meridian altitude of the sun at latitudes 32° and 34°. Lower half: shadow squares with a table of triplicities, other astrological tables; cotangent scales on the rim.

INSCRIPTIONS

There are two inscriptions. The first provides the name of the astrolabe maker. The second inscription which is rather long, speaks of the endowment in AH 1094 (AD 1682-83) of a *waqf* and refers to a patron ᶜAbd al-Ghafūr ibn Zayn al-Dīn, the astronomer al-Lārī. It is not known where exactly these inscriptions, especially the very long second inscription, are engraved. The first inscription is reproduced below; the second may be seen in the Répertoire

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530 Entry based on Répertoire 3.

khādim al-fuḍalā’ ṣanaᶜt aḍaᶜf al-ᶜibād jamāl al-dīn ibn muḥammad muqīm ibn ᶜīsā ibn allāhdād aṣṭurlābī lāhūrī humāyūnī.

‘The servant of the eminent, the weakest of the servants [of God], Jamāl al-Dīn, son of Muḥammad Muqīm, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the emperor] Humāyūn, made [this astrolabe].’

A124 ASTROLABE BY JAMĀL AL-DĪN, 1103 AH (AD 1691-92)[531]

Diameter 254 mm

Istanbul, Türk ve Islam Eserlieri Müzesi (T 3478)

Répertoire 4

RETE

The zodiac ring carries the names of the 12 signs; 56 named star-pointers; line of the southern horizon.

PLATES

Seven plates including two which are blank.

GEOGRAPHICAL GAZETTEER

With place names, longitudes and latitudes.

BACK

Altitude scales divided in 2°. Upper left quadrant with graphs of sines, cosines and versed sines; upper right quadrant with curves of the midday altitude of the sun for ?.

Lower half: shadow squares with the table of triplicities, other astrological tables and cotangent scales on the rim.

INSCRIPTION

> 'The accomplishment of this astrolabe, which was commanded by the model of the trustees and the example of nobility,
> the pupil of the eye of the authority, and the eye of the man of happiness, Sharaf al-Dīn Ḥasan ibn
> Marjūsh al-Ḥusaynī, by the hand of the servant of eminent men, Mullā Jamāl al-Dīn ibn Muḥmammad Muqīm ibn
> ᶜĪsā ibn Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, has taken place in the year one hundred-and-three after one thousand.'

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[531] Entry based on Répertoire 4.

A125 UNIVERSAL ASTROLABE ATTRIBUTABLE TO JAMĀL AL-DĪN[532]

Not dated, 17th century

Diameter 187 mm

Qatar, Doha, Museum of Islamic Art (# MW.352.2007)



Figure A125.1 – Front of the astrolabe (© Christie's, London)

This is a rare *shakkāziyya* type of universal astrolabe designed originally by ᶜAlī ibn Khalaf al-Ṣaydalanī in the elenventh century in Andalusia.[533] The best specimen which follows this design was constructed by Ibn al-Sarrāj in Aleppo in 729 AH (1328-29 AD). It is now preserved in the Benaki Museum at Athens. David King published a description of this specimen.[534] He declares that '[t]his is without doubt the most sophisticated astronomical instrument surviving from the Middle Ages and probably the most sophisticated ever made between Antiquity and 1600.' He goes on to say that this instrument can be universally in five different ways.[535]

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532 Entry based on King 2005, pp. 821-829: 'A universal Astrolabe attributable to Jamāl al-Dīn, a craftsman of 17th-century Lahore'.

533 Cf. Calvo & Puig 2006.

534 King 2005, pp. 694-700.

535 King 2005, p. 694.

The present astrolabe closely resembles ibn al-Sirrāj's specimen. At some stage the two principal parts of the present astrolabe got separated. The rete came up for auction at Christie's on 4 October 1995 and the mater on 5 April 2001. David King, who wrote the descriptions of these two parts for the Christie's catalogue, realized, when he saw the mater, that these two parts belonged together. Fortuitously the two parts were acquired and put together by the Ahuan Gallery, London.

There is no signature or date on this astrolabe. On calligraphic and stylistic grounds, King attributes it to the Lahore family and, in particular, to Jamāl al-Dīn. He goes on to say that 'Jamāl al-Dīn is known by two astrolabes, of which one, dated 1077 H (=1666/7), is the only known Islamic astrolabe bearing a world-map engraved in the mater. The association with Jamāl al-Dīn is strengthened by the fact that on the new rete the star-name *fakkah* is incorrectly written as *falakka,* a mistake also found on the rete of the above-mentioned 1666 instrument.'[536]

But there are some problems with this attribution. The Lahore astrolabes invariably have the trigonometric quadrant in the upper left on the back and the solar quadrant in the upper right. In this astrolabe, this arrangement is reversed. About the trigonometric quadrant, King observes as follows: 'In the upper right, the scale has been labelled the wrong way round, but the maker has added the correct labelling in a smaller script. Such corrections of engraving are extremely rare on Islamic instruments, as are, also, however, mistakes in engraving.'[537] I do not think that numbering in both directions is by mistake, but a deliberate attempt to imitate the practice on the sine quadrants. Such numbering in both directions occurs also in Ḍiyā'al-Dīn's astrolabe of 1656 (A071). However, the numbering on the limb in front where the tops of the letters are towards the centre, is unusual for Lahore astrolabes. Other differences are that in Lahore astrolabes, the finial of the *kursī* is usually trifoliate and the shackle also has a trifoliate shape. These two features are absent in the present astrolabe.

Nevertheless, until evidence to the contrary turns up, we shall follow King's attribution of this astrolabe to Jamāl al-Dīn. King adds that, although this astrolabe

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536 King 2005, pp. pp. 821-829, esp. 829.

537 King 2005, p. 824.

closely resembles the Athens astrolabe of Ibn al-Sirrāj, the rete is not an exact copy, because it contains a quatrefoil and a double zodiac scale on the horizontal diameter, features which are absent in the Athens specimen. Therefore, postulates King, '[i]t is reasonable to suppose that this newly-identified rete was copied from one by Ibn al-Sarrāj, otherwise unknown to us, which also featured a quatrefoil.'[538]

COMPONENTS

Mater with throne (d. 187, t. 5), shackle and ring and rete (d. 168). Alidade, rule, pin and horse appear to have been added later.

FRONT

The *kursī* is solid and plain with lobed profiles; the finial is not trifoliate. The shackle does not have the trifoliate shape either. The bases of the shackle are shaped like flowers. A ring with a square cross-section passes through the shackle. On the front of the *kursī* is engraved *Jamshed,* apparently a late addition by an owner.

The limb is divided in 1° and 6° and numbered clockwise in 6s from 6 to 360. The numbers are engraved upside down, i.e., with their tops towards the centre.

On the inner side of the mater is engraved with *shakkāziyya* universal projection and the markings are inlaid with silver. Meridians are drawn for each 6° and marked on the horizontal diameter (6 to 180 from the left to the right, and again 180 to 360 from the right to the left). Declination circles also are drawn for every 6° and the arguments are marked on the vertical diameter (6 to 90) from the centre both up and down.

RETE

The rete has the *shakkāziyya* markings in the upper half and astrolabe markings in the lower half. In the upper half, meridians and declination circles for each 6° are cut very carefully and accurately and the arguments are engraved on the horizontal diameter and on the circumference. Signs of the ecliptic are also engraved on the horizontal bar in two rows, starting from the centre and proceeding left up to the periphery, then from there up to the right periphery, and from there up to the centre.

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538 King 2005, p. 829.

The lower half displays an arc of the ecliptic and star pointers. On the arc of the ecliptic, the southern signs are superimposed on the northern signs, starting with Aries and Libra at the left. The signs are divided in 6° and labelled.

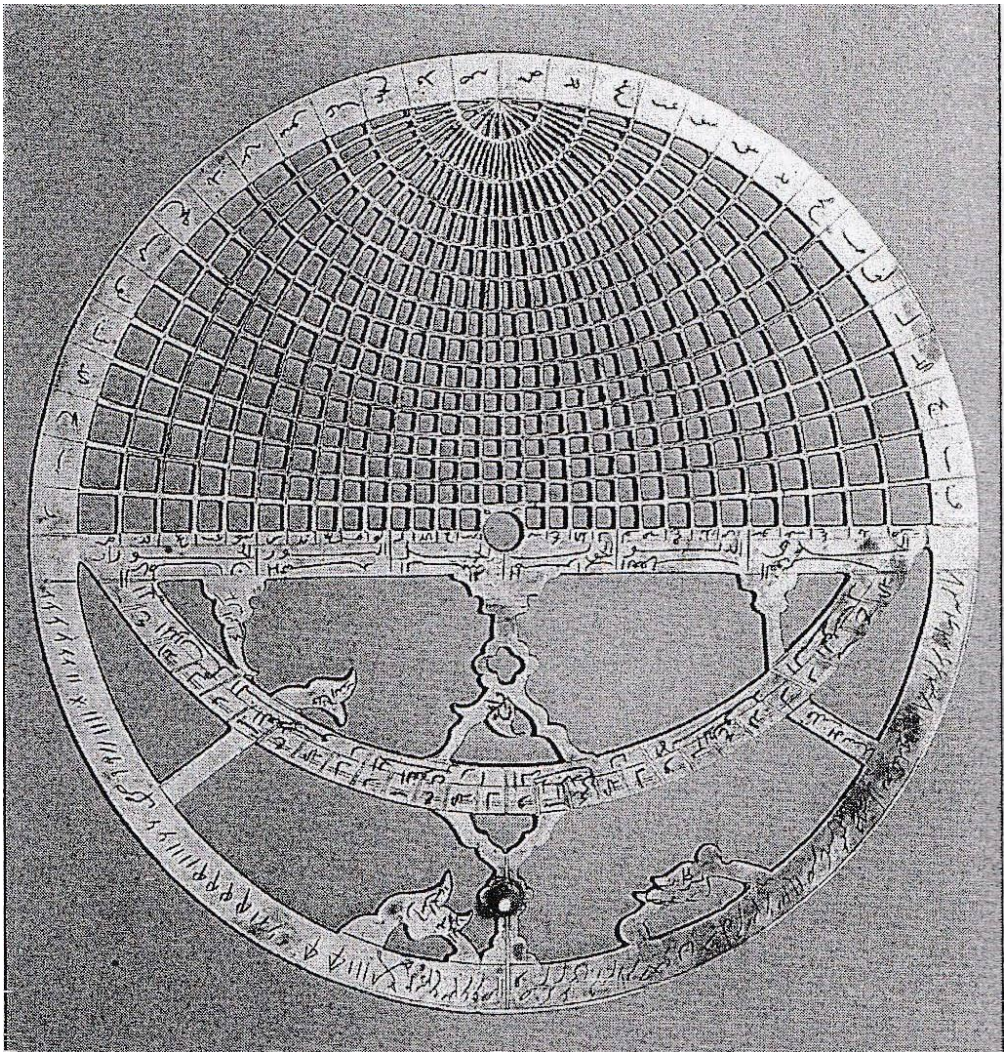


Figure A125.2 – The rete (photo from Sotheby's catalogue of 4 October 1995)

The star pointers serve the following 11 stars (04 and 11 are not named):

Table A125-1 Stars on the Rete

	Star Name	Identification
1	*Simāk al-Rāmiḥ*	α Bootis
2	*Al-Ghūl*	β Persei
3	[*Fakkah*] written *Falakka*	α Coronae Borealis
4	[*al-ᶜAyyūq*]	α Aurigae

	Star Name	Identification
5	*Rās al-Ḥawwā*	α Ophiuchi
6	*Yad al-Jawjā'*	α Orionis
7	*Wāqi*^{c}	α Lyrae
8	*Ghumasyā'*	α Canis Minoris
9	*Nasr al-Ṭā'ir*	α Aquilae
10	*Qalb al-Asad*	α Leonis
11	[*Fam al-Hūt* (?)]	α Piscis Austrini

King notes that '[t]he positions of all but the last star-pointers are extremely accurate for *ca.* 1650. The penultimate pointer, named *Qalb al-Asad,* bears no marker for the star, but the place where its left-hand edge meets the ecliptic is indeed the position of α Leonis (Regulus) for *ca.* 1650.'[539]

The lower half of the circular frame bore originally no markings. This space has been filled by a latter hand with some irrelevant inscriptions.



Figure A125.3 – Back of the astrolabe (© Christie's, London)

[539] King 2005, p. 8

BACK

The rim on the back carries a degree scale which is divided in 1° and 6°. It is numbered in 6°, from 6 to 90, separately in each quadrant. The numbering commences at the east and west points and reaches up to the south and north points. Inside the degree scale, a universal horary quadrant is engraved on the upper left with 6 curves for seasonal hours marked 11/2, 10/3 … 7/5, 6/6. There are no declination arcs in this quadrant. It is framed by the altitude scale which is divided in 1° and 6° and numbered in 6° from 6 to 90, starting from the east point and reaching up to the south point.

A sexagesimal trigonometric quadrant is placed in the upper right, with 20 horizontal and 20 vertical parallels, one for each 3 units of the 60-unit scales. The arguments are engraved on the two radii. A semi-circle is drawn on the horizontal radius for determining the sine and cosine and a quarter circle is drawn with a radius of 24 units for determining the solar declination. The arc framing this quadrant is marked with a degree scale, which is divided in 1° and 6° and numbered in 6s in both directions as is done on solitary sine quadrants.

In the lower half are shadow squares, on the left for a base of 12 and on the right for the base of 7, but without any labels. Inside the degree scales in the lower half are added two cotangent scales; the left one carries the label *ẓill aṣābiʿ* and the scale on the right the label *ẓill aqdām.*

BIBLIOGRAPHY

Christie's, catalogue of 4 October 1995, lot 61, pp. 20-21.

Christie's, catalogue of 5 April 2001, lot 32,

http://www.christies.com/lotfinder/LotDetailsPrintable.aspx?intObjectID=2021394

[also http://goo.gl/kgQYiR, last accessed in May 2016]

King 2005, pp. 821-829: 'A universal astrolabe attributable to Jamal al-Din, a craftsman of 17th-century Lahore'.

Calvo & Puig 2006.

A126 ASTROLABE ATTRIBUTABLE TO JAMĀL AL-DĪN[540]

Not dated, 17th century

Diameter 96 mm

PLU; ex-London, Sotheby's



Figure A126.1 – Front of the astrolabe (photo from Sotheby's catalogue of 5 May 1989)

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[540] Entry based on photos and photocopies of the plates in the archives of the Museum of the History of Science, Oxford, and Sotheby's auction catalogues of 19 October 1982 and 5 May 1989.

The crown of this unsigned and undated astrolabe is somewhat unusual for a Lahore astrolabe, but on the back there are two curves for the midday altitude of the sun at latitudes 27° (Agra) and 32° (Lahore). The coordinates of the several Indian cities in the gazetteer match with the same in Jamāl al-Dīn's astrolabe of 1666 (A121); in particular, both the gazetteers refer to Delhi as Jahānābād instead of Shāhjahānābad. Therefore, this too may have been made by Jamāl al-Dīn.

COMPONENTS

Body with *kursī* (d. 96), shackle, ring, long cord, rete, 7 plates, alidade. Pin and wedge are missing. The ensemble is held together by a long bolt and winged nut.

FRONT

The shackle with rectangular sides and the very low *kursī* with irregular lobes and four circular perforations are most unusual. The surface of the *kursī* is adorned with floral decorations in low relief on both sides.

The limb is divided in 1° and 6° and numbered clockwise from 6 to 90, in each quadrant separately.

RETE

The peripheral Capricorn ring and the eccentric ecliptic ring are held together by the equinoctial bar which has counter changes at the two equinoxes. The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names; each sign is divided into units of 6° and numbered from 6 to 30. There is a handle on the Capricorn ring about 30° south of the west point. The Capricorn index is well defined. The ca. 29 star pointers are joined by an asymmetric tracery.

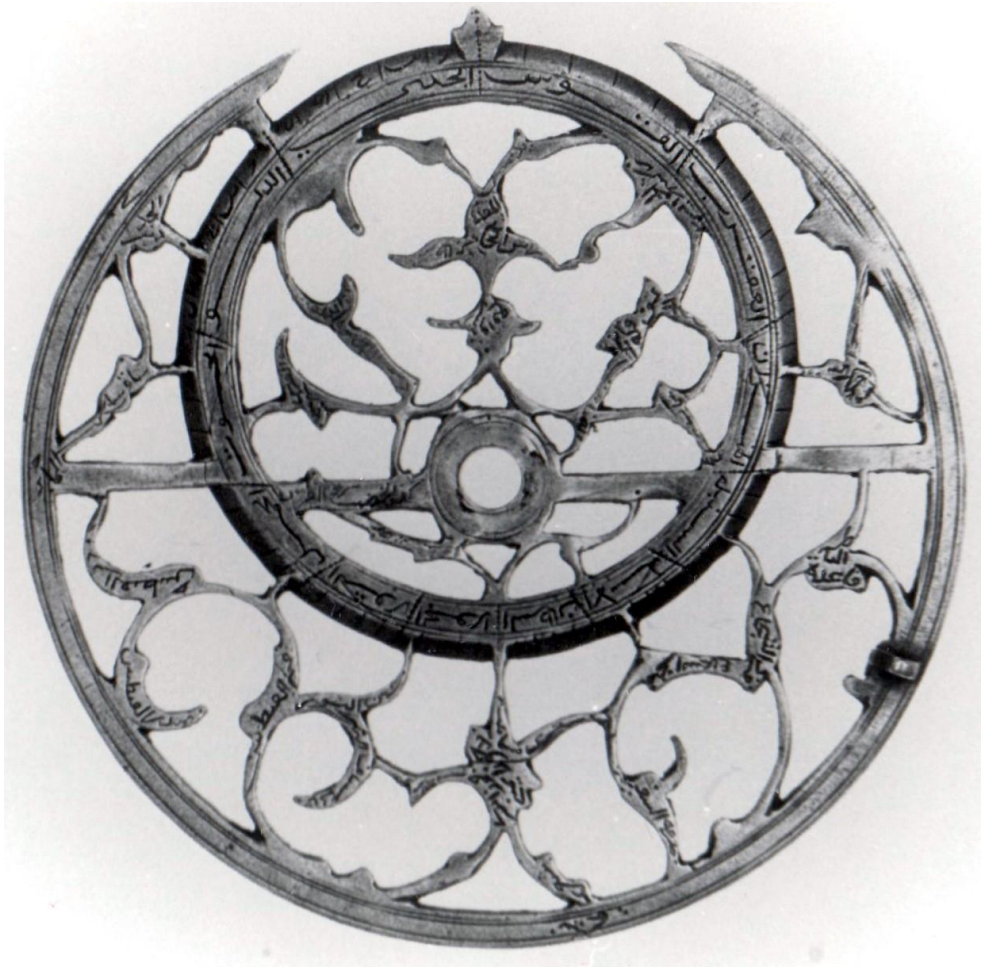


Figure A126.2 – Rete of the astrolabe (photo courtesy Museum of the History of Science, Oxford)

PLATES

There are seven plates. The first four are original and the remaining three with the arguments engraved in large and bold letters belong to some unidentified Persian astrolabe.

Table A126-1 Plates

	φ	Longest Day
1a	22°	12;21 hours
1b	Double projections for 0° + 90°	
2a	25°	13;34 hours
2b	27°	13;58 hours
3a	36°	14;32 hours
3b	40°	14;52 hours

	φ	Longest Day
4a	Plate of ecliptic coordinates with the label *ṣafīḥat mīzān al-ᶜankabūt.*	
4b	Plate of horizons *ṣafīḥa āfāqī.*	
5a	30°	13;17 hours
5b	36°	14;18 hours
6a	32°	14;7 hours
6a	Plate of horizons	
7a	?	?
7b	astrological houses at latitude ?	

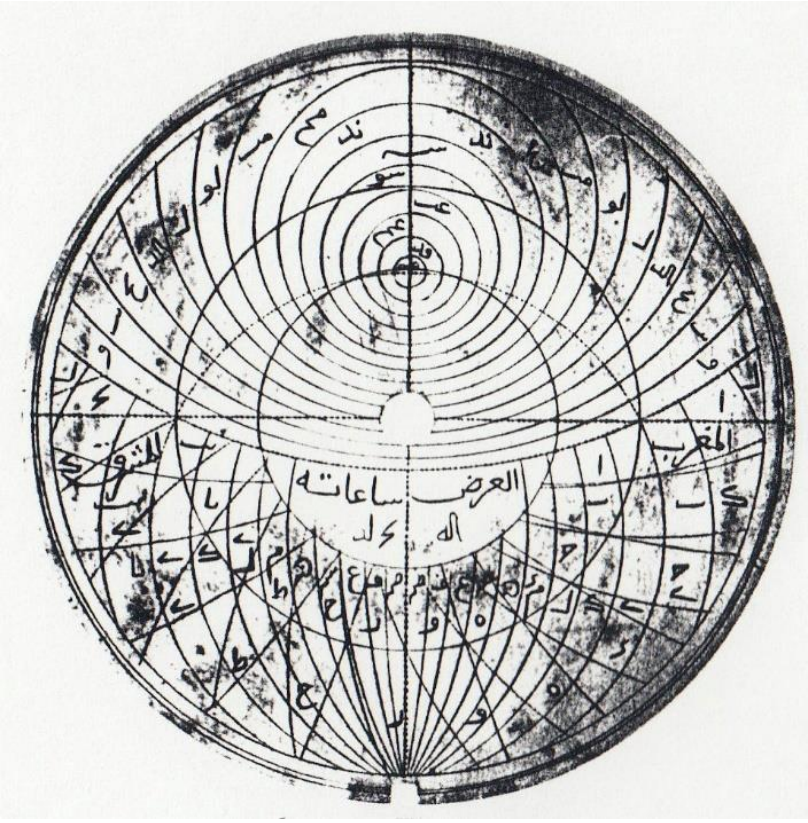


Figure A126.3 – Plate 2a for the latitude 25°
(photo courtesy Museum of the History of Science, Oxford)

On plates 2 and 3, altitude circles are drawn for every 6° and numbered on both sides of the meridian; azimuth arcs are drawn for every 10° below the horizon and numbered below the circle of Cancer. There are lines for seasonal hours and lines drawn

from the western horizon for equal hours. On plate 1a, altitude circles are drawn for 6°, but there are no azimuth arcs. There are lines for seasonal hours and the lines for equal are hours drawn from the western and eastern horizons up to the meridian.

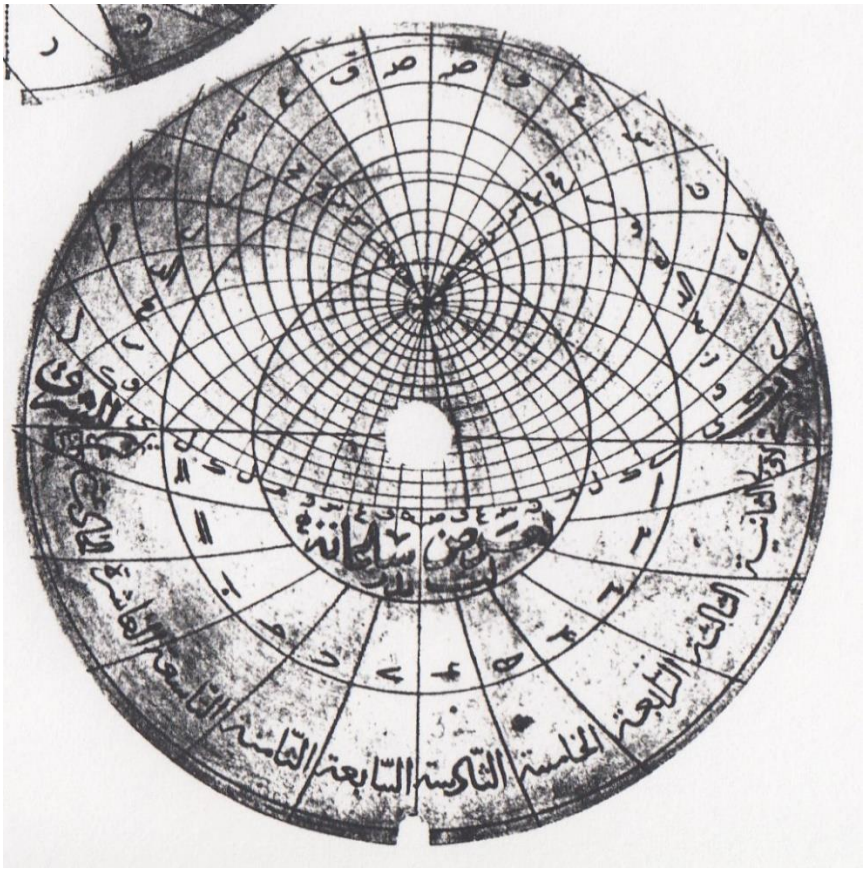


Figure A126.4 – Plate 6a for latitude 32°
(photo courtesy Museum of the History of Science, Oxford)

Plates 5, 6, 7 are quite different. On these the terms *al-ʿarḍ, sāʿāt, maghrib* and *mashriq* are engraved in very large and bold letters. On plate 5a and 5b, altitude circles are drawn for every 6° and azimuth arcs for every 10° above the horizon. On 5a, there are only lines for seasonal hours; these are numbered in *Abjad* below the equator and in common numerals above the equator. On 5b there are also lines drawn from the western horizon for equal hours.

On 6a for 32°, there are altitude circles for every 6°, azimuth arcs for every 10° above the horizon and lines only for seasonal hours as on 5a. But here the seasonal hours are labelled in ordinal numbers written in ornate letters just above the circle of Capricorn. In Lahore astrolabes, the geographical coordinates and the maximum number of daylight hours given for many localities are not always consistent. However, for Lahore, the latitude is invariably 31;50° and the maximum number of hours 14;8. But here the maximum duration engraved is 14;7 hours, indicating that this plate is not

produced in Lahore. The reverse of the plate is engraved with multiple half-horizons, with bold labels.

On plate 7a the arguments *al-ᶜarḍ* and *al-sāᶜāt* are engraved in bold letters, but the actual values are not filled. The plate appears to be made for 32° with altitude circles for every 6°, azimuth arcs above the horizon for every 10° and just lines for seasonal hours numbered in both *Abjad* and common numerals.

On plate 7b are drawn astrological houses, each divided into decans marked as 10, 20 and 30 below the circle of equator. The houses are numbered, anti-clockwise from vernal equinox in common numerals below the circle of Cancer and in ordinal numbers (*al-ṭāliᶜ* to *al-thānī ᶜashar*) above the circle of Capricorn.

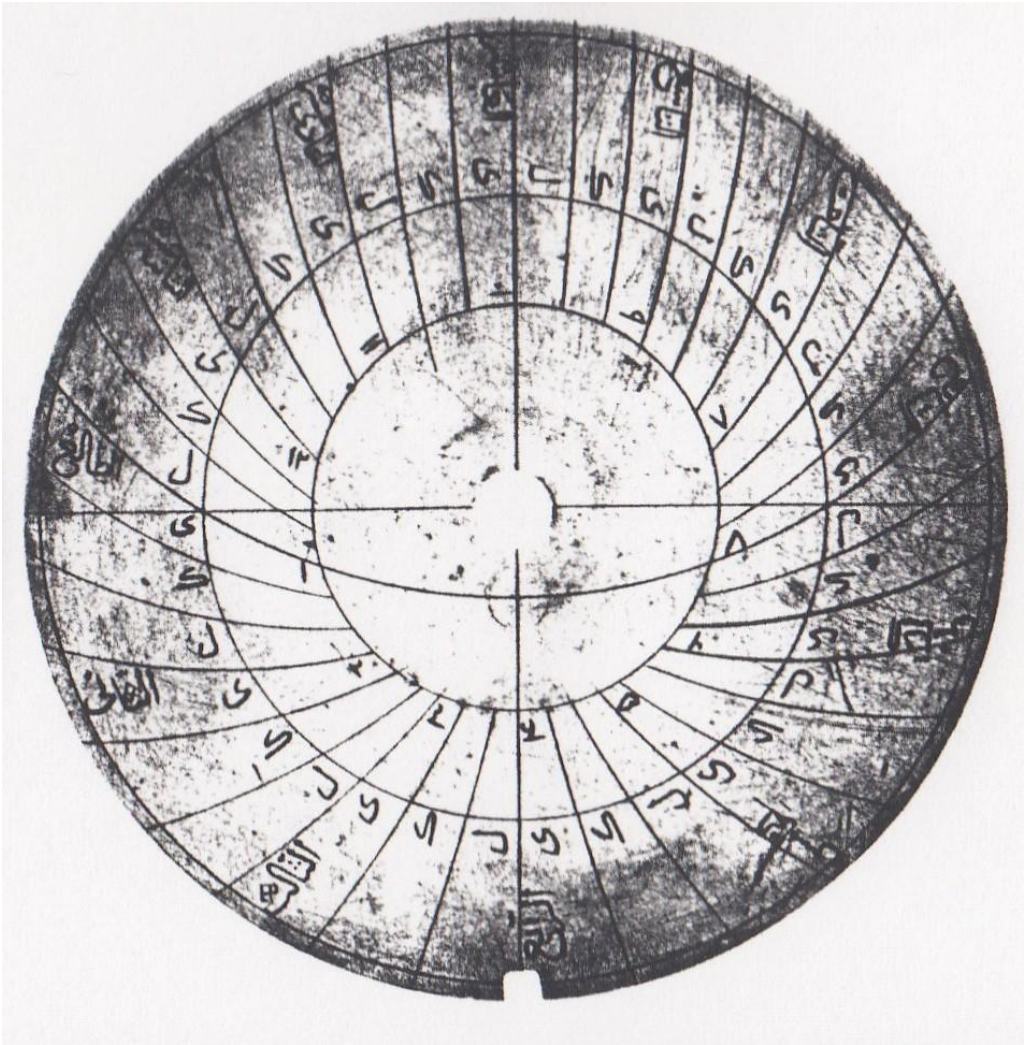


Figure A126.5 – Plate 7b with the astrological houses
(photo courtesy Museum of the History of Science, Oxford)



Figure A126.6 – Geographical gazetteer
(photo courtesy Museum of the History of Science, Oxford)

GEOGRAPHICAL GAZETTEER

The geographical gazetteer provides the names and coordinates of 54 localities in two circles.

Table A126-2 Geographical Gazetteer

	Place Name	L	φ
	Outer Circle		
1	Makka Muᶜaẓẓam	77;10	21;40

	Place Name	L	φ
2	Madīnat Musharrafa	75;20	25;0
3	Ṭāʿif	72;30	21;20
4	Bayt al-Maqdis	66;30	31;50
5	Qayrawān	41;0	31;0
6	Baghdād	82;0	33;35
7	Tabrīz	82;0	38;0
8	Fīrūzābād	87;30	28;10
9	Shīrāz	88;0	29;36
10	Qazwīn	85;0	36;45
11	Iṣfahān	86;40	32;35
12	Mashhad	92;30	36;0
13	Yazd	89;0	32;0
14	Harat	94;20	34;30
15	Balkh	101;0	36;11
16	Bukhārā	97;30	39;50
17	Samarqand	99;16	39;37
18	Kashghar	106;30	44;0
19	Khutan	107;0	92;0 ! it should read 42;0
20	Hurmūz	92;20	25;0
21	Kirmān	41;30!	30;5 it should read 91;30
22	Ghazna	104;20	33;35
23	Kābul	104;40	34;30
24	Tubbat	110;0	40;0

	Place Name	L	φ
25	Kashmīr	108;0	35;0
26	Qandahār	107;40	33;0
27	Sālkūt	109;0	33;0
28	Multān	107;25	29;40
29	Lāhūr	109;20	31;50
30	Jahānābād	113;0	29;0 for Shāhjahānābād !
31	Akbarābād	115;0	26;43
	Inner Circle		
32	Qannawj	114;50	26;20
33	Banāras	117;20	26;15
34	Burhānpūr	113;0	20;30
35	Bījāpūr	114;20	17;40
36	Ajmīr	111;0	26;0
37	Kūlkanda	114;19	28;4!
38	Sarāndīb	130;0	10;0
39	Kanbayāt	109;20	26;20
40	Aḥmadnakar	115;0	19;0
41	Aḥmadābād	108;40	23;15
42	Jadda	76;0	21;0
43	Ujjayn	110;50	23;30
44	Kawāliyar	114;0	26;39
45	Jamkūt	170;0	5;0
46	Samīr ?	105;40	32;15
47	Khabīr ?	110;0	18;48

	Place Name	L	φ
48	Dawlatābād	111;5	20;30
49	Jawnpūr	119;6	26;36
50	Awadh	118;6	27;32
51	Badāūn	114;15	27;30
52	Pānīpatah	113;20	28;12
53	Tānīsar	112;0	32;15
54	Sunām	112;25	32;30

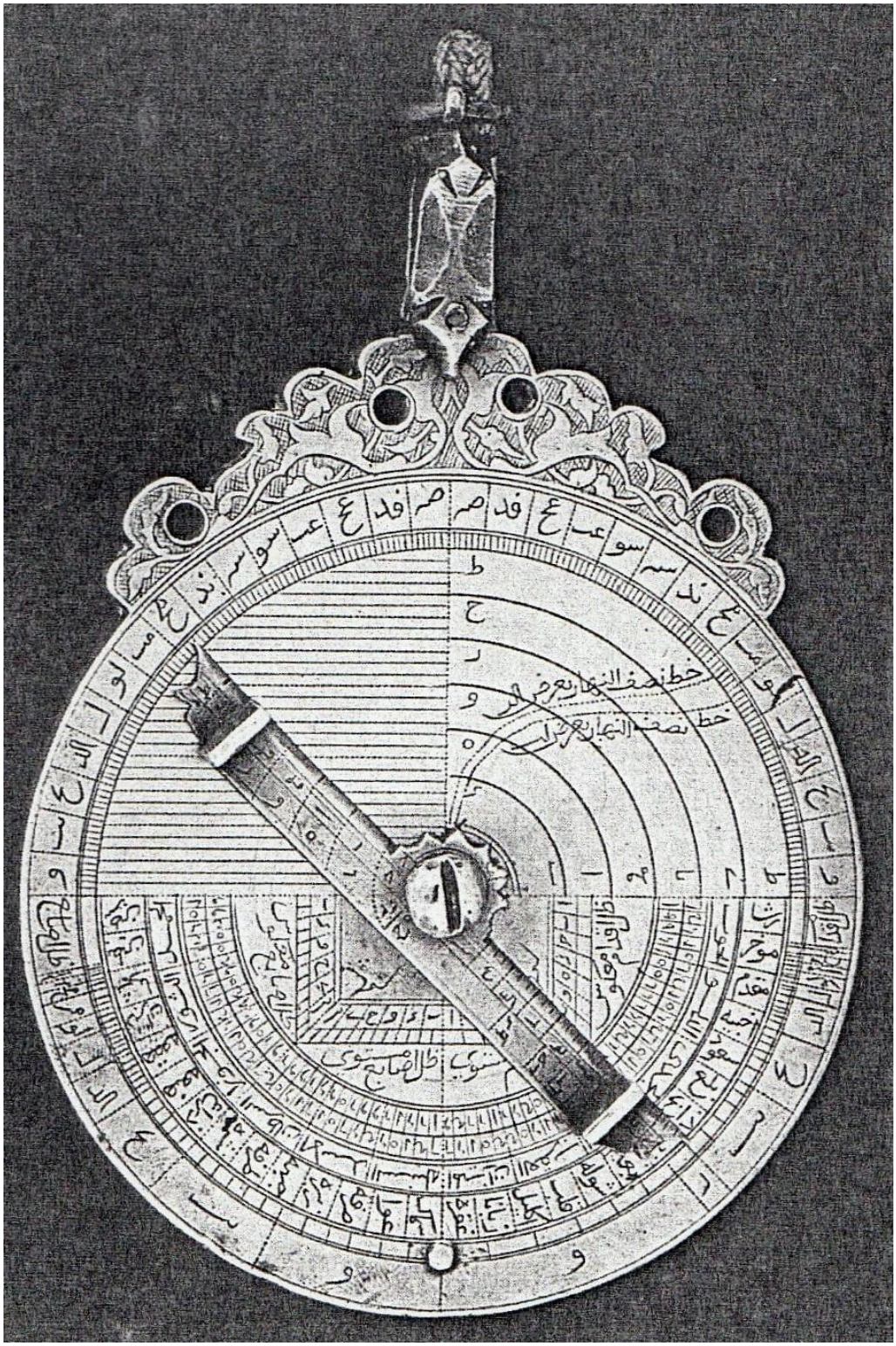


Figure A126.7 – Back of the astrolabe (photo from Sotheby's catalogue of 5 May 1989)

BACK

On the back, the rim of the upper half is engraved with altitude scales, divided in 1° and 6° and numbered as 6---90; 90---6. In the upper left is the trigonometric quadrant with 30 horizontal parallels, showing cosines for each 2 parts of the 60 parts of the

Radius. In the upper right is the solar quadrant with 6 declination arcs and two graphs for the meridian altitude of the sun at 27° and 32° with the appropriate labels.

There are shadow squares in the lower half; on the left for a base of 12 and on the right for a base of 7.

The rim of the lower half carries cotangent scales and their subdivisions. Between these and the shadow squares, there are four semi-circular rows. Here the first two rows are filled with the names of the 28 lunar mansions and those of the 12 corresponding zodiac signs. The next two rows contain the table of limits.

Alidade

The alidade carries declination scales on the left half and linear scales on the right half. In the lower register on the right, there are marks of unequal hours when the alidade is used as a sundial.

Provenance

In the archives of the Museum of the History of Science, Oxford, there are photos of the rete, gazetteer and back of this astrolabe, and photocopies of all components, with a note by Francis Maddison in his characteristic handwriting which says: 'Astrolabe | Indo-Persian | Not Signed | Not Dated. Late 17th century | Brass | Brought to MHS on 14 April 1981 by … f[o]r examination | Neg. ref. no. 81-10abc.35.S.'

The astrolabe came up for auction at Sotheby's on 19 October10.1982 (lot 50) and on 5 May 1989 (lot 213)

ASTROLABES ATTRIBUTABLE TO THE LAHORE WORKSHOP

There are a few Indo-Persian astrolabes which display certain characteristic features of the Lahore astrolabes, but are difficult to be assigned to any individual member of the Lahore family. Some of these may have been commenced by Muqīm or Ḍiyā' al-Dīn, but completed by the apprentices in the Lahore workshop.

A127⊙ ASTROLABE ATTRIBUTABLE TO THE LAHORE WORKSHOP

Not dated, 17th century

Diameter 183 mm

Hyderabad, State Museum of Archaeology (# P720)



Figure A127.1 – Front of the astrolabe (photo by S. R. Sarma)

This is a well-crafted astrolabe; the elegant *kursī* is reminiscent of Muqīm's work and the rete could have been fashioned by Ḍiyā' al-Dīn; the calligraphy and engraving

are of high quality. Curves for the solar meridian altitude at latitudes 27° and 32° are drawn on the back. But there are inconsistencies and gaps which are inexplicable. In the gazetteer, the sequence of the three elements (i.e., place name, longitude and latitude) varies in each of the three circles. In the plate of ecliptic coordinates, the latitude circles are not numbered. On the back, grids are drawn for astrological tables, but not completely filled in.

COMPONENTS

Body with *kursī* (d. 183, h. 247, t. 9), shackle, rete for 43 stars, 5 plates. Ring, alidade, horse and pin are missing; held together by a bolt and a nut.

FRONT

The shackle is not trifoliate; it is just circular and has a rectangular cross-section. The *kursī* is elegantly reticulated. The profiles are formed by the flared petals of tulips at the base; the finial is trifoliate. The limb is graduated in 1° and in 5° and numbered in 5s from 5 to 360.

RETE

The Capricorn and ecliptic rings are held together by the equinoctial bar which has counter-changes at its two intersections with the ecliptic ring. The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names. Each sign is divided in groups of 6° and numbered from 6 to 30. There is a handle near the west point. At the south point of ecliptic is the Capricorn index. The 43 star pointers are joined by an almost symmetric floral tracery.

PLATES

There are 5 plates.

Table A127-1 Plates

	φ	Longest Day
1a	20°	13;34 hours
1b	22°	13 hours !
2a	27°?	---

	φ	Longest Day
2b	32°	14;8 hours
3a	34°	14;22 hours
3b	36°	14;32 hours
4a	38°	14;44 hours
4b	40°	14;54 hours
5a	Plate of ecliptic coordinates	
5b	Plate of horizons	

On plates 1 to 4, altitude circles are drawn for every 2° and numbered; every fifth circle is dotted. Azimuth arcs are traced for every 6° below the horizon; every fifth arc is dotted and drawn both below and above the horizon. Plate 4b, however, carries no azimuth arcs. In the lower half, there are plain lines for seasonal hours and dotted lines for equal hours which are drawn from the western horizon.

Plate 5a carries the plate of ecliptic coordinates. Here latitude circles are traced for every 3°, every fifth dotted. But they are not numbered. Longitude circles are drawn for every 6°, every fifth circle which represents the beginning of a zodiac sign is dotted. The names of the signs are written along the ecliptic together with the values of the longitude circles. There is no label mentioning the name of the plate.

The plate of horizons carries four sets of half horizons for every degree of latitude from 3° to 66°, spaced at intervals of 4° in the following manner:

3 7 11 … 55 59 63
4 8 12 … 56 60 64
5 9 13 … 57 61 65
6 10 14 … 58 62 66.

The horizon arcs are numbered at both the extremities. There are declination scales along the radii between the equator and the two tropics, divided in 2° and labelled as 6, 12, 18, 23;30, the last value being the obliquity of the ecliptic. There is no label mentioning the name of the plate.

GEOGRAPHICAL GAZETTEER

The geographical gazetteer, engraved in three circles on the inner surface of the mater, provides the names, longitudes and latitudes of 109 localities. But the sequence of the three elements is not uniform in the three circles.

Outer circle: place name, longitude and latitude

Middle circle: longitude, place name and latitude

Inner circle: Place name, latitude and longitude.

Such inconsistency does not occur in any other astrolabe. In the table below, however, we follow the usual practice of place name, longitude and latitude. The lines separating the cells in the three circles create a spiral formation.

Table A127-2 Geographical Gazetteer

	Place name *(al-bilād)*	**L** *(al-ṭūl)*	**φ** *(al-ᶜarḍ)*
	Outer Circle		
1	Qayrawān	41;0	31;40
2	Mahdiyya	42;15	32;30
3	Miṣr	63;20	30;20
4	ᶜAdan	76;0	11;0
5	Madīnat Tayyiba	75;20	25;0
6	Makka Musharraf	77;10	21;40
7	Ṭā'īf	77;30	21;20
8	Bayt al-Maqdis	66;30	31;50
9	Dimashq	70;0	33;15
10	Ḥalab	72;10	35;30
11	Ardabīl	82;30	38;0
12	Quway	66;30	31;0
13	Raqah	73;55	36;0
14	ᶜĀna	76;30	34;0

	Place name *(al-bilād)*	**L** *(al-ṭūl)*	**φ** *(al-ᶜarḍ)*
15	Mawṣil	75;0	34;30
16	?	75;0	34;30
17	Mūqān	83;0	28;0
18	Bardaᶜa	83;0	40;30
19	Bāb al-Abwāb	85;0	43;0
20	Bulghār	90;0	49;30
21	Kūfa	79;30	31;30
22	Madāīn	72;0	23;10
23	Baghdād	80;0	23;25
24	Baṣra	84;0	30;0
25	Farrūkhābād	87;30	28;10
26	Shīrāz	88;0	29;36
27	Yazd	109;0	32;0
28	Abhar	84;30	36;45
29	Hamadān	83;0	35;10
30	Karaj	84;45	34;0
31	Sāwah	85;0	35;0
32	Qazwīn	80;0	36;0
33	Iṣfahān	86;40	32;35
34	Kāshān	86;0	34;0
35	Qumm	85;40	34;45
36	Rayy	86;20	35;0
37	Ṭāliqān	85;45	36;10
38	Astarābād	89;35	36;50

	Place name *(al-bilād)*	**L** *(al-ṭūl)*	**φ** *(al-ᶜarḍ)*
39	Samnān	88;0	36;0
40	Dāmghān	88;15	36.20
41	Bisṭām	89;30	36;10
42	Sabzawār	91;30	36;5
43	Nishābūr	91;30	36;21
44	Mashhad	92;30	36;0
45	Tūn	92;30	34;30
46	Qāīn	93;20	23;40
47	Harāt	94;20	34;30
	Middle Circle		
48	Marw	90;0	37;40
49	Fāriyāb	99;0	36;45
50	Balkh	101;0	36;41
51	Andarāb	103;45	36;0
52	Badakhshān	104;27	34;10
53	Hazār Asb	95;0	41;0
54	Qannawj	105;50	26;35
55	Khabrī ?	95;30	39;0
56	Samarqand	99;16	39;37
57	Khujand	89;35	44;55
58	Kāshghar	106;30	44;0
59	Khutan	105;0	42;0
60	Qarāqūrum	105;0	46;0
61	Hurmūz	92;0	25;0

	Place name *(al-bilād)*	**L** *(al-ṭūl)*	**φ** *(al-ᶜarḍ)*
62	Kirmān	91;30	30;5
63	Ghazna	104;20	23;35 ! (it should be 33;35)
64	Kābul	104;40	35;30
65	Daybul	102;30	25;10
66	Dakar ? (Mansūra al-Sind?)	105;0	27;40
67	Qandahār	105;40	23;0
68	Tubbat	110;0	40;0
69	Kashmīr	108;0	35;0
70	Pīshāwar	105;50	31;0
71	Multān	105;35	29;40
72	Siyālkūt	---	23;0
73	Lāhūr	109;20	31;50
74	Pānīpatah	113;20	28;12
75	Tānīsar	112.23	30;20
76	Sanbhal	115;0	28;28
77	Sunām	112;25	30;30
78	Dihlī	113;35	28;12
79	Akbarābād	115;0	26;43
80	Banāras	117;20	26;35
81	Kawāliyar	114;0	26;29
82	Kūl [wa] Jalālī	114;19	28;4
	Inner Circle		
83	Brūj (Bharuch)	101;5	21;20

	Place name *(al-bilād)*	**L** *(al-ṭūl)*	**φ** *(al-ᶜarḍ)*
84	Kālpī	116;45	26;36
85	Hāpanāsar (?)	118;45	32;30
86	Jawnpūr	119;6	26;36
87	Kara wa Mānikpūr	118;10	29;49
88	Badāūn	114;19	27;32
89	Sarwaj (?)	72;40	35;50
90	Ujjayn	110;50	23;30
91	Ajmīr	111;05	26;0
92	Awadh	118;6	27;32
93	Lakhnaū	114;23	26;30
94	Kūpāmāū	106;23	26;45
95	Qarmal (?)	104	12;15
96	Baran	114;0	28;48
97	Nawshahr	78;20	38;10
98	Pakand (?)	90;30	19;44
99	Mandū	101;25	22;15
100	?	103;20	20;30
101	Dawlatābād	101;0	20;30
102	Bījāpūr	105;30	16;20
103	Kulkanda	114;19	18;4
194	Sarandīb	130;0	10;0
195	Kanbāyat	109;4	21;20

BACK

The rim of the upper half carries altitude scales which are divided in 1° and 5° and numbered 5—90; 90—5. On the upper left quadrant are engraved 60 horizontal parallels. In the upper right quadrant are drawn declination arcs for each 10°. The names of the related signs and the numbers of their divisions (10, 20, 30) are written along the two radii. Two sigmoid graphs of the solar meridian altitude for latitudes 27 and 32 are superimposed on this quadrant with the labels *khaṭṭ niṣf al-nahār bi-ᶜarḍ 27* and *khaṭṭ niṣf al-nahār bi-ᶜarḍ 32* respectively.

In the lower half are shadow squares, on the left for a base of 12 digits and on the right for a base of 7 feet. The labels of the four scales read as follows:

Vertical scale on the left: *ẓill aṣābiᶜ maᶜkūs*

Horizontal scale on the left: *ẓill aṣābiᶜ mustawī*

Horizontal scale of the right: *ẓill aqdām mustawī*

Vertical scale on the right: *ẓill aqdām maᶜkūs.*

Grids are drawn inside the shadow squares for two rectangular tables; apparently for the table of excess of revolution on the left and for the table of triplicities on the right, but these are not filled in.

The shadow squares are enclosed by eight semi-circular rows; each two are separated by double semi-circular lines. Starting from the outside, rows 1 and 2 are marked for cotangents and their subdivisions, but row 1 is not filled in with numbers; only the last cell on the left is engraved with *ẓill aṣābiᶜ* and the last cell on the right with *ẓill aqdām.*

Rows 3 and 4 carry the names of the 12 signs of the zodiac and the names of the 28 corresponding lunar mansions.



Figure A127.2 – Back of the astrolabe (photo by S. R. Sarma)

Rows 5 and 6 are to bear the table of the limits. In row 5 are engraved the names of the planetary lords of the five limits of each sign, but the row 6 is blank.

Rows 7 and 8 are drawn for the table of decans. In row 8 are written the values of decans (10, 20, 30) for each sign; but the names of their regents are not engraved in row 7.

In is inexplicable why these astrological tables were not completed in the otherwise well-crafted astrolabe.

A128 ASTROLABE ATTRIBUTABLE TO THE LAHORE WORKSHOP[541]

Not dated, 17th century

Diameter 153 mm

Washington, D.C., National Museum of American History (#2569)



Figure A128.1 – Front view of the astrolabe
(courtesy Museum of the History of Science, Oxford)

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[541] Entry based of Gibbs & Saliba 1984, no. 2569, pp. 165-169. The star names and the geographical gazetteer are deciphered and added by me.

This unsigned and undated astrolabe is clearly made by some member of the Lahore family. The *kursī,* elegantly reticulated with three large apertures, indicates the work of Muqīm, so also the two graphs of the solar meridian altitude for 27° and 32°. But the zero symbol in the gazetteer which resembles a small pair of scissors is characteristic of Ḍiyā' al-Dīn. The zigzag pattern of the gazetteer is also indicative of Ḍiyā' al-Dīn. But there Delhi (no. 36) is referred to as Jahānābād and not Shāhjahānābād. It is Jamāl al-Dīn who, for inexplicable reason, lists Delhi as Jahānābād in his astrolabes A121 and A126. Did he then engrave the gazetteer in the present astrolabe? Interestingly, there are two retes.

COMPONENTS

Body with *kursī* (d. 153), shackle, ring, chain, rete for 43 stars, 5 plates, alidade, pin and horse. Shackle, ring and chain may not be original.

FRONT

The ring and shackle have a diamond cross-section. The shackle is not trifoliate; may be a replacement. The *kursī* is high but narrow, pierced with just three large holes, one oval, two others paisley-shaped, placed slightly below it symmetrically; the finial cannot be seen in the photo, probably trifoliate. The surface is decorated on both sides with embossed vines, leaves and flowers on a hatched background.

The degree scale on the limb is divided in 1°, 2°, 6° and labelled in 6s from 6 to 90, in each quadrant separately, all in clockwise direction.

RETE I

The astrolabe is equipped with two retes, one larger and the other smaller. The larger one is of the standard type. Here the slender Capricorn ring and the wider ecliptic ring are held together by the equinoctial bar which has counter changes at its two intersections with the ecliptic ring. The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names. Each sign is subdivided into units of 6° and labelled accordingly from 6 to 30. The edge of the ecliptic ring is divided in 2°.

There are 43 named star pointers which are joined by a floral tracery. Part of it appears to be broken off in the lower right. The positions of the stars are indicated by thick dots. Often these dots are not at the tips of the pointers as they should be, but in the middle of broader bands or rings. Since these star pointers are not thus properly

defined, it would be difficult to align them with the appropriate altitude circle. Star no. 7 is mislabeled.



Figure A128.2 – Rete of the astrolabe
(© National Museum of American History, Washington, D.C.)

Table A128-1 Stars on the Rete I

	Star Name	Identification
1	*Dhanab al-Qayṭus Sh[amālī]*	ι Ceti
2	*Dhanal al-Qayṭus J[anūbī]*	β Ceti
3	*Baṭn al-Ḥūt*	β Andromedae

	Star Name	Identification
4	*[Rijl al-] Musalsala*	γ Andromedae
5	*Fam al-Qayṭus*	γ Ceti
6	*Ṣadr al-Qayṭus*	π Ceti
7	*Kaff al-Khaḍīb* !	β Cassiopeiae
8	*Al-Ghūl*	β Persei
9	*Mirfaq Thurayyā*	α Persei
10	*Masāfat al-Nahr*	γ Eridani
11	*ᶜAyn al-Thawr*	α Tauri
12	*Rijl al-Jawzā' al-Yusrā*	γ Orionis
13	*Yad al-Jawza' al-Yusrā*	β Orionis
14	*Yad al-Jawzā' al-Yumnā*	α Orionis
15	*Rijl al-Jawzā' al-Yumnā*	κ Orionis
16	*Shiᶜrā Yamānī*	α Canis Majoris
17	*Shiᶜrā Shāmī*	α Canis Minoris
18	*Mankhar Shujāᶜ*	σ Hydrae
19	*Fard al-Shujāᶜ*	α Hydrae
20	*Ṭarfat al-Safīna*	ρ Puppis
21	*Qā'idat al-Bāṭiya*	α Crateris
22	*Janāḥ al-Ghurāb*	γ Corvi
23	*Al-ᶜAnāq*	ζ Ursae Majoris
24	*Simāk Aᶜzal*	α Virginis
25	*Simāk Rāmiḥ*	α Bootis
26	*Nayyir Fakkah*	α Coronae Borealis
27	*ᶜUnuq al-Ḥayyah*	α Serpentis

	Star Name	Identification
28	*Rukbat al-Ḥawwā al-Yusrā*	ζ Ophiuchi
29	*Rās al-Jāthī*	α Herculis
30	*Rās al-Ḥawwā*	α Ophiuchi
31	*ᶜAyn al-Tinnīn*	γ Draconis
32	*Yad al-Ḥawwā al-Yumnā al-Muqaddam*	δ Ophiuchi
33	??	
34	*Nasr Wāqiᶜ*	α Lyrae
35	*Minqār al-Dajājah*	β Cygni
36	*Nasr Ṭā'īr*	α Aquilae
37	*Dhanab al-Dajājah*	α Cygni
38	*Fam al-Faras*	ε Pegasi
39	*Dhanab al-Jadī*	δ Capricorni
40	*Sāk Sākib al-Mā J[anūbī]*	δ Aquarii
41	*Mankib al-Faras*	β Pegasi
42	*Surrat atl-Faras*	δ Pegasi
43	*Kaff al-Kaḍīb*	β Cassiopeiae



Figure A128.3 – The second Rete (from Gibbs & Saliba 1984)

RETE II

The second rete consists of just the ecliptic ring; it is reminiscent of the minimal rete Ḍiyā' al-Dīn devised for his north-south astrolabe of 1674 (A090). It is divided into the 12 signs of the zodiac and is inscribed with their names. Each sign is divided into 5 and 10 parts on the edge. Three arcs cut across bearing the following 10 named star pointers which are shaped like tiger's claws.

Table A128-2 Stars on the Rete II

	Star Name	Identification
1	*ᶜAyyūq*	α Aurigae
2	?	

	Star Name	Identification
3	*ᶜUnuq [al-Ḥayyah]*	α Serpentis
4	*[Simāk] Rāmiḥ*	α Bootis
5	*Rās [al-Jāthī]*	α Herculis
6	*[Nasr] Wāqiᶜ*	α Lyrae
7	*[Nasr] Ṭā'ir*	α Aquilae
8	*Dhanab [al-Dajājah]*	α Cygni
9	*Fam [al-Faras]*	ε Cygni
10	*[Surrat al-] Faras*	δ Pegasi

PLATES

There are five plates with the following functions:

Table A128-3 Plates

	φ	Longest Day
1a	25°	13;25 hours
1b	27°	13;47 hours
2a	29°	13;52 hours
2b	32°	14;8 hours
3a	30°	13;53 hours
3b	38°	14;42 hours
4a	36°	14;32 hours
4b	40°	14;52 hours
5a	Plate of ecliptic coordinates	
5b	Plate of horizons	

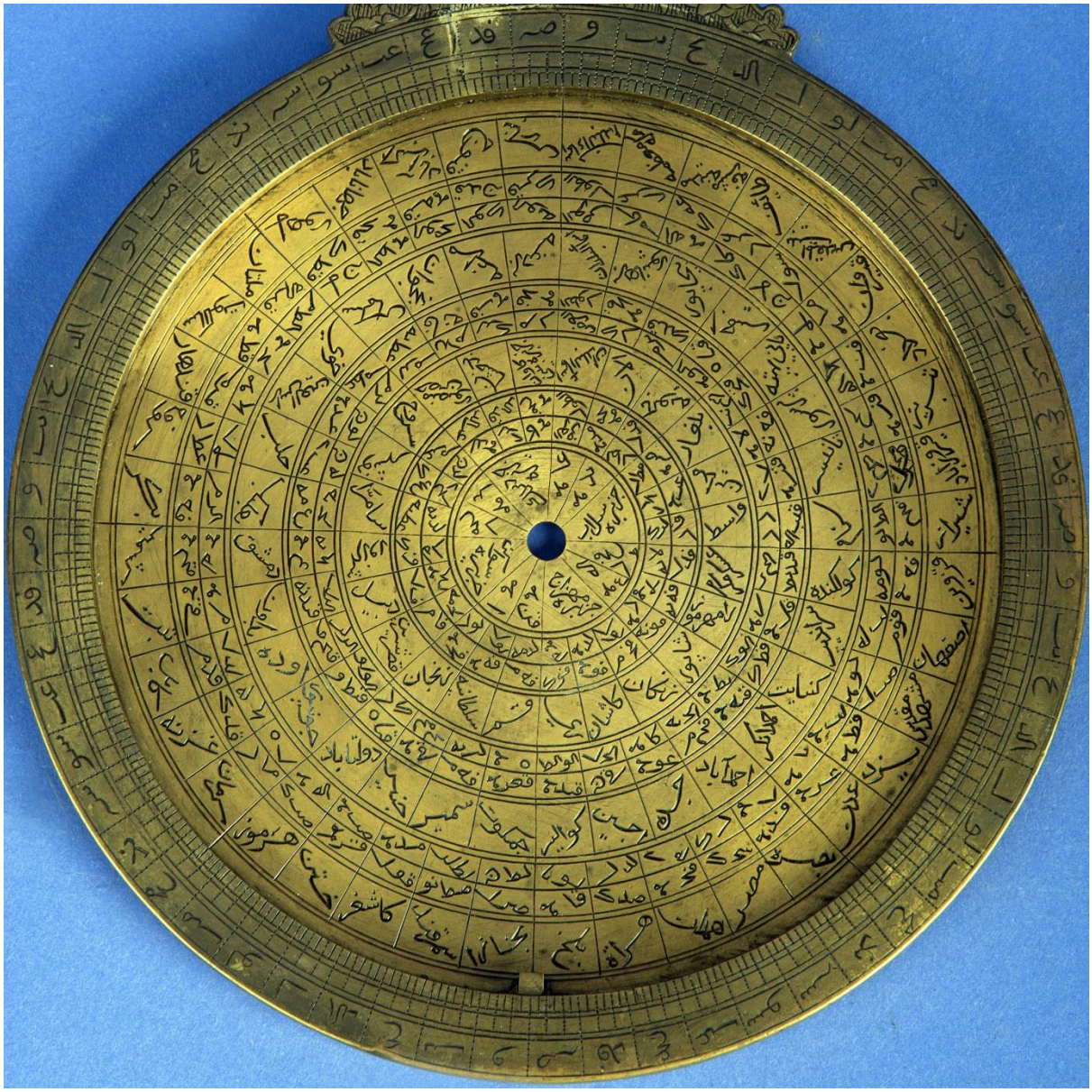


Figure A128.4 – Geographical Gazetteer
(© National Museum of American History, Washington, D.C.)

GEOGRAPHICAL GAZETTEER

The geographical gazetteer provides the names, longitudes and latitudes of 97 localities in three circles. The names are engraved upside-down with the tops of the letters towards the centre and the names and coordinates are arranged in a zigzag fashion. The grid is formed by six double circles intersected by segmented radial lines. The gazetteer commences with Mecca and proceeds up to India, but the localities appear to be arbitrarily arranged without any discernable pattern of increasing or decreasing longitudes or latitudes.

Table A128-4 Geographical Gazetteer

	Place Names *(asmā al-buldān)*	**L** *(al-ṭūl al)*	**φ** *(ᶜarḍ)*
	Outer Circle		
1	Makka Muᶜaẓẓam	77;10	21;40
2	Madīnat Musharrafa	75;20	25;00
3	Ṭā'īf	77;30	21;20
4	Bayt al-Maqdis	66;30	31;50
5	Qayrawān	41;0	31;0
6	Baghdād	82;0	33;25
7	Tabrīz	82;0	38;0
8	Fīrūzābād	87;30	28;10
9	Shīrāz	88;0	27;16
10	Qazwīn	85;0	36;45
11	Iṣfahān	86;40	32;35
12	Mashhad Maqdis	92;30	36;0
13	Yazd	89;0	32;0
14	ᶜAdan	77;0	11;0
15	Baṣra	74;0	30;0
16	Miṣr	63;20	30;20
17	Hamadān	83;0	35;10
18	Harāt	94;20	34;10
19	Balkh	101;0	36;11
20	Bukhārā	97;30	39;50
21	Samarqand	99;56	39;37
22	Kāshghar	106;30	45;0

	Place Names *(asmā al-buldān)*	**L** *(al-ṭūl al)*	**φ** *(ᶜarḍ)*
23	Khutan	107;?	42;0
24	Hurmūz	92;20	25;0
25	Kirmān	41;30	30;5
26	Ghazna	104;20	33;35
27	Kābul	104;40	34;30
28	Tubbat	110;0	40;0
29	Kashmīr	108;0	35;0
30	Bakar	105;0	27;0
31	Kūfa	79;30	31;30
32	Qandahār	107;40	33;0
33	Sālkūt	109;0	33;0
34	Multān	104;25	29;40
35	Lāhūr	109;20	31;50
36	Jahānābād (for Shāhjahānābad)	103;0	29;0
37	Akbarābād	115;0	26;43
38	Qannawj	114;50	26;20
39	Banāras	117;20	25;15
	Middle Circle		
40	Burhānpūr	113;0	20;30
41	Bījāpūr	114;20	17;40
42	Ajmīr	111;5	26;0
43	Pānīpatah	112;0	30;10
44	Parsūr	85;35	31;0

	Place Names *(asmā al-buldān)*	**L** *(al-ṭūl al)*	**φ** *(ᶜarḍ)*
45	Tānīsar	112;0	30;10
46	Sunām	112;25	30;30
47	Kūlkanda	114;19	28;4
48	Sarāndīb	130;0	10;0
49	Kanbayāt	109;20	26;20
50	Ahmadnakar	115;0	19;0
51	Ahmadābād	108;40	23;15
52	Jadda	108;40	23;15
53	Ujjayn	110;50	23;30
54	Kawāliyār	114;0	26;29
55	Jamkūt	174/7;0	5;0
56	Samīr[um]	85;40	32;15
57	Janīr ?	110;0	38;48
58	Dawlatābād	111;5	20;30
59	Jawnpūr	119;40	26;36
60	Awadh	118;6	27;32
61	Badāwan	114;55	27;32
62	Dimashq	70;0	33;15
63	Baᶜālbak	70;45	33;15
64	Ḥalab	72;10	35;50
65	Rās Alᶜayn	74;0	36;50
66	Khuway	79;40	37;40
67	Salmās	79;15	37;40
68	Nakhjawān	81;55	38;40

	Place Names *(asmā al-buldān)*	**L** *(al-ṭūl al)*	**φ** *(ᶜarḍ)*
69	Marāgha	82;0	37;20
70	Bardaᶜa	83;0	40;30
	Inner Circle		
71	Alān	83;0	44;0
72	Bākūya	84;30	39;30
73	Bulghār	90;0	49;30
74	Madā'īn	72;0	33;10
75	Wāsit	81;30	32;20
76	ᶜAskar Mukram	84;30	31;15
77	Rāmhurmūz	85;15	31;0
78	Shāpūr	86;55	30;0
79	Zankān	83;40	36;30
80	Kāshān	86;0	34;0
81	Rayy	86;20	35;0
82	Qumm	85;40	34;45
83	Sulṭāniyya	85;0	36;30
84	Zanjān	83;0	36;30
85	Qaṣr Shīrīn	81;40	33;45
86	Dabīl	80;30	38;0
87	Shahrazūr	80;20	35;30
88	Sāmarrā'	79;15	34;15
89	Nawshahr	78;20	38;10
90	Sarūj	72;40	34;50
91	Ḥiṣn Manṣūr	72;24	34;0

	Place Names *(asmā al-buldān)*	**L** *(al-ṭūl al)*	**φ** *(ᶜarḍ)*
92	Badakhshān	104;24	37;10
93	Jazīra Banī Kāwan	88;0	21;0
94	Jazīra Sulāb[542]	88;30	25;0
95	Jazīra Mahrāj	150;0	2;0
96	Jazīra Sawākin	48;30	17;0
97	Jazīra Dahlāk	71;0	14;0

BACK

The rim of the upper half carries the altitude scales which are divided in 1°, 2° and 6° and numbered in 6s as 6—90; 90—6. The upper left quadrant has 60 horizontal parallels to measure the cosine of each 1/60th part of the Radius; every sixth of these lines is emphasized with dots. The upper right quadrant is engraved with declination arcs, one for each 10° of solar longitude. Every third of these, forming the boundary between two successive signs, is dotted. The names of the corresponding zodiac signs are written along the two radii together with the numerical values of their subdivisions, viz., 10, 20, 30. Two sigmoid curves for the midday latitude of the sun in all seasons are plotted in this quadrant with the labels *khaṭṭ niṣf al-nahār bi-ᶜarḍ 27* and *khaṭṭ niṣf al-nahār bi-ᶜarḍ 32.*

542 These four names are engraved inside the third circle around the centre.



Figure A128.5 – Back of the Astrolabe
(© National Museum of American History, Washington, D.C.)

In the lower half, below the horizontal diameter are engraved the shadow squares. The square on the left is for a gnomon of 12 digits and 60 units. Here the vertical and horizontal scales are divided into 12 units each; each unit is again subdivided into 5 divisions. These are numbered in 5s from 5 to 60. The vertical scale is accompanied by

the label *ẓill sullam sittaynī aṣābiᶜ maᶜkūs* and the horizontal scale by *ẓill sullam sittaynī aṣābiᶜ mustawī.*

On the right is the shadow square for a gnomon of 7 feet. The vertical and horizontal scales are divided accordingly into 7 parts and numbered from 1 to 7. The vertical scale carries the label *ẓill sullam aqdām maᶜkūs* and the horizontal scale *ẓill sullam aqdām mustawī.*

These shadow squares enclose three rectangular scales; one long table below and two shorter tables above. The longer table bears the title *jadwal faḍl al-dawr* (excess of revolution) and provides multiples (of 1, 2, 3 …9 and 10, 11, 12 … 90) of the difference between the correct length of the year and 365 days. The short table above it on the left is the table of triplicities with the heading *jadwal arbāb muthallathāth laylī wa nahārī* (table of the regents of the triplicities, nocturnal and diurnal). The table on the upper right is entitled *jadwal ᶜarḍ iqlīm wa sāᶜāt niṣf al-nahār* (table of the latitudes of climates and the hours of the midday ?). It gives the latitudes and the lengths of the maximum daylight at the beginning and middle of the seven climates.[543]



Figure A128.6 – Tables inside the shadow Squares (detail of Figure A128.5)

543 Cf. A048; Kaye 1918, p. 132. Gibbs & Saliba 1984, p. 167, say that the ‘table gives the length of longest daylight in hours and the corresponding latitude for the upper and lower limits of the seven “climates”.’ It is not the upper limits but the midpoints of the climates.

Table A128-5 Table of Climates

	climate		hours	latitude
I	*awwal*	*ibtidā'* (beginning)	12;45 h	12;48°
		wāsiṭ (middle)	13;0	16;47
II	*dūyam*	*ibtidā'* (beginning)	13;15	20;31
		wāsiṭ (middle)	13;30	24;2
III	*sīwum*	*ibtidā'* (beginning)	13;45	27;34
		wāsiṭ (middle)	14;0	30;45
IV	*cahārum*	*ibtidā'* (beginning)	14;15	33;43
		wāsiṭ (middle)	14;30	36;28
V	*panjum*	*ibtidā'* (beginning)	14;45	39;1
		wāsiṭ (middle)	15;0	41;21
VI	*shashum*	*ibtidā'* (beginning)	15;15	43;30
		wāsiṭ (middle)	15;30	45;39
VII	*haftum*	*ibtidā'* (beginning)	15;45	47;38
		wāsiṭ (middle)	16;0	48;59

The shadow squares are enclosed by a series of semi-circular rows. The three outermost rows on the rim of the lower half are engraved with cotangent scales and their subdivisions. These are followed by 6 semi-circular rows containing the names of the 28 lunar mansions, the names of the 12 zodiac signs, the planetary lords of the limits and the regents of the decans.



Figure A128.7 – Alidade
(© National Museum of American History, Washington, D. C.)

ALIDADE

The alidade has ornate ends and an ornate centre-piece. It is engraved with three scales; on the right are a sexagesimal scale and a scale of seasonal hours and on the left a zodiac scale containing the serial numbers of the signs and their subdivisions of 10°.

BIBLIOGRAPHY

Gibbs & Saliba 1984, no. 2569, pp. 165-169.

A129⊙ ASTROLABE ATTRIBUTABLE TO THE LAHORE WORKSHOP

Not dated, 17th century

Diameter 240 mm

Paris, PC



Figure A129.1 – Front of the astrolabe (photo by S. R. Sarma)

The astrolabe is well made, the *kursī* is reminiscent of Muqīm's work, the rete is elegantly designed and the gazetteer lists many Indian localities which are not mentioned in other astrolabes. But the arrangement of the cells in the gazetteer is not symmetric and Delhi is listed as Jahānābād as in A128. There are inconsistencies in the plates as well. On the back, the engravings on large areas are removed by crude chiselling on the surface.

Components

Body with *kursī* (d. 240, h. 308, t. 9), shackle and ring, rete (d. 226), 5 plates, alidade, pin and horse.

Front

The ring is plain; the shackle trifoliate with ornate bases; the *kursī* is elegantly reticulated with six large perforations. The profiles are made up of ogees at the base and the top with a lobe between them with a trifoliate finial. The limb divided in 1° and 6° and numbered in 6s from 6 to 360.

Rete

The Capricorn and the broader ecliptic ring are held together by the slender equinoctial bar which is counter-changed once at the centre. The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names, each sign is divided into units of 6° and numbered accordingly. The edge of the ecliptic ring is divided in 1°. There are some 40 named star pointers; one pointer is broken. An ornate handle is on the left segment of the equinoctial bar. In contrast to the handle, the Capricorn index with a flat tip is not well shaped.



Figure A129.2 – Rete of the astrolabe (photo by S. R. Sarma)

PLATES

There are 5 plates serving different latitudes. The choice of latitudes is rather strange. Projections for latitude 26° is repeated on two plates. The maximum duration of the daylight is not carefully chosen.

Altitude circles are drawn for each 1° with every sixth dotted. Azimuth arcs are drawn below the horizon for each 6°. There are plain lines for seasonal hours and dotted lines for equal hours drawn from the western horizon.

There is no plate for the ecliptic coordinates and multiple horizons.

Table A129-1 Plates

	φ	Longest Day
1a	24°	13;29 hours
1b	26°	13;38 hours
2a	26°	13;38 hours
2b	29°	13;12 hours!
3a	28°	13;47 hours!
3b	30°	13;36 hours
4a	31°	14;1 hours
4b	33°	14;11 hours
5a	32°	14;6 hours
5b	35°	14;22 hours

GEOGRAPHICAL GAZETTEER

The gazetteer is arranged in three circles, which are not divided symmetrically. The outer circle is divided into 49 cells, the middle circle into 25 cells, but the inner circle into 20 cells. Of the 91 localities listed along with their longitudes and latitudes, some 70 are from Mughal India, which too is unusual. On the other hand, there is no discernible pattern of arrangement. The listing begins with Mecca, Medina and Jerusalem, enumerates some 70 places in Mughal India, and concludes with localities in the Middle East. Shāhjahānābād is misspelt as Jahānābād. Several place names are difficult to decipher.



Figure A129.3 – Geographical Gazetteer (photo by S. R. Sarma)

Table A129-2 Geographical Gazetteer

	Place Name	L	φ
	Outer Circle		
1	Makkā Mubarak	77;10	21;40
2	Madīnat Rasūl	75.20	25; ?
3	Bayt al-Maqdis	66;30	32;15
4	Miṣr	63;20	30;20
5	Iṣfahān	86;40	32;25
6	Balkh	101;0	36;41

	Place Name	L	φ
7	Badakhshān	105;24	37;0
8	Baghdād	80;0	35;25
9	Bulghār	90;0	49;30
10	Baṣrā	84;0	30;0
11	Bukhārā	97;0	39;50
12	?	69;16	39;37
13	Qandahār	107;40	33;0
14	Daubul ᶜAraftatah (?)	102;30	25;12
15	?	104;25	26;40
16	Bahkar (?)	105;0	27;40
17	Mūltān	107;35	29;40
18	Kīch az Makrān	99;0	28;0
19	Ghaznī	104;5	35;20
20	Kābul	105;0	34;30
21	Jalālābād	104;40	34;10
22	Pīshāwar	106;40	33;50
23	?	?	?
24	Rahnās (?)	?	32;45
25	Kashmīr	108;0	35;0
26	Tubbat	110;0	40;0
27	Kach az Shān (?)	108;35	32;30
28	Bahīra (?)	108;0	31;40
29	Lāhūr	109;20	31;50
30	Lūdhiyānā	110;40	31;10

	Place Name	L	φ
31	Sarhind	111;30	30;30
32	Sunām	111;30	29;30
33	??	112;0	30;0
34	Hardwār	113;0	30;0
35	Sar^{c}ankar (?)	112;52	33;10
36	Kānkarā (Kangra?)	111;35	33;35
37	Kīrānā (?)	113;20	29;40
38	Sūrat	108;10	21;25
39	Patan Kujarāt	107;25	23;35
40	Naharbār (?)	109;40	21;0
41	Burhānpūr	112;20	21;30
42	Aurankābād	111;30	19;0
43	Bīdar	110;3	18;39
44	Kūlkandā	114;45	18;35
45	Bījāpūr	113;25	17;0
46	Mandū	111;36	22;0
47	Ujjayn	112;30	22;15
48	Sarūnj	114;42	24;48
	Middle Circle		
49	Narwar	114;55	25;30
50	Jahānābād (Shāhjahānābād)	113;35	28;34
51	Hānsī Hissār	112;0	29;45
52	Amrūhā	114;45	28;40
53	Sanbhal	114;40	28;32

	Place Name	L	φ
54	Akbarābād	115;0	26;43
55	Ajmīr	111;5	25;50
56	Ahmadābād Kujarāt	108;20	23;0
57	Kawāliyār	114;56	25;56
58	Kālpī	116;0	27;35
59	Qannawj	116;15	26;55
60	Bahrāīch	116;30	28;0
61	Allāhābād	116;50	26;12
62	Banāras	117;20	27;0
63	Jawnpūr	117;6	27;11
64	Patnā	119;12	26;40
65	Mūnkīr	120;0	27;6
66	Rājmahal	121;5	25;15
67	Kawr Bankālā (Gaur in Bengal)	121;12	25;0
68	Udīsā (?)	120;0	18;0
69	Dhākā	122;0	23;35
70	Sulṭānpūr	115;0	28;30
71	Pānīpat	113;10	28;52
72	Sālkūt	109;0	33;0
	Inner Circle		
73	Mīwāt	117;10	32;50
74	Baran	114;0	28;48
75	Kūl	114;19	28;4

	Place Name	L	φ
76	Mānikpūr	118;10	26;45
77	Khujand	109;36	41;55
78	Awad[h]	118;7	26;32
79	Thānīsar	117;38	?.?
80	Nīshābūr	86;55	30;?
81	Lankā	11;0	0;0
82	Jamkūt	170;0	5;0
83	Fīrūzābād	87;0	28;30
84	Qurqur (?)	65;15	50;40
85	Mārī Kirmān	65;45	50;45
86	Kāzirūn	87;0	30;0
87	Sawādaq (?)	66;0	31;0
88	Ḥalab	72;10	35;50
89	Sabarwār (?)	91;30	36;0
90	Kirmān	91;30	30;5
91	Ghāzīpūr	119;40	26;40

BACK

The back of the astrolabe is planned quite ambitiously as can be seen still in the two upper quadrants. The rim of the upper half carries two altitude scales divided in 1° and in 6° and numbered in 6s as 6---90; 90---6.



Figure A129.4 – Back of the astrolabe (photo by S. R. Sarma)

The upper left quadrant is engraved with a sine-cosine graph with 60 horizontal and 60 vertical parallels where each sixth line is dotted. The horizontal lines are numbered in 5s along the vertical radius. Semicircles are drawn on the two radii. Radial lines connect the centre with the arc at every 15°. Furthermore, 6 quarter circles (which

form the boundaries between two zodiac signs) from the upper right quadrant are extended into this quadrant.

The upper right quadrant carries 6 dotted quarter circles, dividing the area into 6 segments, one for each pair of zodiac signs. Each segment is divided by 5 quarter circles into 6 parts so that each part represents 5° of solar longitudes.[544] The names of the corresponding signs and their 1/6th parts in degrees (5, 10, 15, 20, 25, 30) are engraved along the two radii. Three sigmoid graphs of the solar meridian altitude for the latitudes 27°, 29° and 32° are engraved with the usual labels.

In the lower half are drawn the shadow squares, on the left for 12 digits and on the right for 7 digits with the usual labels in bold letters. It was planned to insert the table of excess of revolution inside the shadow squares; for this purpose, a grid of 4 columns is drawn, the name of the table *jadwal faḍl al-dawr* is engraved at the top and the arguments in the two outer columns, but the actual values of the multiples are not filled in.

The rim of the lower half carries two cotangent scales and their subdivisions. The unequal divisions in the scale on the left are numbered as 6, 12, 18, 24, 36, 48, 60, followed by the label *aṣābi*^{c}. The unequal divisions in the scale on the right are numbered as 7, 14, 21, 28, 59, followed by the label *aqdām.*

Inside these cotangent scales, 8 semi-circular rows are drawn and filled with different scales. But 5 of these scales ((i.e. rows 1, 5-8 as counted from the outside) were erased by crudely chiselling the surface for reasons unknown. Row 2 carries the names of the 12 signs of the zodiac and row 3 the names of the corresponding 28 lunar mansions. In the next row, under each lunar mansion, three numbers in *Abjad* notation are engraved. Thus under the first lunar mansion *sharṭayn* the numbers are 0, 0, 0; under the second lunar mansion *buṭayn* the numbers are 0. 12, 11. The significance of these numbers is not known.

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544 Five parts of 6° each is the more usual practice.

ALIDADE ETC

The straight alidade with ornate ends and an ornate centre-piece is not graduated. The tip of the pin is decorated with an elegant flower of six petals. The end of wedge is shaped like a horse’s head with eyes and ears.

A130⊙ ASTROLABE ATTRIBUTABLE TO THE LAHORE WORKSHOP

Not dated, 17th century

Diameter 204 mm

Patna, Khuda Bakhsh Oriental Public Library



Figure A130.1 – Front view of the astrolabe (photo by S. R. Sarma)

This is a massive and ambitious astrolabe, but it is poorly made with an inelegant rete. It is also quite worn out. The configuration on the back with the curves for the solar

meridian altitude and the several astrological tables and also the plate marked with astrological houses at latitudes 27°, 29° and 32° indicate that the astrolabe was produced in the Lahore family. I regret that I do not have good photos of this astrolabe.

COMPONENTS

Body with *kursī* (d. 204, h. 241, t. 13), swivel ring, shackle, rete (d. 183) for 45 stars, 8 plates, alidade and pin. The horse is missing; in its place an index belonging to a quadrant is used as a wedge.

FRONT

The ring is attached to the top of the shackle in such a manner that it can swivel all around. The *kursī* is solid and low with lobed profiles. It is made separately and joined to the main body, rather crudely, with two nails. The limb is divided in 1° and 6° and labelled from 6 to 90 clockwise, separately in each quadrant.

RETE

The peripheral Capricorn ring and the eccentric ecliptic ring are held together by the equinoctial bar which has two counter-changes at its two intersections with the ecliptic ring. The solstitial bar is also represented fully, but it often merges with the tracery that connects the star pointers. The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names; each sign is divided into units of 6° and numbered 6 to 30; the bevelled edge is graduated in 2°. There is a handle affixed to the pointer of the star α Hydrae. The Capricorn index is not sharply pointed. There are 45 named star pointers that are joined by a most inelegant tracery.



Figure A130.2 – Rete of the astrolabe (photo by S. R. Sarma)

Table A130-1 Stars on the Rete

	Star Name	Identification
01	*Dhanab al-Qayṭus [Janūbī]*	β Ceti
02	*Baṭn al-Ḥūt*	β Andromedae
03	*Fam al-Qayṭus*	γ Ceti
04	*Ṣadr al-Qayṭus*	π Ceti
05	*Rās al-Ghūl*	β Persei
06	*Kaff al-Jadhmā'*	α Ceti

	Star Name	Identification
07	*Tālī Masāfat al-Nahr*	γ Eridani
08	*ᶜAyn al-Thawr*	α Tauri
09	*ᶜAyyūq*	α Aurigae
10	*Riǰl al-Jawzā' al-Yusrā*	β Orionis
11	*Yad al-Jawzā' al-Yusrā*	γ Orionis
12	*Yad al-Jawzā'al-Yumnā*	α Orionis
13	*Riǰl al-Jawzā' al-Yumnā*	κ Orionis
14	*Shiᶜrā Yamānī*	α Canis Majoris
15	*Shiᶜrā Shāmī*	α Canis Minoris
16	*Ṭarfat al-Safīna*	ρ Puppis
17	*Mankhar al-Shujāᶜ*	σ Hydrae
18	*Fard al-Shujāᶜ*	α Hydrae
19	*Qalb al-Asad*	α Leonis
20	*Qāᶜidat al-Bāṭiya*	α Crateris
21	*Ṣarfa*	β Leonis
22	*ᶜAnāq*	ζ Ursae Majoris
23	*Janāḥ al-Ghurāb*	γ Corvi
24	*Simāk al-Aᶜzal*	α Virginis
25	*Simāk Rāmiḥ*	α Bootis
26	*Nayyir al-Fakkā*	α Coronae Borealis
27	*ᶜUnuq al-Ḥayyā*	α Serpentis
28	*Qalb al-ᶜAqrab*	α Scorpii
29	*Rukbat al-Ḥawwā al-Yusrā*	ζ Ophiuchi
30	*Rās al-Jāthī*	α Herculis

	Star Name	Identification
31	*Rās al-Ḥawwā*	α Ophiuchi
32	*Yad al-Muqaddam Yumnā*	δ Ophiuchi
33	*Nasr Wāqi*^{c}	α Lyrae
34	*Minqār al-Dajājah*	β Cygni
35	*Nasr Ṭā'ir*	α Aquilae
36	*Dhanab al-Dulfīn*	ε Delphini
37	*Dhanab al-Dajājah*	α Cygni
38	*Fam al-Faras*	ε Pegasi
39	*Dhanab al-Jadī*	δ Capricorni
40	*Mankib Sākib al-Mā'*	α Aquarii
41	*Sāq Sākib al-Mā'*	δ Aquarii
42	*Dhanab al-Qayṭus [Shamālī]*	ι Ceti
43	*Janāḥ al-Faras*	γ Pegasi
44	*Surrat al-Faras*	δ Pegasi
45	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are eight plates. A ring is added to the rim of plate 6 to increase its thickness. Plates 1 to 5a are engraved with altitude circles for each 2°, with every fifth highlighted with dots. In the lower half, there are plain lines for seasonal hours and dotted lines drawn from the western horizon for equal hours. Care is not taken to write on the plates the exact duration of the maximum daylight.

Table A130-2 Plates

	φ	Longest Day
1a	21°	13 hours!
1b	24°	13 hours!
2a	26°	13 hours!
2b	27°	13 hours!
3a	29°	13;52 hours
3b	32°	14;8 hours
4a	34°	14 hours!
4b	36°	14 hours!
5a	30°	14 hours!
5b	double projection of 90° + 72°	
6a	38°	15 hours!
6b	double projection of 42 + 48°	
7a	Plate of ecliptic coordinates with the label *ṣafīḥat mīzān al-ᶜankabūt*	
7b	Plate of horizons with the label *ṣafīḥa āfāqī*	
8a	Astrological houses at latitude 27°	
8b	Astrological houses at latitudes 29° and 32°	

Plate 8 deserves attention. On the obverse side, arcs are drawn to indicate astrological houses at latitude 27° with the label *ṣafīḥat maṭraḥ shuᶜāᶜ bi-ᶜarḍ 27* (plate for finding astrological rays at latitude 27°). On the reverse side, astrological houses at latitude 29° are marked in one half and the same for the latitude 32° in the other half with labels *ṣafīḥat maṭāriḥ shuᶜāᶜ bi-ᶜarḍ 29* and *ṣafīḥat maṭārḥ shuᶜāᶜ bi-ᶜarḍ 32* respectively (see Figure A099.3) To facilitate the use of these two halves, notches are made at the north and south points of this plate, while all other plates have a single notch

at the north point. On both sides of the plate, names of the 12 zodiac signs are engraved along the rim together with their subdivisions marked as 6, 12, 18, 24 and 30.

GEOGRAPHICAL GAZETTEER

The geographical gazetteer provides the names and coordinates of 81 localities in three circles, each separated from the others by a blank annulus. The enumeration commences with Mecca and Medina in the inner circle. Kannauj (no. 58) is given the attribute 'Dār al-Mulk Hind' (Capital City of India), obviously borrowed from Ulugh Beg's gazetteer (see also A072).

Table A130-3 Geographical Gazetteer

	Place Name	L	φ
	Inner Circle		
1	Makka Muᶜazzam	77;10	21;40
2	Madinat Munawwara	75;20	25;0
3	Mahdiyya Maghrib	52;05	32;30
4	Iskandariyya	61;54	30;38
5	Miṣr	68;20	30;20
6	Sanaᶜā Dar-al Mulk Yaman	77;10	15;30
7	Dimashq	70;0	38;55
8	Baᶜalback	70;55	38;58
9	Ḥalab	72;10	35;50
10	Qustantiniyya	59;50	45;00
11	Arzan Rūm	77;00	39;40
	Middle Circle		
12	Mawṣil	77;0	34;30
13	Tabrīz	86;0	38;0
14	Bardaᶜa	88;0	40;30

	Place Name	L	φ
15	Bulghār	95;0	49;30
16	Kūfa	79;30	31;30
17	Madāin	72;0	38;25
18	Baghdād	80;30	38;25
19	Baṣra	84;0	30;0
20	Shīrāz	88;0	29;36
21	Yazd	89;0	32;30
22	Hamadān	88;0	35;10
23	Karkh	84;45	34;0
24	Kazwīn	85;5	36;55
25	Iṣfahān	86;40	32;25
26	Rayy	86;20	35;0
27	Astarābād	89;30	36;55
28	Jurjān	95;0	36;55
29	Biṣṭām	89;30	36;10
30	Sabzawār	91;30	36;5
31	Nyshābūr	92;30	36;21
32	Ṭūs	94;30	37;0
33	Tūn	92;30	32;30
34	Harat	94;38	34;30
	Outer Circle		
35	Sarakhs	94;0	32;0
36	Marw	97;0	34;40
37	Balkh	101;0	36;41

	Place Name	L	φ
38	Badakhshān	104;27	37;10
39	Bukhārā	97;30	39;50
40	Samarqand	99;56	39;37
41	Khujand	105;10	41;55
42	Kāshghar	106;30	44;0
43	Hurmūz	92;0	25;0
44	Aḥmadābād	108;40	23;28
45	Ujjayn	104;0	23;0
46	Kābul	104;40	34;40
46	Mewāt	117;50	32;50
48	Badā'ūn	114;59	27;32
49	Hānsī	112;35	29;15
50	Akbarābād	114;0	27;18
51	Dihlī	118;0	28;20
52	Ajmīr	111;05	26;0
53	Kawāliyar	105;08	26;29
54	Kashmīr	108;0	35;40
55	Tubbat	110;0	40;0
56	Sarandīb	104;0	10;0
57	Banāras	117;20	26;55
58	Qannawj Dār al-Mulk Hind	105;50	26;50
59	Lāhūr	109;20	31;50
60	Qandahār	107;40	38;0
61	Multān	104;40	29;40

	Place Name	L	φ
62	Sultānkūt	109;0	28;10
63	Mashhad	105;0	28;10
64	Khamabayāt	109;00	28;0
65	Jadda	76;0	21;0
66	Burhānpūr	109;0	21;20
67	Bījāpūr	109;0	17;20
68	Dawlatābd	112;0	20;40
69	Gopāmāū	106;35	27;45
70	Mānikpūr	118;-	27;49
71	Awadh	118;06	27;22
72	Purshawār	104;55	31;50
73	Mansūrā Sind	104;0	27;40
74	Baran	114;0	28;48
75	Kūl	114;39	28;10
76	Aḥmadnakar	106;0	19;0
77	Kūlkunda	114;35	18;10
78	Surunj	72;40	34;50
79	Kalpī	116;45	26;45
80	Dhākā Bangālā	130;0	27;0
81	Lakhnaū	114;10	26;30

BACK

On the back of the astrolabe, the rim of the upper half is engraved with altitude scales which are divided in 1°, 2° and 6° and labelled as 6---90; 90---6.

The trigonometric quadrant in the upper left carries 60 vertical and 60 horizontal parallels with every sixth line dotted. Semi-circles are drawn on both the radii; also quarter circles at 12 units and 23;30 units of the radii. The solar quadrant on the upper right is divided by 18 declination arcs, with each third highlighted with dots. The names of the corresponding zodiac signs are written along the two radii. Five curves of the meridian altitude of the sun in all seasons at latitudes 21°, 27°, 29°, 32° and 36° are plotted on this quadrant. To the last curve is added the full label *khaṭṭ niṣf al-naḥār bi-ʿarḍ 36;* in the case of other curves, just the latitude is mentioned.

In the lower half are the double shadow squares, on the left for the base of 12 and 60 and on the right for the base of 7. Inside the squares, there are five concentric semi-circles bearing the tables of the limits and faces.

The rim of the lower half carries cotangent scales in feet and in digits. Inside these scales are two semi-circular rows carrying the names of the 12 zodiac signs and the names of the 28 corresponding lunar mansions.

Alidade

The alidade has ornate ends and a simple centre-piece. The right half carries a sexagesimal scale numbered in 6s from 6 to 60 to match with the trigonometric quadrant. The left half is divided into the signs of zodiac. The sighting plates have three apertures of different dimensions. The pin has an ornate tip. The horse is lost. In its place, the graduated index of a quadrant (which is no more extant) is used.

A131⊙ ASTROLABE ATTRIBUTABLE TO THE LAHORE WORKSHOP

Not dated, 17th century

Diameter 124 mm

Jaipur, Jai Singh's Observatory

CCA 76



Figure A131.1 – Front of the astrolabe (photo by S. R. Sarma)

This small but exquisitely fashioned astrolabe carries no signature or date; it contains many elements not found in Lahore astrolabes, especially on the back. The horizontal lines in the trigonometric quadrant are not evenly spaced. In the solar quadrant, there are no curves of the midday altitude of the sun; instead there is a universal horary quadrant. There are no shadow squares in the lower half. Even so, the well-crafted *kursī* and rete and the gazetteer arranged by climates suggest that the astrolabe may have emanated from the workshop of the Lahore Family.

COMPONENTS

Body with *kursī* (d. 124), shackle, ring, rete, 5 plates, alidade, pin and wedge.

FRONT

The shackle is trifoliate with trowel-like bases. The *kursī* is rather high; it is reticulated intricately and very elegantly to produce tulip-like flowers with long stems. The finial is trifoliate. On the vertical axis there are two floral ornaments one below the other.

The trefoil motif is frequently repeated; in the finial, in the perforation at the top of the *kursī,* in the two floral ornaments immediately below, and again in the rete in the frame surrounding the bird-like pointer of the star α Lyrae and immediately below the ecliptic ring. The limb is graduated in 1° and 5° and numbered in 5s from 5 to 90 clockwise, separately in each quadrant. The numbers are so written that their tops are towards the centre.

RETE

The two rings of the Tropic of Capricorn and the ecliptic are held together by the equinoctial bar without counter changes. Unusually for a Lahore astrolabe, a segment of the equator ring is represented in the lower half. The ecliptic ring is divided into the 12 signs of the zodiac, with their names engraved neatly in each division. The signs are divided in groups of 6° and are numbered from 6 to 30 clockwise.

The star pointers are joined by a perfectly symmetric tracery consisting of straight and inverted arch-like frames. A small segment of the solstitial bar is shown below and above the central ring. The pointer of the star *Nasr Wāqiʿ* (falling eagle) is depicted as a bird with outstretched wings perched on the upper segment of the solstitial bar. The bird is framed by a trifoliate form. There are 21 leaf-shaped star pointers. A handle to rotate

the rete is placed on the tracery on the meridian between the ecliptic ring and the peripheral ring. It too has a trifoliate form when seen from the side.



Figure A131.2 – Rete of the astrolabe (photo by S. R. Sarma)

Table A131-1 Stars on the Rete

	Star Name	Identification
1	*Al-Ḥūt*	β Andromedae
2	*Fam al-Qayṭus*	γ Ceti
3	*Ghūl*	β Persei
4	*Al-Dabarān*	α Tauri
5	*ᶜAyyūq*	α Aurigae
6	*Al-Rijl*	β Orionis

	Star Name	Identification
7	*Yad*	γ Orionis
8	*Nathra*	ε Cancri
9	*al-Shāmī*	α Canis Minoris
10	---	
11	*Fard*	α Hydrae
12	*Qalb al-Asad*	α Leonis
13	*Sāq ??*	
14	*Al-Aᶜzal*	α Virginis
15	*Al-Rāmiḥ*	α Bootis
16	*Al-Fakkah*	α Coronae Borealis
17	*Qalb al-ᶜAqrab*	α Scorpii
18	*Al-Ḥawwā*	α Ophiuchi
19	*Al-Wāqiᶜ*	α Lyrae
20	*Ṭā'ir*	α Aquilae
21	*Al-Dajājah*	α Cygni
22	*Dhanab al-Jadī*	δ Capricorni
23	*Mankib*	α Aquarii
24	*Dhanab al-Qayṭus*	ι Ceti

PLATES

There are five plates; they all carry a hole a little above the north point so that they are held in position by a pin at the corresponding place in the mater.

Table A131-2 Plates

	φ	Longest Day
1a	18°	13;6 hours
1b	21°	13;18 hours
2a	24°	13;31 hours
2b	36°	14;32 hours
3a	27°	
3b	42° ?	
4a	28°	
4b	32°	
5a	40°	
5b	Plate of horizons	

On the plates serving latitudes, altitude circles are drawn for every 6° and azimuth arcs for each 10°. On some plates, the hours of maxim duration of the daylight are not mentioned. In the lower half there are plain lines for seasonal hours and dotted lines for equal hours drawn from the western horizon; on some plates the dotted lines for equal hours are drawn from both the horizons. On all plates there are labels *maghrib* near the west point and *mashriq* near the east point.

On the plate of horizons on 5b, half horizons are drawn in four sets, together with declination scales along the radii on either side of the equator circle. The scales are divided in 2 units and numbered in 6s from 6 to 24; the accompanying labels reads *al-mayl al-kullī* (maximum declination).

Geographical Gazetteer

The geographical gazetteer is arranged by climates in four annuli. In the first annulus are engraved the names of the climates, followed by place names, longitudes and latitudes, however, without the argument in the first cell. For each climate, five localities are chosen so that the gazetteer covers 35 localities. The four annuli occupy

just about the two-thirds of the space on the inner surface of the mater and the rest of the space in the middle is empty.



Figure A131.3 – Geographical gazetteer (photo by S. R. Sarma)

Table A131-3 Geographical Gazetteer

	Place Name	L	φ
	Outer Circle		
[I] *al-iqlīm awwal min khaṭṭ al-istiwā' ilā ᶜarḍ 20;27* (the first climate from the line of equator to latitude 20;27°)			

	Place Name	L	φ
1	Arīn al-Arṣāmah (?)	90;0	0;0
2	ᶜAdan	59;45	14;0[545]
3	Sarāndīb	130;0	10;0
4	Madīna	18;0	14;0
5	Ṣānᶜnah (?)	76;0	15;30
[II] *al-thānī min 20;27 ilā ᶜarḍ 27;30* (the second [climate] from 20;27° to latitude 27;30°)			
6	Makka	77;0	21;40
7	Madīnat Rasūl	75;0	25;0
8	Jawnpūr	119;6	26;16
9	Banāras	119;20	26;15[546]
10	Awadh	118;30	26;22
[III] *al-thālith min 27;30 ilā ᶜarḍ 33;37* (the third [climate] from 27;30° to latitude 33;37°)			
11	Dihlī	113;35	28;39
12	Lāhūr	109;20	31;50
13	Kashmīr	108;55	35;0
14	Akra	115;0	24;43
15	Qannawj	115;50	26;35
[IV] *al-rābiᶜ min 33;37 ilā ᶜarḍ 38;54* (the fourth [climate] from 33;37° to latitude 38;54°)			
16	Harat	96;20	34;30

545 By mistake, the engraver interchanged the longitude and latitude here.

546 Erroneously 16;15 instead of 26;15.

	Place Name	L	φ
17	Qazwīn	85;0	34;55
18	Balkh	--;0 !	36;41
19	Tabrīz	83;35	38;0
20	Badakhshān	107;24	36;10
[V] *al-khāmis min 33;54 ilā ᶜarḍ 43;22* (the fifth [climate] from 33;54° to latitude 43;22°)			
21	Samarqand	99;30	39;34
22	Bukhārā	94;30	39;50
23	Khwārizm	94;0	42;47
24	Farghān[a]	92;0	42;0
25	Adharbayjān	89;0	0;3 !
[VI] *al-sādis min 43;22 ilā ᶜarḍ 47;12* (the sixth [climate] from 43;22° to latitude 47;12°)			
26	Qustantiniyya	89;50	45;0
27	Awrkand	82;50	44;51
28	Al-Bāligh	82;30	44;0
29	Bīsh Bāligh	81;30	45;50
30	Qarāqurum	115;0	46;30
[VII] *al-sābiᶜ min 47;12 ilā ākhir al-ᶜimārat* (the seventh [climate] from 47;12° to the last architecture)			
31	Balāsāghūn	81;30	47;40
32	Bulghār	87;0	49;30
33	Lārsū	89;0	54;0
34	Alqura	80;0	48;20
35	Fawra	78;0	60;30

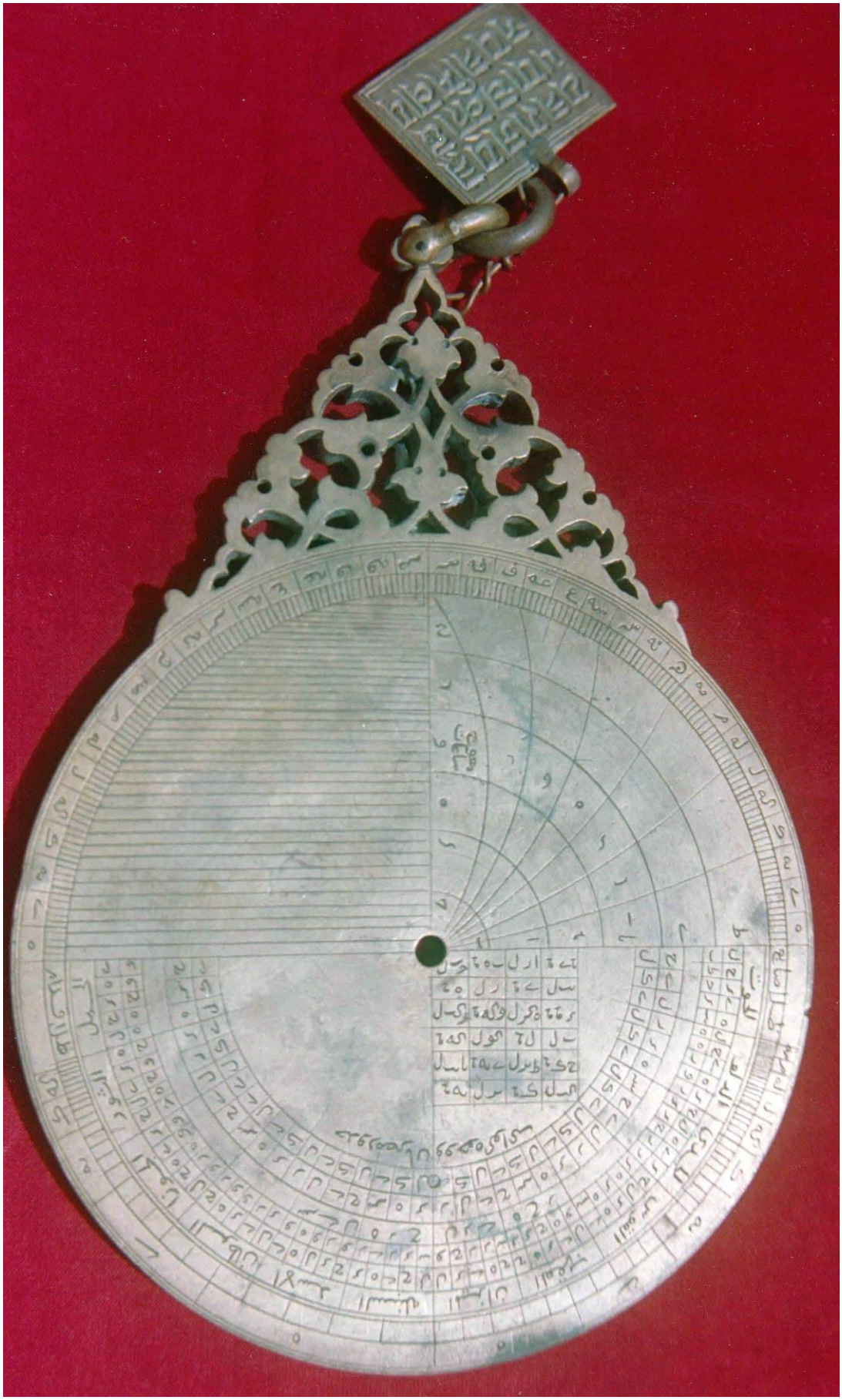


Figure A131.4 – Back of the astrolabe (photo by S. R. Sarma)

BACK

Altitude scales are engraved on the upper half of the rim; these are divided in 1° and 5° and numbered 5---90; 90---5. The trigonometric quadrant on the upper left is engraved with some 36 (!) horizontal parallels at gradually decreasing intervals.

The solar quadrant on the upper right is divided by five declination arcs into 6 zones, one for each pair of zodiac signs. The signs are marked with their serial numbers along the two radii. On this is drawn a universal horary quadrant with six lines of unequal hours, which are numbered serially as they proceed from the horizontal radius to the vertical radius. Near the vertical radius is a label *sāᶜāt muᶜawwaj* (unequal hours ?).

In the lower half there are no shadow squares, but there are co-tangents scales and their subdivisions on the rim. In the scale on the left, the unequal divisions are numbered clockwise from the meridian onwards as 0, 10, 15, 20, 25, followed by the label *ẓill aqdām.* On the right the divisions are numbered anti-clockwise as 0, 10, 15, 20, 25, 30, 35, 40, 45, followed by the label *ẓill aṣābiᶜ*.

These scales are followed by 6 semi-circular rows. Counting from the outside, rows 1-3 contain the table of limits, with the names of the signs in row 1, the names of the planets, except the sun and the moon, (expressed by the last consonants of their names) in row 2 and their individual strengths (indicated by *Abjad* numerals) in row 3.

Table A131-4 Table of the Limits

Aries	Jupiter	6	Venus	6	Mercury	8	Mars	5	Saturn	5
Taurus	Venus	8	Mercury	6	Jupiter	8	Saturn	5	Mars	3
Gemini	Mercury	6	Jupiter	6	Venus	5	Mars	7	Saturn	6
Cancer	Mars	7	Venus	6	Mercury	6	Jupiter	7	Saturn	4
Leo	Jupiter	6	Venus	5	Saturn	6	Mercury	7	Mars	6
Virgo	Mercury	7	Venus	10	Jupiter	7	Mars	4	Saturn	2
Libra	Saturn	6	Mercury	8	Jupiter	7	Venus	7	Mars	2
Scorpio	Mars	7	Venus	4	Mercury	8	Jupiter	5	Saturn	6
Sagittarius	Jupiter	12	Venus	5	Mercury	4	Saturn	5	Mars	4
Capricorn	Mercury	7	Jupiter	7	Venus	8	Saturn	4	Mars	4
Aquarius	Mercury	7	Venus	6	Jupiter	7	Mars	5	Saturn	5
Pisces	Venus	12	Jupiter	4	Mercury	3	Mars	9	Saturn	2

Rows 5-6 contain the tables of faces with the names of the planets in row 5 and the numerical values of the faces in 6. Row 4 is only partially filled, with three names each for the four signs Leo, Virgo, Libra and Scorpio, as shown the last three columns in the table below; the significance of these additions eludes us.

Table A131-5 Table of the Decans and their Regents

Signs	10°	20°	30°		10°	20°	30°
Aries	Mars	Sun	Venus				
Taurus	Mercury	Moon	Saturn				
Gemini	Jupiter	Mars	Sun				
Cancer	Venus	Mercury	Moon				
Leo	Saturn	Jupiter	Mars		Sun	Jupiter	Saturn
Virgo	Sun	Venus	Mercury		Venus	Moon	Mars
Libra	Moon	Saturn	Jupiter		Saturn	Mercury	Jupiter
Scorpio	Mars	Sun	Venus		Venus	Mars	Moon
Sagittarius	Mercury	Moon	Saturn				
Capricorn	Jupiter	Mars	Sun				
Aquarius	Venus	Mercury	Moon				
Pisces	Saturn	Jupiter	Mars				

Under these rows are written the names of these tables: *ḥudūd miṣriyān wa wujūh kawākib* (the limits of the signs according to the Egyptians and the faces of the planets).

Finally, in the space between these semi-circular scales and the horizontal diameter, a rectangular table is engraved on the right with 4 columns and 6 rows. I am unable to explain this table.

ALIDADE

The alidade is a straight bar alidade with ornate ends and a plain centre-piece. The right arms bears, in the upper register, a sexagesimal scale to match the trigonometric quadrant on the back; the lower register is marked with seasonal hours for the occasion when the alidade is used as a sundial. The left arm of the alidade is marked with declination arcs and the serial numbers of the zodiac signs as in the solar quadrant on the back.



Figure A131.5 – The *kursī* and the plaque (photo by S. R. Sarma)

PROVENANCE

This astrolabe, along with other Lahore astrolabes, was acquired by Sawai Jai Singh of Jaipur in the first quarter of the eighteenth century and formed part of his personal collection, where a small copper plaque was added to it in Devanagari script and Rājasthānī dialect. The plaque reads:

ya[n]trarāja patra 5 pā[ṃ]c ko chai bhapatra sivāy

'Astrolabe plates 5 five [.] six along with the rete [.]'

BIBLIOGRAPHY

Kaye 1918, p. 16, figs. 10 (front), 11 (back) and 14 (gazetteer).

Gunther 1932, no. 76, pp. 206, 208; figs. 107, 108.

A132⊙ ASTROLABE ATTRIBUTABLE TO THE LAHORE WORKSHOP

Not dated, 17th century

Diameter 130 mm

London, Science Museum (#1953-264)



Figure A132.1 – Front of the astrolabe (photo courtesy Anthony J. Turner)

This astrolabe is slightly larger than the previous specimen and has a different type of *kursī;* otherwise the rete is exactly similar and the configuration on the back is almost the same. As in the previous astrolabe, here also the plates are held in position by a pin projecting out of the mater a little above the north point. Therefore, these two astrolabes must have been produced by the same maker.

Components

Body with *kursī* (d. 130, h. 163, t. 6.5), ring and shackle, rete (d. 114), 4 plates, alidade, pin and horse.

Front

The ring is larger than the shackle, the shackle is trifoliate. The *kursī* is solid, with complex profiles and two large ornamental holes on each side; the finial does not appear to be trifoliate. The limb is divided in 1° and 5° and numbered in 5s clockwise from 5 to 90, separately in each quadrant.

Rete

The rete is exactly the same as in the previous astrolabe with the same star pointers.

Plates

There are four plates, serving latitudes 18° and 37°; 22° and multiple horizons; 24° and 27°; 30° and 36°. The duration of the maximum daylight is not mentioned on the plates. Altitude circles are drawn for every 6° and azimuth arcs for every 10°. There are lines for seasonal hours and equal hours.

Geographical Gazetteer

As in A0131, here also the inner surface of the mater is filled only in the outer periphery, by the names and coordinates of 42 localities, and a large space in the middle is left empty.

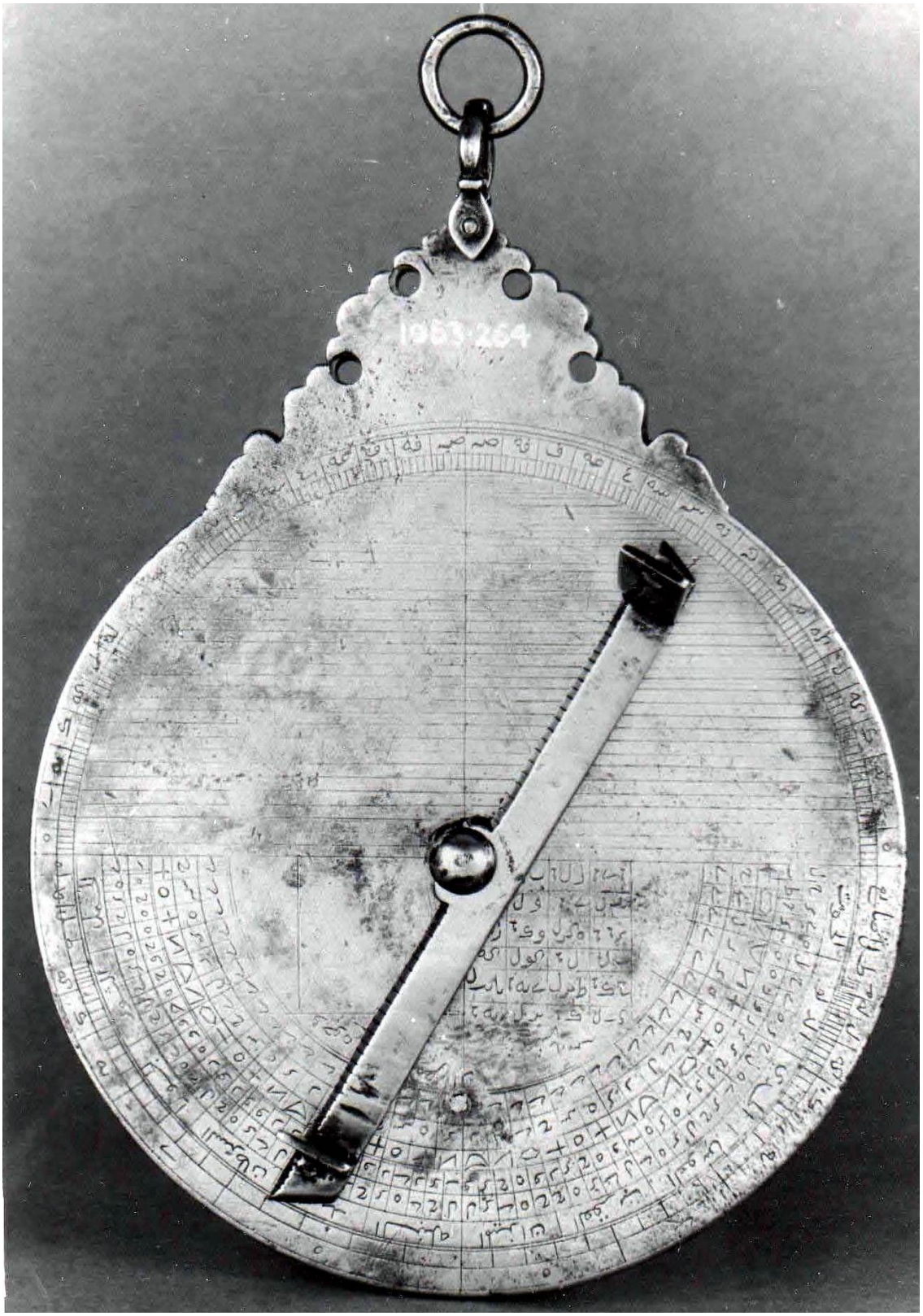


Figure A132.2 – Back of the astrolabe (photo courtesy Anthony J. Turner)

BACK

On the back, the upper half of the rim carries two altitude scales which are divided in 1° and 5° and numbered as 5—90; 90—5. In the previous astrolabe, in the upper left

quadrant, some 36 horizontal parallels are drawn with gradually decreasing intervals. These are drawn in both the upper quadrants in this astrolabe.

The lower half is almost the same as in A131. There are the cotangent scales, the table of limits in rows 1-3 and the table of faces in rows 5-6 as in A131. In row, however, the individual values of each face is given as 10 in each cell, instead of the cumulative values 10, 20, 30 as is the general practice. The label is slightly different: *wujūh wa ḥudūd miṣriyān* (the faces and the limits of the signs according to the Egyptians). There is also the unidentifiable table on the right-hand side. The main difference is row 4 which is filled with strange symbols as shown in Figure A132.3 below.



Figure A132.3 – Unusual symbols in the third row from below (detail of Figure A132.2

ALIDADE

The two ends and the centre-piece of the alidade are plain. The upper edge on both sides is graduated.

A133 ASTROLABE ATTRIBUTABLE TO THE LAHORE WORKSHOP[547]

Not dated, 17th century

Diameter 95 mm

PLU; ex-collection of Henri Michel



Figure A133.1 – Front view of the astrolabe
(photo courtesy of the Museum of the History of Science, Oxford)

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[547] Entry based on the photos in the archives of the Museum of the History of Science, Oxford.

This small astrolabe, dominated by the huge donkey's head adorning the wedge, should be well known to the readers of Henri Michel's *Traitè de l'Astrolabe* (plate XXIII). It was in his personal collection; its present location is not known. The *kursī* is reticulated and carries a trifoliate finial as in the Lahore astrolabes. The configuration on the back with three curves of the meridian altitude of the sun at latitudes 27°, 29° and 32° in the solar quadrant and the astrological table inside the shadow squares are reminiscent of the small astrolabes by Ḍiyā' al-Dīn Muḥammad. But unlike the Lahore astrolabes, the equator is represented on the rete in two segments. Since the solar meridian altitude curve at latitude 29° began to be added on the Lahore astrolabes after Shah Jahan shifted the Mughal capital from Agra to Delhi 1648, this astrolabe may have been manufactured after his date. No details are available save the photos of the front and back.

COMPONENTS

Body with *kursī* (d. 95), ring and shackle, rete, plates (?), alidade, pin and wedge.

FRONT

The shackle is trifoliate and the reticulated *kursī* bears a trifoliate finial. The limb is divided in 2° and 6° and numbered clockwise in 6s from 6 to 90, separately in each quadrant.

RETE

In the rete, the two rings of the Tropic of Capricorn and the ecliptic are held together by the equinoctial bar which has counter changes at its two intersections with the ecliptic ring. The ecliptic ring is divided in 12 signs of the zodiac; in each division the name of the sign is engraved. Each sign is divided in 6° and numbered from 6 to 30. Two large segments of the equatorial ring are represented, one inside the ecliptic ring and the other below it. Traces of the circles of equator and of the Tropic of Cancer are visible on the surface. About 28 named star pointers can be seen in the available photo. These are joined by an irregular tracery.

PLATES

It is not known how many plates are in this astrolabe. In Fig. A133, the plate beneath the rete carries a double projection with altitude circles for every 6° and lines for seasonal hours, but no azimuth arcs.

GEOGRAPHICAL GAZETTEER

No information is available.

BACK

The rim of the upper half carries two altitude scales which are divided in 2° and 6° and numbered in 6s as 6—90; 90—6. In the upper left quadrant are traced 30 horizontal lines. The upper right quadrant is divided by 5 declination arcs into 6 zones, each of which represents a pair of zodiac signs. Three sigmoid curves are drawn here to indicate the sun's midday altitude throughout the year at latitudes 27° (Agra), 29° (Delhi) and 32° (Lahore). The last curve is accompanied by the label *khaṭṭ niṣf al-nahār bi-ᶜarḍ 32* (the line of midday at latitude 32°); the others have shorter labels: *bi-ᶜarḍ 27* and *bi-ᶜarḍ 29.*

Two shadow squares are engraved in the lower half; on the left for a base of 12 and on the right for a base of 7. The vertical and horizontal scales on both sides are divided and numbered accordingly. They are accompanied by the following labels:

Vertical scale on the left:	*ẓill sullam aṣābiᶜ maᶜkūs* (scale of reverse shadows in digits)
Horizontal scale on the left:	*ẓill sullam aṣābiᶜ mustawī* (scale of direct shadows in digits)
Horizontal scale on the right:	*ẓill sullam aqdām mustawī* (scale of direct shadows in feet)
Vertical scale on the right:	*ẓill sullam aqdām maᶜkūs* (scale of reverse shadows in feet).

The lower half of the rim is engraved with two cotangent scales; the scale on the left is in feet; it is accompanied by the label *ẓill aṣābiᶜ* (shadows in digits) and that on the right by the label *ẓill aqdām* (shadows in feet).

Inside the shadow squares there are two semi-circular rows; while the outer one carries the serial numbers of the signs, the inner one carries the names of the 28 lunar mansions.

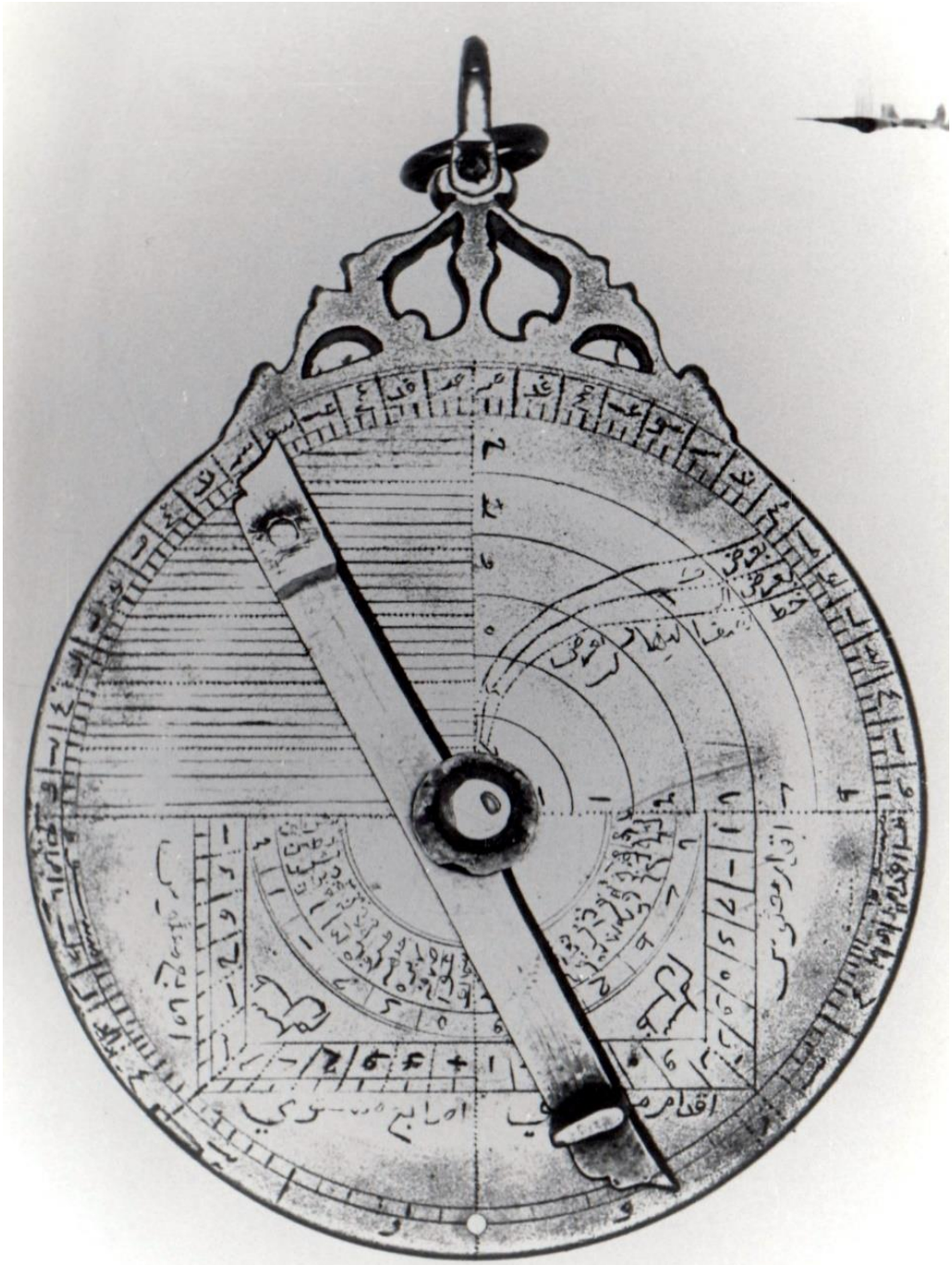


Figure A133.2 – Back view of the astrolabe
(photo courtesy of the Museum of the History of Science, Oxford)

ALIDADE

The alidade has ornate ends and an ornate centre-piece, but is not graduated.

A134 ASTROLABE BY MUḤAMMAD SHARĪF IBN MUḤAMMAD[548]

Not dated, 17th century

Diameter 102 mm

Chicago, Adler Planetarium (# DPW 52)



Figure A134.1 – Front of the astrolabe
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

On the inner surface of the mater, in the middle of the geographical gazetteer is engraved *min sanᶜat muḥammad sharīf ibn muḥammad* around the central hole. Pingree

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548 Entry based on Pingree 2009, no. 34, pp. 160-165.

renders it as 'from the manufacture of Muḥammad Sharīf ibn Muḥammad' and remarks: 'As noted by W. Hartner, this maker is probably identical with Muḥammad Muḥsin ibn Muḥammad ᶜAlī al-Sharīf al-Kirmānī.' Probably because of this assumed identity, Pingree dates this astrolabe ca. 1780. However, Hartner is not listed in the bibliography of Pingree 2009. It is not clear where Hartner made the above mentioned identification. The only place where he could have made such an identification is Hartner 1968, but in this work neither Muḥammad Sharīf ibn Muḥammad is mentioned, nor Muḥammad Muḥsin ibn Muḥammad ᶜAlī al-Sharīf al-Kirmānī.[549]

Leaving aside the above-mentioned inscription in the middle of the geographical gazetteer (it can be a later addition), the astrolabe appears to be a seventeenth-century product of the Lahore workshop, especially the *kursī* and the mater. But the star pointers on the rete are not correctly labelled and some plates are not completely engraved.

The *Abjad* numbers on the limb in the front and those on the rim in the back are large and bold; so also the labels of on the back and on the plate of horizons.

The astrolabe appears to be gilded; the gilding is coming off at the edges of the engravings.

COMPONENTS

Body with *kursī* (d. 102, h. 137, t. 11), ring and shackle, rete, 6 plates, alidade, pin and horse.

FRONT

The ring and shackle are rather plain. The *kursī* is reticulated with a central motif of a small flower with three petals below which is an inverted flower with five petals, a motif which occurs frequently in the Lahore astrolabes.[550] The profiles are made up of ogees at the base followed by a series of lobes. Decorative lines are engraved on both surfaces.

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549 CCA 3521 lists an astrolabe by MUHSIN B M 6AL AL-SHARIF AL-KIRM in PBC (Paris, Alain Brieux Collection); but gives no other particulars. Since the late Alain Brieux's collection is all dispersed, it is not possible to trace this particular item.

550 See, e.g. A127.

The limb carries two bands; the inner band is graduated in 1° and the much wider outer band in 6° and numbered clockwise from 5 to 90, separately in each quadrant.

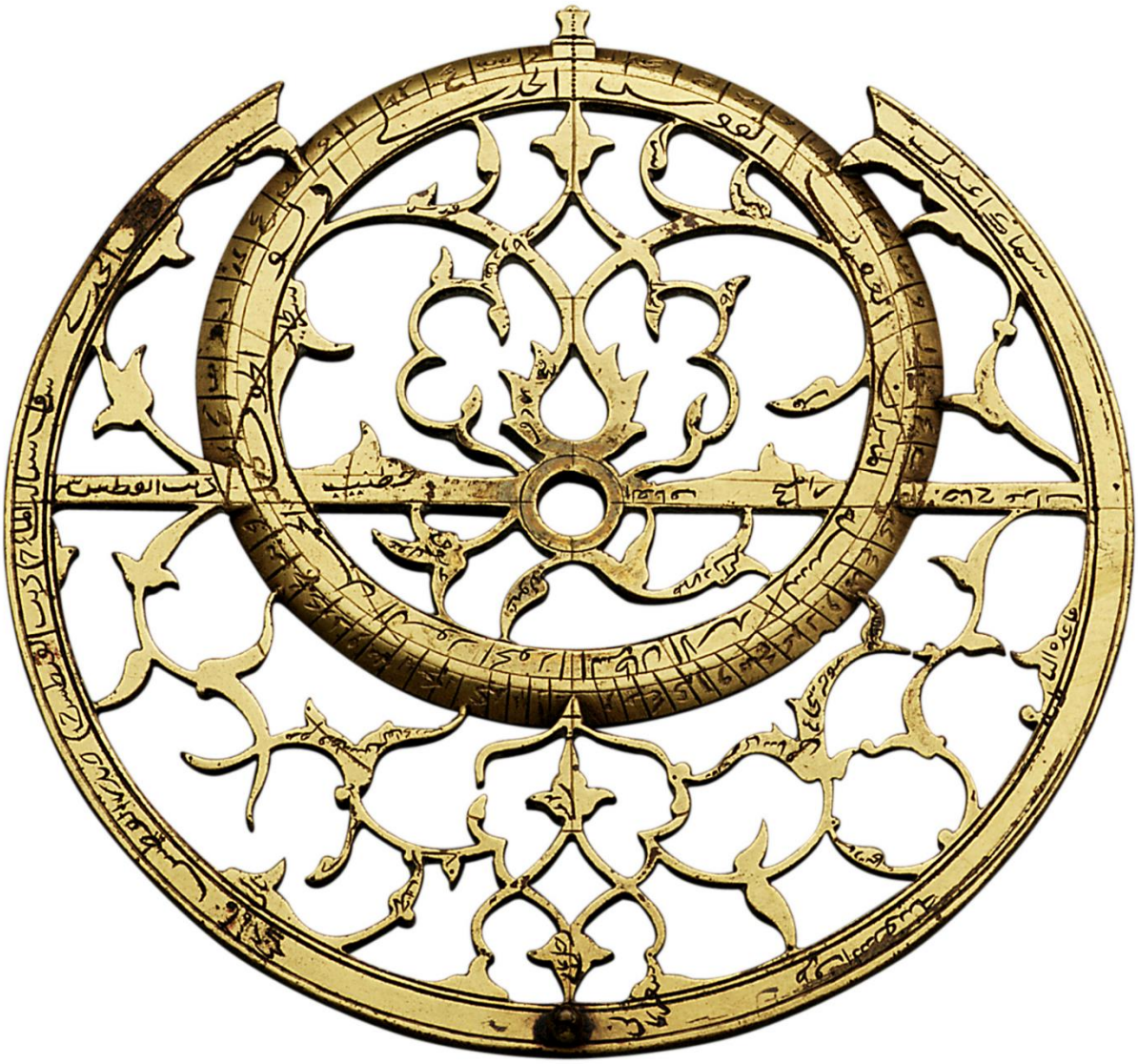


Figure A134.2 – Rete of the astrolabe
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

RETE

The rete and the plates display the same kind of workmanship with the rim fashioned in the same manner. On the rete, and also on all the plates, immediately inside the edge, a single circle is drawn and a little away from the edge two concentric circles are drawn to represent the Tropic of Capricorn. The ring of Capricorn and the wider ring of ecliptic are held together by the equinoctial bar which is without counter change and by the almost symmetric tracery that joins the star pointers. There a handle at the north point and an ornate Capricorn index at the south point.

Superficially the rete appears to be well-made, especially the ecliptic with its sloping edge. It is divided into the 12 signs of the zodiac and their names are carefully engraved. Each sign is divided in 6°, and these divisions are numbered from 6 to 30 on the sloping edge; it is rather unusual to engrave the numbers on the edge and there are errors in certain places.

More problematic are the names engraved on the star pointers. Many star pointers are uninscribed and some star names are engraved at wrong places; e.g. the pointer of *Qalb al-ᶜAqrab* (α Scorpionis) is given the label *Simāk Aᶜzal* (α Virginis); the pointer of *Dhanab al-Qayṭus Janūbī* (β Ceti) is given the name *Sāk Sāqib al-Mā' J[anūbī]* (δ Aquarii); the name *ᶜAyyūq* (α Aurigae) is engraved at two different places. Of the star name *Kaff al-Kaḍīb* (β Cassiopeiae), *Kaff* is at one place and *Khaḍīb* at another place. Likewise, in *Mankib al-Faras* (β Pegasi) the two words are placed at different locations.

Either the rete is a fake or the artisan engraved the star names with extreme carelessness. It is too good to be a fake; on the other hand, it is impossible to believe that an assistant in the Lahore workshop can be so careless. In either case, the rete does not serve its purpose.

PLATES

There are six plates, all with a notch at the north point; the plug at the corresponding place inside the raised rim is lost; there remains just a hole.

Table A134-1 Plates

	φ	Longest Day
1a	72°+18°	double projection
1b	27°	13;43 hours 34;7 *kurrī* (=*ghaṭī*)
2a	Plate of ecliptic coordinates	
2b	23;30°[551]	13;24 hours
3a	32°	14;8 hours

[551] Pingree 2009 attributes this plate to 33°.

	φ	Longest Day
3b	18°	13;9 hours
4a	36°	14;32 hours
4b	40°	14;54 hours
5a	30°	southern projection
5b	21°	13;19 hours
6a	25°	13;25 hours
6b	Plate of horizons	

On all latitude plates altitude circles are drawn for 6°. Azimuth arcs are traced for every 10°;[552] sometimes below the horizon (1a, 2b, 3a, 4b, 6a), sometimes above the horizon (3b, 5b) and once above and below the horizon (4a).

In the lower half, there are plain lines for seasonal hours on all plates; dotted lines for equal hours are drawn from the western horizon on some plates (3a, 4b) and from both the western and eastern horizons on some other plates (1b, 2b, 3b, 5b). On 6a, there are no lines for equal hours.

Plate 2a was intended to be prepared as the plate of ecliptic coordinates, but is not completed.[553] Horizontal and vertical diameters are drawn as dotted lines and the circles of equator and tropic of cancer are traced as plain lines. Altitude circles are drawn for every 6°. Longitude circles radiating from the zenith are drawn for every 6° and those for 30° are dotted. But the ecliptic circle is not drawn and no signs are marked. The longitude circles are not numbered; but the altitude circles are numbered incorrectly.

Plate 5a carries altitude circles in southern projection for latitude 30°. They are drawn for every 6° drawn below the horizon up to the north point and numbered 6 to 90. At line 30° which is a straight line, there is a label *ᶜarḍ janūbī 30 ᶜarḍ janūbī 30*

552 Pingree 2009 states that no azimuth arcs are drawn on 1b, 2b, 3a, 4b and 6a, but they all have azimuth arcs for every 10°!

553 Pingree 2009 attributes this plate to 36° and adds that altitude circles and azimuths are drawn in both hemispheres, which is not the case.

(southern latitude 30°, southern latitude 30°).[554] Azimuth arcs are drawn above the horizon and numbered from the meridian below the centre from 10 to 90 and then in the reverse direction from 10 to 90 up to the meridian above zenith.

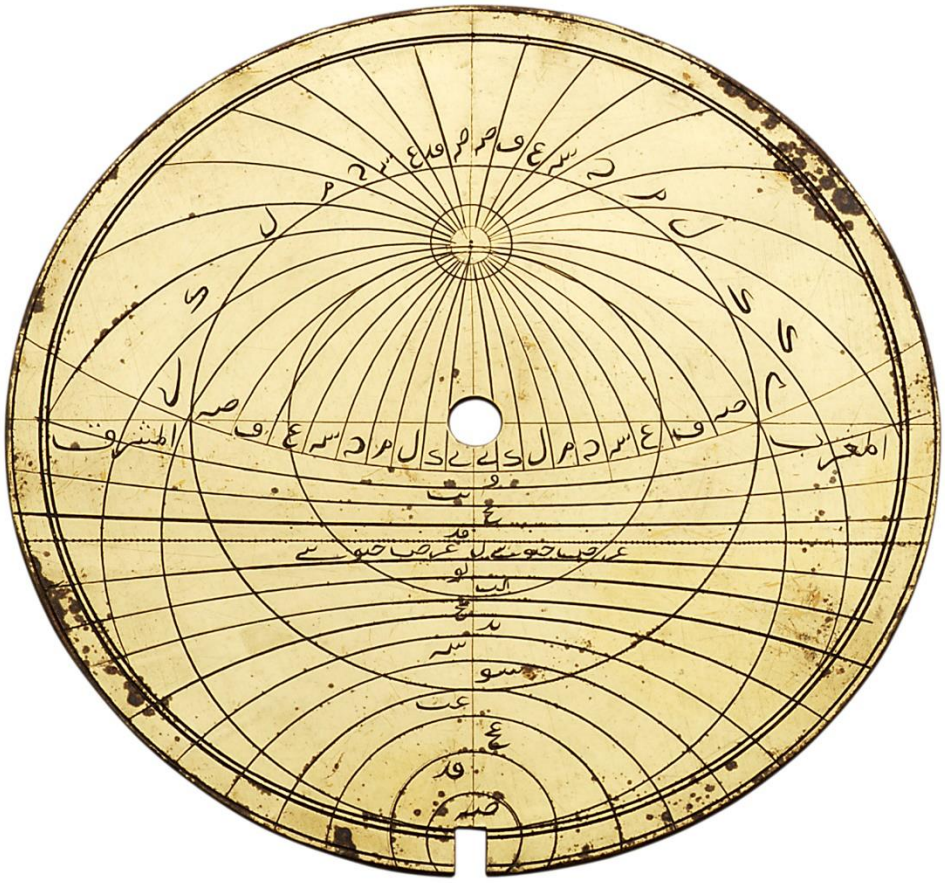


Figure A134.3 – Plate 5a for 30° S
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

554 Cf. Figure A013.6, A057, D025.5 for similar southern altitude circles.



Figure A134.4 – Geographical Gazetteer
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

GEOGRAPHICAL GAZETTEER

The geographical gazetteer of provides the names, longitudes and latitudes of 69 localities in 3 circles. It commences with Miṣr in the inner circle and proceeds from right to left in each circle.[555] Interestingly more than half the localities are from the Indian subcontinent.

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555 Pingree 2009, p. 163, reads it from the outer circle and from left to right in each circle.

Table A134-2 Geographical Gazetteer

	Place Names (*al-buldān*)	L (*al-ṭūl*)	φ (*al-ᶜarḍ*)
	Inner Circle		
1	Miṣr	63;20	30;20
2	Madīnat Ṭayyiba	75;20	25;0
3	Makka Masharraf	77;10	21;40
4	Bayt al-Maqdis	66;30	31;50
5	Dimashq	70;0	33;15
6	Ḥalab	72;10	35;50
7	Marāgha	82;0	37;20
8	Tabrīz	82;0	38;0
9	Kūfa	79;10	31;30
10	Baghdād	82;0	33;25
11	Baṣra	84;0	30;11
12	Fīrūzābād	84;30	28;10
13	Shīrāz	83;0	29;36
14	Yazd	89;0	32;0
15	Qaz[w]īn	85;0	36;0
	Middle Circle		
16	Iṣfahān	87;40	22;26
17	Kāshān	86;0	36;0
18	Basṭām	89;30	36;10
19	Sabzawār	91;30	36;0
20	Mashhad	92;30	32;0
21	Harāt	94;20	34;30

	Place Names (***al-buldān***)	**L** (***al-ṭūl***)	**φ** (***al-ᶜarḍ***)
22	Balkh	91;0	36;41
23	Badakhshān	94;24	34;10
24	Bukhārā	94;30	39;50
25	Samarqand	99;36	39;32
26	Khujand	100;35	41;55
27	Kāshghar	106;30	44;0
28	Khutan	107;0	42;0
29	Hurmūz	92;0	25;0
30	Kirmān	91;30	30;5
31	Ghazna	104;20	33;35
32	Kābul	104;40	34;50
33	Daybul	102;30	25;10
34	Qandahār	107;40	33;0
35	Tubbat	110;0	40;0
36	Kashmīr	108;0	35;0
37	Multān	107;35	29;40
38	Lāhūr	109;20	31;50
	Outer Circle		
39	Ḥaḍrat Dihlī	113;35	28;19
40	Akra	115;0	27;43
41	Qannawj	115;50	26;35
42	Banāras	117;20	26;52
43	Kawāliyar	114;0	26;29
44	Ajmīr	111;5	26;0

	Place Names (*al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-ᶜarḍ*)**
45	Awadh	113;6	27;22
46	Kūpāmāū	116;43	26;45
47	Lahknawtī	114;33	26;30
48	Karah wa Mānikpūr	113;10	29;49
49	Hānsī	112;25	29;45
50	Bānībatah	113;20	28;52
51	Sunām	112;25	30;30
52	Badā'ūn	114;19	27;32
53	Sulṭānkūt	115;0	23;30
54	Sanbhal	115;0	28;28
55	Tānīsar	112;23	30;10
56	Kūl Jalālī	114;19	28;10
57	Siyālkūt	109;0	38;0
58	Nawshahr	105;14	28;10
59	Purushawar	105;14	31;0
60	Jamkūt	177;0	5;0
61	Jidda	76;0	21;0
62	Sarūj	72;40	34;50
63	Ujjayn	110;50	23;30
64	Jawnbūr	119;6	26;36
65	Burhānbūr	108;0	20;30
66	Bījāpūr	105;30	16;20
67	Kūlkunda	114;19	18;10

	Place Names (*al-buldān*)	**L** (*al-ṭūl*)	**φ** (*al-ᶜarḍ*)
68	Kanbayāt	109;10	22;20
69	Sarandīp	130;0	10;0

BACK

Like the limb in the front, the rim on the back is also divided in a narrow inner band and the much wider outer band. The upper half of the rim is divided in 1° in the inner band and in 6° in the outer band; the outer band is numbered as 5—90; 90—5.



Figure A134.5 – Back of the astrolabe
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

The trigonometric quadrant in the upper left carries 30 horizontal lines with each third highlighted with dots. On the solar quadrant in the upper right, declination arcs are drawn for each 10° of solar longitude. The names of the corresponding signs and their divisions of 10° are inscribed along the two radii. Two sigmoid graphs of the sun's meridian altitude at latitudes 27° and 32° are plotted along with the labels *khaṭṭ niṣf al-nahār bi-ᶜarḍ 27* and *khaṭṭ niṣf al-nahār bi-ᶜarḍ 32.*

Shadow squares are drawn in the lower half, on the left for a base of 12 and on the right for a base of 7; the vertical and horizontal scales are divided accordingly and are accompanied by the usual labels. Inside the shadow squares is a semi-circular table of the planetary regents (denoted by the final letters of their names) of the triplicities, arranged in four groups according to the elements: *nārī* (fiery), *tarābī* (earthy), *hawā'ī* (airy) and *māhī* (watery).

The shadow squares are enclosed by two semi-circular rows filled with the names of the zodiac signs and with those of the lunar mansions respectively. The lower half of the rim carries cotangent scales and their subdivisions. The scales are numbered in 6s from 6 to 42, followed by labels, on the left *al-aṣābiᶜ* and on the right *al-aqdām.*

Alidade

The alidade is endowed with ornate terminals and an ornate centre-piece. The right hand side is engraved with a sexagesimal scale, numbered in 6s from 6 to 60, starting from the centre and going up to the tip. The lower register on the same side is marked with numbers of seasonal hours to be used when the alidade is employed as a sundial.

The left hand side of the alidade is engraved with declination arcs and with the serial numbers of the corresponding zodiac signs.

The broad-headed pin has a finely shaped spherical end which projects out on the front of the astrolabe. The wedge is shaped like a horse's head with mouth, eye and an upright ear.

Inscription

In the middle of the geographical gazetteer, around the centre is engraved

min sanaᶜat muḥammad sharīf ibn muḥammad

'of the work of Muḥammad Sharīf ibn Muḥammad.'

It is an unusual place to inscribe the astrolabe maker's signature. Either it was added later or this Muḥammad Sharīf was somehow connected with the workshop of the Lahore family.

PROVENANCE

Mercator, Paris, 1921; Richard Wheatland, Sr., 1921; David P. Wheatland, Topsfield, MA, 1943; AP gift, 1988.

BIBLIOGRAPHY

Pingree 2009, no. 34, pp. 160-165.

B. INDO-PERSIAN ASTROLABES PRODUCED BY OTHERS

INTRODUCTION

Compared to the output of the various members of the Lahore family, the astrolabes produced by instrument makers outside this family are not many. As against the 130 and odd surviving astrolabes of the Lahore family, those produced by others in the sixteenth and seventeenth centuries do not even come up to a score. Likewise, the names of the instrument makers who are not member of this family can be counted on one's fingers.

In the seventeenth century, Pandit who produced the bilingual astrolabe B002 and possibly his teacher were active at the court of Jahāngīr at Agra; ᶜAbd al-Qādir Muḥibb and his son Ibn Muḥibb Ḥaqīqa, and Muḥammad Ṣāliḥ of Thatta were engaged in instrument production in Panjab. While ᶜAbd al-Qādir Muḥibb does not show any familiarity with the Lahore astrolabes, his son Ḥaqīqa and Ṣāliḥ emulate in their astrolabes certain features of the Lahore astrolabes. Two outstanding astrolabes of the seventeenth century are the bilingual astrolabe of 1616 by Pandit (B002) and the Frankfurt astrolabe by ᶜAbd al-Qādir Muḥibb of about the same period (B006).

Of the eighteenth century, just one astrolabe bearing a date at the beginning of the century (B017) and another produced towards the end of century (B018) are extant. A third astrolabe (B019) may also have been made by the same person who produced B018. It is inexplicable why there was such a shortfall in the production of astrolabes in this century. Lack of patronage could not have been the reason; even in the nineteenth century, several princely states patronised instrument makers. Moreover, the theory and practice of the astrolabe continued to be taught in madrasas in the Indian subcontinent. Even if the teachers and pupils used simple astrolabes, some of these should have survived.

However, towards the middle of the nineteenth century, there was an upsurge in the production of astrolabes. This happened not through any external causes, but due to a remarkable man, Lālah Bulhomal Lāhorī, who was at home both in the Islamic and the Sanskrit traditions of astronomical instrumentation and was also exposed to the new developments taking place in Europe. He was attached to the court of Kapurthala.

Bulhomal, a Hindu of Khatri caste, together with his associates — two Muslims named Pīr Bakhsh Lāhorī and Ghulām Qādir Kapūrthalī, and a Hindu Brahmin Joshī Dharm Chand— made Lahore once again a vibrant centre of production of astronomical instruments. I have counted 45 instruments of diverse types, with legends either in Arabic/Persian, or in Sanskrit, or in English, produced by Bulhomal and his associates in and around Lahore towards the middle of the nineteenth century.[556]

Aside from this group around Bulhomal of Lahore, two other names are known. Muḥammad Faḍl Allāh was associated with the court of the Nizam of Hyderabad. A celestial globe made by him in 1808 is extant.[557] His grandfather Muḥammad Mūsā, a resident of Aurangabad, sported the sobriquet *asṭurlābī.* He must have produced astrolabes in the eighteenth century, but none came to light. The second is Ghulām Ḥussayn Jawnpūrī who was the court astronomer of the Raja of Tikari in Bihar. He composed a large encyclopaedia of astronomy and mathematics entitled *Jāmiᶜ Bahādur Khānī* in Persian in 1833; a lithograph edition was published from Calcutta in 1835.[558] In the second chapter of the fifth book of this work, he describes the construction and use of 12 different astronomical instruments together with their illustrations. These are the celestial globe, astrolabe, sine quadrant, *dhāt al-ḥalqatayn* (double ring), *labna* (meridian wall or mural quadrant), *suds-i fakhrī* (Fakhrī sextant), *dhāt al-ḥalaq* (armillary sphere), *dhāt al-shuᶜbatayn* (triquetrum), *dhāt al-thuqbatayn* (dioptre), *ḥalqā-i iᶜtidālī* (horizontal ring), *shāmlah ufaqī* and *suds-i inᶜikās*. Ten of these are traditional Islamic instruments and the last two are of European origin. *Shāmlah ufaqī* consists of a mounting system for the telescope which can be rotated in horizontal as well as in vertical planes. *Suds-i Inᶜikās* is Hardley's Reflecting Sextant.[559]

What is of immediate interest for us is that a celestial globe made by him in 1816 is extant and will be described below (G006).[560] It is possible that he may have also

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556 Sarma 2015b; see also the short introduction to his work in the following pages.

557 Sarma 1996a, pp. 27-28.

558 Jawnpūrī 1835.

559 Ansari & Sarma 1999-2000.

560 Ansari & Sarma 1999-2000, pp. 84-87, Figs. 1-4.

produced astrolabes and other instruments, but these have not come to light so far. His illustration of the astrolabe is reproduced below.

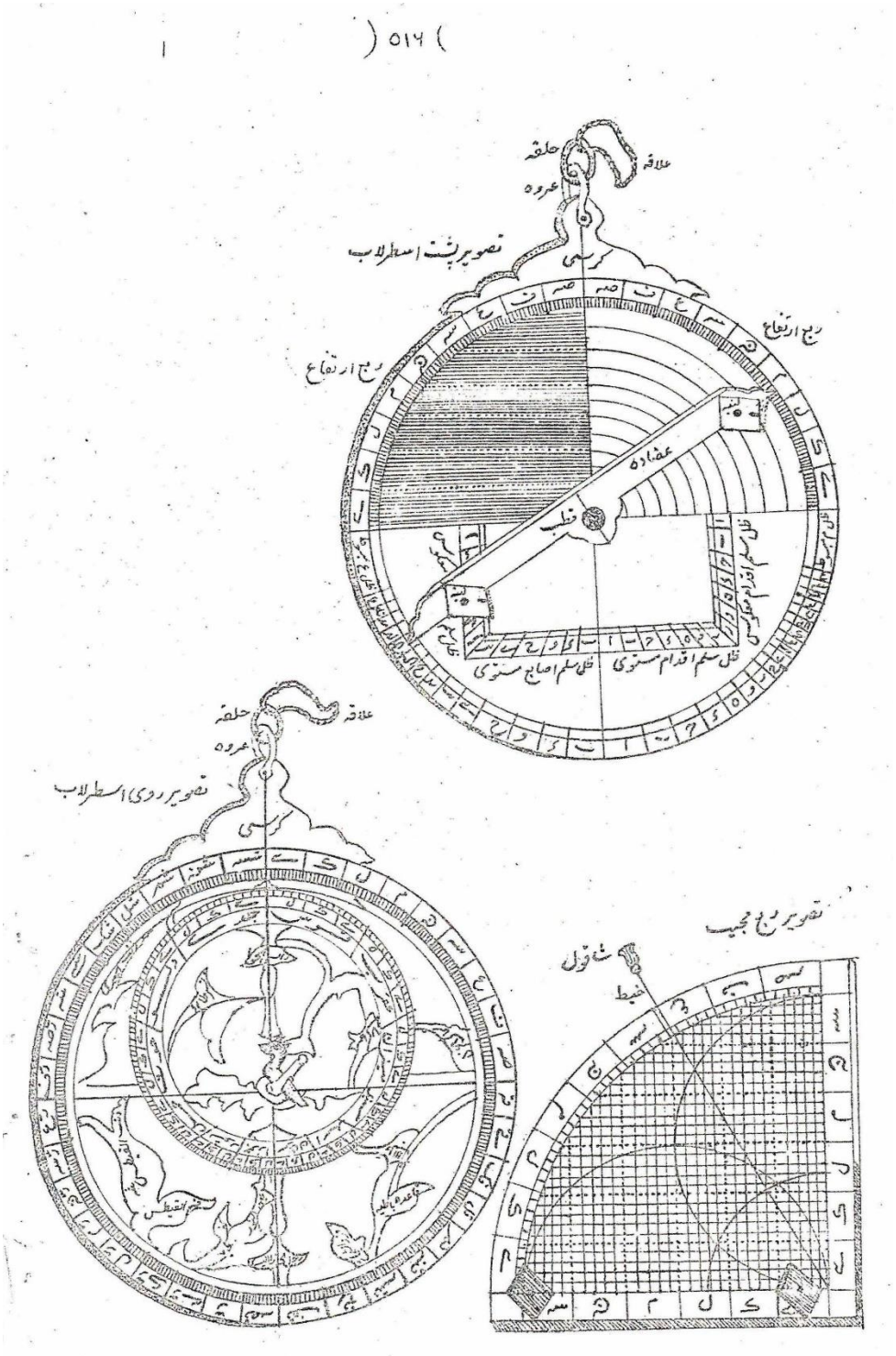


Figure B1 – Illustrations of the astrolabe (front and back) and sine quadrant (from the *Jamiᶜ-i Bahādur Khānī,* p. 516)

B001 COPY OF AN ASTROLABE OF MĪRZĀ BĀYSUNGHUR[561]

1587, Lahore

Diameter 151 mm

Moscow, The State Museum of Oriental Art



Figure B001.1 – Front of the astrolabe (© The State Museum of Oriental Art, Moscow)

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561 Entry based on Maslikov & Sarma 2016.

The inscription on the front of the *kursī* states that the astrolabe was copied (*naql shud*) from an astrolabe belonging to Haḍrat Mīrzā Bāysunghur in the year 996 AH (AD 1587-88) in the city of Lahore. There are at least three historical figures named Bāysunghur in the fifteenth century. One is Giāṭ al-Dīn Bāysunghur (1397-1433) who was a brother of the more famous Ulugh Beg. The second was the son of the first Bāysunghur and ruled Khurāsān from 1449 to 1457. The third one also belonged to the same Timurid family and ruled Samarqand from 1490 to 1493. It is not certain to which of these three belonged the original astrolabe, which was copied at Lahore in 1587. But it certainly was associated with an exalted family.

This astrolabe is relevant in this catalogue for two reasons: first, although it is a copy, it is the second extant dated astrolabe produced in Lahore, after Allāhdād's astrolabe of 1567 (A001). Secondly, the rete in this astrolabe has close similarity to the rete in Allāhdād's astrolabe of 1567, in its form as well as in the star pointers in it.



Rete in Allāhdād astrolabe of 1567 Rete in the copy of 1587

Figure B001.2 – Comparison of the two retes

The copy of 1587 has 33 star pointers with their names engraved as follows:

Table B001-1 Stars on the Rete

	Star Name	Identification
1	*Kaff al-Khaḍīb*	β Cassiopeiae
2	*Dhanab al-Qayṭus Janūbī*	β Ceti

	Star Name	Identification
3	*Baṭn al-Ḥūt*	β Andromedae
4	*Fam al-Qayṭus*	γ Ceti
5	*Ghūl*	β Persei
6	*cAyn al-Thawr*	α Tauri
7	*cAyyūq*	α Aurigae
8	*Rijl [al-Jawzā'] al-Yusrā*	β Orionis
9	*Muqaddam al-Minṭaqa*	δ Orionis
10	*Yad al-Jawzā' al-Yumnā*	α Orionis
11	*Shicrā Yamānī*	α Canis Majoris
12	*Shicrā Shāmī*	α Canis Minoris
13	*Nathra Saḥābī*	ε Cancri
14	*Fard al-Shujāc*	α Hydrae
15	*Qalb al-Asad*	α Leonis
16	*Ẓahr al-Asad*	δ Leonis
17	*Ṣarfa*	β Leonis
18	*Janāḥ al-Ghurāb*	γ Corvi
19	*Simāk Aczal*	α Virginis
20	*al-ᶜAnāq*	ζ Ursae Majoris
21	*Simāk Rāmiḥ*	α Bootis
22	*Nayyir al-Fakkā*	α Coronae Borealis
23	*ᶜUnuq al-Ḥayyah*	α Serpentis
24	*Qalb al-cAqrab*	α Scorpii
25	*Rās al-Ḥawwā*	α Ophiuchi
26	*Nasr Wāqic*	α Lyrae

	Star Name	Identification
27	*Rās al-Jāthī*	α Herculis
28	*Minqār al-Dajājah*	β Cygni
29	*Nasr Ṭā'ir*	α Aquilae
30	*Dhanab al-Jadī*[562]	δ Capricorni
31	*Fam al-Faras*	ε Pegasi
32	*Mankib al-Faras*	β Pegasi
33	*Sāq Sākib al-Mā'*[563]	δ Capricorni

However, the rete in Allāhdād's undated astrolabe at Oxford (A002) has a totally different design in which the various star pointers are joined by an elegant floral tracery of tendrils, leaves and flowers. Such floral traceries became the characteristic feature of most of the astrolabes of the Lahore family. As against these aesthetically pleasing floral retes, the rete in the astrolabe of 1567 sticks out as a sore thumb. The only possible explanation is that Allāhdād knew the original astrolabe belonging to Mīrzā Bāysunghur which must have been in Lahore in the latter half of the sixteenth century. Because of the exalted position of its owner, Allāhdād imitated its rete in his astrolabe of 1567 (it was also imitated in A003which is attributable to Allāhdād and in Muqīm's undated astrolabe A033).

This assumption is reinforced by the fact that some other patron got made a complete copy of Bāysunghur's astrolabe at Lahore in 1587 and proudly proclaimed the fact in the inscription on the front of the *kursī.* We know at least one more case where a copy was made of the astrolabe belonging to an illustrious person. Shāh Abbās of Iran is said to own an astrolabe belonging to Ulugh Beg; as a diplomatic gesture, he gifted it to the Mughal Emperor Jahāngīr and got a copy made for himself.[564]

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562 Wrongly named *Dhanab al-Ḥūt.*

563 Wrongly named *Dhanab al-Jadī.*

564 Sarma 2011a, p. 112.

Shāh Abbās may have had a competent artisan to make a copy of Ulugh Beg's astrolabe. But the patron at Lahore was not so lucky with his copy which was fabricated by at least two artisans. The first artisan produced the rete, the alidade and one plate with projections for Mecca on one side and with multiple half-horizons on the other, reasonably well. The second artisan made the mater and four latitude plates most incompetently. The enigmas in the construction of this copy of 1587 are discussed elsewhere in great detail.565 They are not pertinent here. What is pertinent is the reason for the strange alidade in Allāhdād's astrolabe of 1567. The copy of 1587 offers a plausible reason.

BIBLIOGRAPHY

Maslikov & Sarma 2016.

565 Maslikov & Sarma 2016.

B002⊙ BILINGUAL ASTROLABE MADE BY PANDIT AT THE COURT OF JAHĀNGĪR[566]

11th regnal year of Jahāngīr (AD 1616-17)

Diameter 402 mm

Varanasi, Sampurnanand Sanskrit University, Saraswati Bhavan Library



Figure B002.1 – Front of the astrolabe (photo by S. R. Sarma)

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[566] This is an abridged version of Sarma 2011a.

In this bilingual astrolabe the legends are in Arabic/Persian and in Sanskrit; the scales are labelled in the *Abjad* notation and also in Devanagari numerals. A long Persian inscription occupying the entire upper right quadrant at the back informs that the astrolabe was produced in the eleventh regnal year of Mughal Emperor Jahāngīr, i.e. in AD 1616-17. But the name of the astrolabe maker as engraved in the inscription is problematic. His first name is indicated by the two letters *alif* and *wāw* without any diacritical points. The second name is given as *pandit.* The designation 'Pandit' suggests that he was a Hindu and a Brahmin. Since no diacritical points are added, the personal name of this Brahmin cannot be fully reconstructed; it can be 'Attū', 'Appū', 'Abīv' and the like, but none of these is satisfactory as the personal name of a Brahmin. Henceforth, he will be simply called 'Pandit'. About his identity, he refers to himself as 'the lowliest of the disciples' (*kamtarīn murīdān*) of Jahāngīr. Professor Irfan Habib, who kindly deciphered the long inscription and translated for me, informs that the expression is used by those employed in the court in relation to the emperor.

As will be shown in the sections on Sanskrit astrolabes, Brahmin astronomers held the astrolabe in high esteem. They composed many manuals in Sanskrit on its construction and use. They also got astrolabes produced in great numbers with Sanskrit legends for their use. However, not one of the Sanskrit astrolabes was actually manufactured by a Brahmin. It was always made by a low-caste brass-worker according to the technical drawings prepared by the Brahmin astronomer.

In these circumstances, this Pandit seems to be the only Brahmin who took to astrolabe making. Even more surprising is the fact that he sets out to produce, not a Sanskrit astrolabe, but a bilingual astrolabe, mainly with Persian labels and inscriptions which are frequently augmented by Sanskrit labels. However, Pandit's Persian is not elegant and his calligraphy is rather poor. His Sanskrit names are full of errors. He must be a Brahmin apprentice of an established Muslim astrolabe maker at Jahāngīr's court and tried his hand to produce a bilingual astrolabe.

This astrolabe differs from the astrolabes of the Lahore family in certain respects. Of course, when this astrolabe was made in 1616, only the astrolabes by Allāhdād and his son ʿĪsā had appeared. These, however, contain already the main features of the Lahore family which have been perpetuated by the succeeding members of the family. The *kursī* is plain in the present astrolabe. On its back, there are no graphs for the

meridian altitude of sun and no astrological tables. What is more important, the plates carry the names and latitudes of some localities which lie close to the latitude of the plate and where the same plate can be used for observation. On the rete the floral tracery joining the star pointers has a particular pattern which is emulated at least in nine Sanskrit astrolabes.[567]

Pandit did not make these deviations on his own. He must be following the style of his *ustād* which differed in this manner from the Lahore astrolabes. Therefore, Pandit's bilingual astrolabe, though not an outstanding specimen of the art or science of the astrolabe, is nevertheless an important historical document in that it testifies the existence of a certain style of Indo-Persian astrolabes which is distinct from that of the Lahore family and which exercised a greater influence on the style of Sanskrit astrolabe design than the Lahore school did.

COMPONENTS

Body with *kursī* (d. 402, h. 506, t. 13), ring and shackle, rete (d. 368, t. 3) for 28 stars, 4 plates (d. 368, t.1), alidade, pin, wedge.

FRONT

This is a massive astrolabe made of brass with a diameter of 402 mm and a thickness of 13 mm, weighing more than 5 kg. It is well crafted and the geometrical lines are drawn accurately and neatly. It is in a fairly good state of preservation,[568] but for the heavy patina on many of the plates.[569]

The *kursī* is high and solid with its profiles shaped in the form of four ascending lobes. At the base of the profile on each side, there is a projection resembling a tiger's claw. The top of the *kursī* is shaped as a trefoil, to which is attached the shackle, the two

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567 Sarma 2011a, pp. 107-110, Fig. 8.

568 At three places where damages were repaired: a large patch of brass hammered to the back of the crown; on the inner surface of the mater, two small patches of brass were added just above the gazetteer and on either side of the south point.

569 Therefore, it was difficult to photograph the engravings on the plates. Because of the large size, photographing the astrolabe in general was very difficult, before the advent of the digital cameras. The late Professor R. C. Sharma, the then Director of the Bharat Kala Bhavan Museum of the Banaras Hindu University, very kindly lent me the services of the museum photographer P. S. Prakasa Rao who took the photos of this astrolabe.

terminals of which also have the form of a trefoil. A rather large ring passes through the shackle. The crown, the main circular body and the upraised rim or limb are all cast as a single piece.

The *kursī* is plain without any surface decoration. On the front side, there is an inscription in large letters, which reads *Allāhu Akbar*. Just above this is engraved, in relatively smaller letters, *śrīḥ* (auspiciousness) in Devanagari, which is preceded and followed by two vertical strokes.

The limb is engraved with a double band of scales. The inner band is graduated in single degrees. The outer band is divided into groups of 5° and is numbered from 5 to 90 separately for each quadrant in the *Abjad* notation and in Devanagari numerals, the former occupying the left half of each cell and the latter the right half. However, most unusually, the numbers proceed anti-clockwise and not clockwise as is the usual practice.

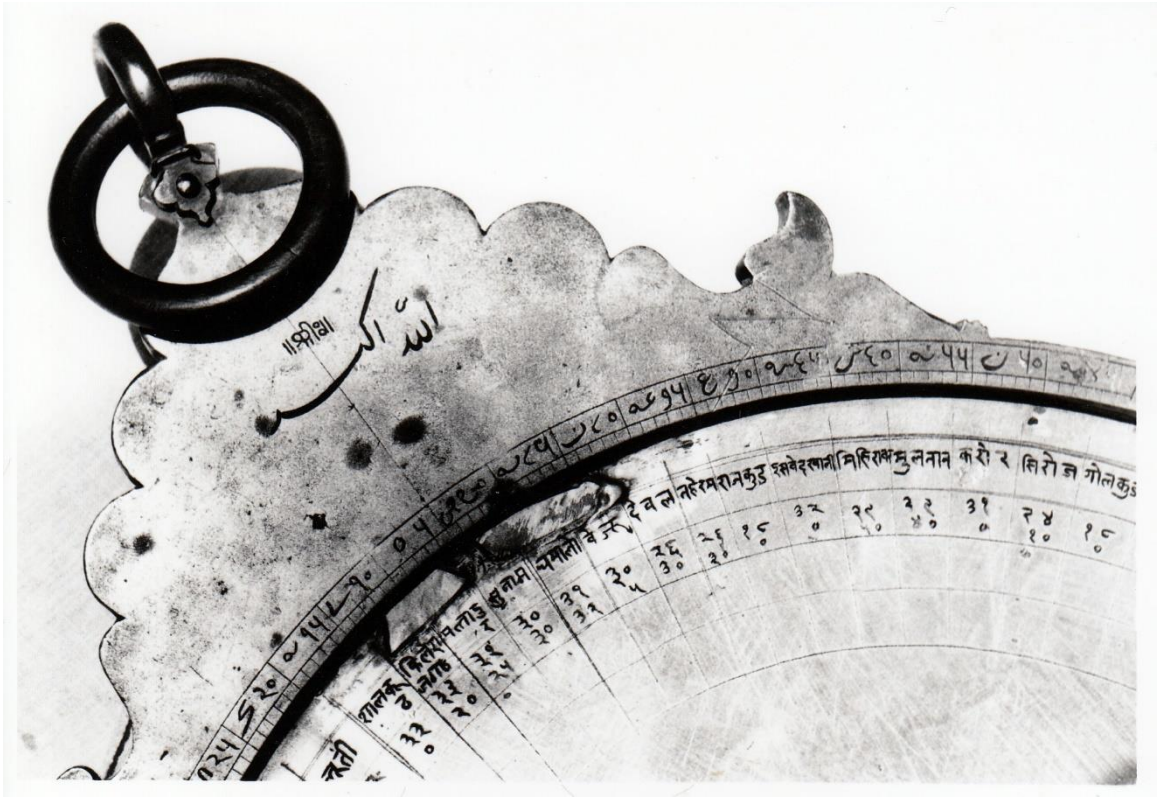


Figure B002.2 – The *kursī* and the limb of the astrolabe. (photo by P. S. Prakasa Rao)

On the limb, numbers proceed anti-clockwise from the south point; Devanagari numerals are on the right and the *Abjad* symbols on the left

RETE

The rete consists of a broad ring that contains the ecliptic circle. The ring bearing the circle of the celestial equator, which is interrupted where it intersects with the ecliptic, is somewhat narrow, so also the ring bearing circle of Capricorn which forms the outer periphery. There is a small ring around the hole at the centre. These four rings are held together by the east-west equinoctial bar which is without counter change. Unusually, the lower half of the equator ring is joined to the east-west bar by a small band which is bent at right angles.

The ecliptic is divided into the 12 zodiac signs; the signs are labelled in Arabic as *al-Ḥamal* (Aries), *al-Thawr* (Taurus), *al-Jawzā'* (Gemini), *al-Saraṭān* (Cancer), *al-Asad* (Leo), *al-Sunbulah* (Virgo), *al-Mīzān* (Libra), *al-ᶜAqrab* (Scorpio), *al-Qaws* (Sagittarius), *al-Jadī* (Capricorn), *al-Dalw* (Aqarius) and *al-Ḥūt* (Pisces). These names are engraved with a horizontal flourish that stretches across the entire length of 30°. In the space above this flourish, names in Sanskrit have been added, but only from Cancer to Capricorn: *Karka* (Cancer), *Siṃha* (Leo), *Kanyā* (Virgo), *Tulā* (Libra), *Vṛścika* (Scorpio), *Dhana* (sic! read *dhanuḥ*) (Sagittarius), *Makara* (Capricorn). The outer edge of the ecliptic is bevelled and graduated in single degrees. Groups of 3° are numbered in Devanagari only, separately for each sign from 3 to 30, starting from the east point and proceeding anti-clockwise.

From the centre, twelve radial lines are drawn up to the ecliptic, dividing it into the 12 signs of the zodiac. These lines can be clearly seen on the central ring and also on some star-pointers. They are drawn on the reverse side as well.

On the ring of the equator where it intersects the ecliptic in the east is a small knob with which the rete can be rotated around the centre.

From the ring of Capricorn and from the east-west bar, there arise short creepers which terminate in what look like leaf clusters, or tulip flowers with two or three outstretched petals, the tips of which function as star pointers. The astrolabe maker tried to achieve a perfect lateral symmetry around the vertical axis in the arrangement of creepers and flowers with which the star pointers are joined. Though pretty, the rete is not crafted as delicately as in the Lahore astrolabes. It also contains fewer star pointers as compared to the Lahore astrolabes.

The rete has yet a characteristic pattern. There is a small ring around the central hole, on which is perched a dove-like bird with raised neck. The tip of its beak points to the star *Nasr Wāqi*^{c} (α Lyrae). The figure of the bird is framed by two creepers that arise from the ring, encircle the bird, and then entwine together for a short while along the south-north solstitial bar, then branch off and, after touching the inner periphery of the ecliptic ring, bend downwards and terminate in three-petalled flowers just as they reach the upper part of the equator ring. Thus the two creepers look like the mirror images of the Roman letter 'S' joined together. The bird representing Vega looks as if it is sitting inside a cage formed by the two creepers. Above the cage, there is a rounded M-like figure, the lower tips of which terminate in the star pointers of *Nasr Tā'ir* (α Aquilae) and *Rās al-Ḥawwā* (α Ophiuchi). I call this 'bird in a cage' pattern.

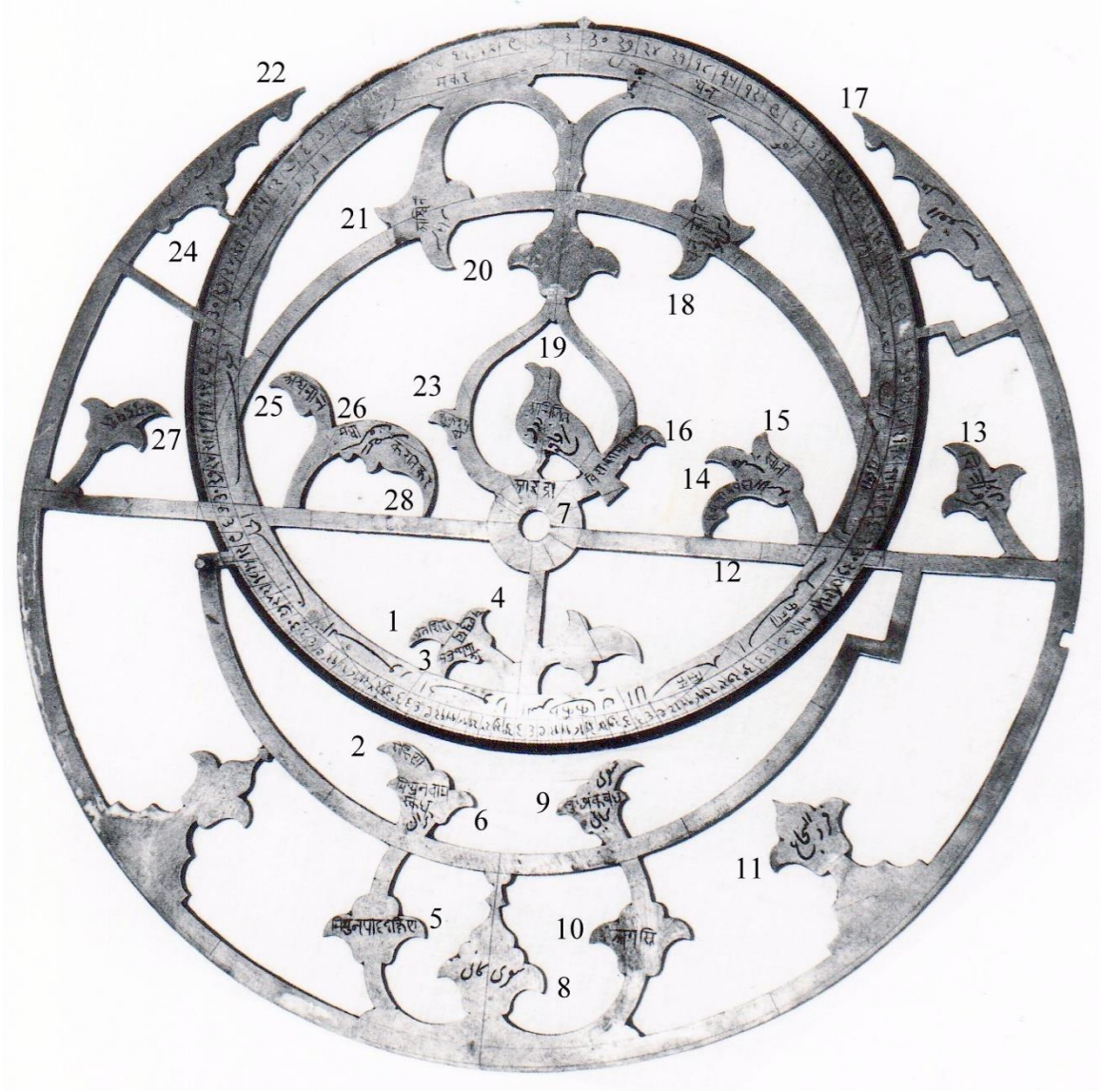


Figure B002.3 – Rete of the astrolabe (photo by P. S. Prakasa Rao)

Besides the ‘bird in a cage’ pattern, the configuration of the stars directly below also has a distinct pattern. β Persei, α Aurigae and α Persei at the tips of the three petals just above the ring of the equator are counterbalanced by a similar tulip with no stars on the right hand side. Below the ring of the equator, the three groups of (1) α Tauri, γ Orionis and κ Orionis, (2) α Canis Majoris, (3) α Canis Minoris and α Carinae are arranged in three creepers rising from the ring of Capricorn symmetrically on both sides of the meridian. Likewise, the flower containing the pointer for α Hydrae on the right is counter-balanced by a flower on the left which however does not contain any star pointer. This pattern is significant because it occurs at least in nine Sanskrit astrolabes, albeit with slight variations, produced in western India between 1618 and 1884. It must be added that these astrolabes display not only the ‘bird in a cage’ in the upper part but also an almost-identical configuration of star pointers in the lower part below the equator. It also occurs in several Islamic astrolabes.[570]

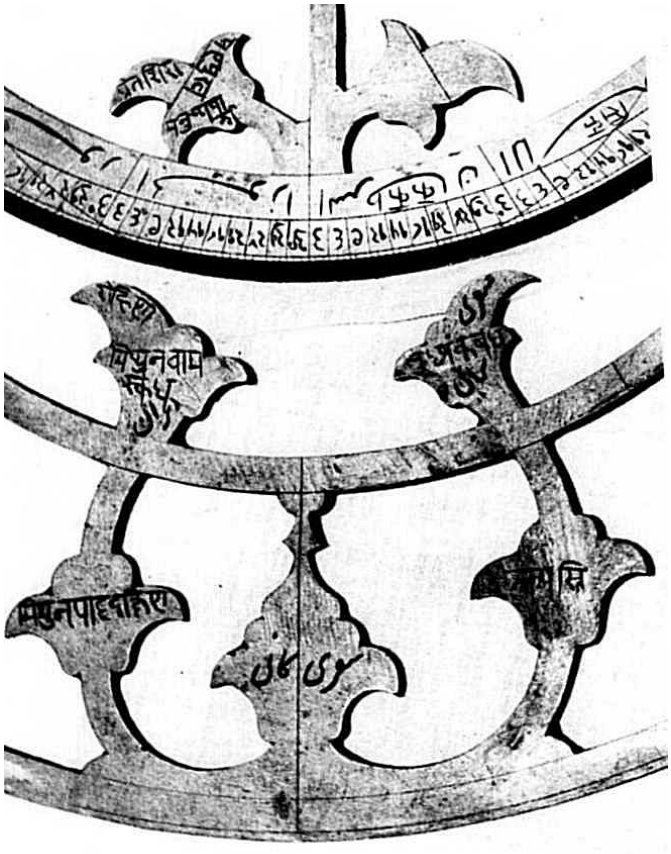


Figure B002.4 – Detail of the rete (detail of Figure B002.3)

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570 See Sarma 2011a, pp. 111-113.

There are 28 named star pointers. Of these 7 have names in only Arabic, 15 in Sanskrit and the remaining 6 in both Arabic and Sanskrit. In the table below these names are listed in the order of increasing right ascension. The star pointers are not clearly defined; occasionally it is difficult to decide which of the two or three projecting tips is meant as the pointer (e.g. *Fard al-Shujāᶜ* numbered 11 in Figure B002.3). Four names (one Arabic and three Sanskrit) are engraved at wrong places, viz. *Muqaddam, Ārdrā, Aśvinī* and *Maghā.* In the table below these are marked with an asterisk before the name. Several Sanskrit names are incorrectly transcribed; the correct forms are added in parentheses.

Table B002-1 Stars on the Rete

S.No.	Star Name in Arabic	Star Name in Sanskrit	Identification
1		*Preta-śirā*	β Persei
2	*Dabarān*	*Rohiṇī*	α Tauri
3		*Manuṣya-pārśva*	α Persei
4		*Ṣaṇmukha*	α Aurigae
5		*Mithuna-pāda-dakṣiṇa*	κ Orionis
6		*Mithuna-vāma-skandha*	γ Orionis
7		**Āradrā* (*Ārdrā*)	α Orionis
8	*Shiᶜrā Yamānī*		α Canis Majoris
9	*Shiᶜrā Shāmī*	*Ludhvaka-badha* (*Lubdhaka-bandhu*)	α Canis Minoris
10		*Agasti (Agastya)*	α Carinae
11	*Fard al-Shujāᶜ*		α Hydrae
12		*Pūrva-phālgunī*	δ Leonis
13	*Simāk Aᶜzal*	*Citrā*	α Virginis
14	*Qalb al-Asad*		α Leonis
15		*Svātī* (*Svāti*)	α Bootis

S.No.	Star Name in Arabic	Star Name in Sanskrit	Identification
16		*Viśākhā-mātṛmaṇḍala*	α Coronae Borealis
17	*Qalb al-ᶜAqrab*		α Scorpii
18	*Rās al-Ḥawwā*	*Dhanukoṭi* (*Dhanuḥkoṭi*)	α Ophiuchi
19	*Nasr Wāqiᶜ*	*Abhijit*	α Lyrae
20	*Nasr Ṭā'ir*		α Aquilae
21		**Aśvina* (*Aśvinī*)	β Arietis
22	**Muqaddam*		ρ Ophiuchi
23		*Kakuṃda-puccha* (*Kukkuṭa-puccha*)	α Cygni
24	*Dhanab al-Jadī*		δ Capricorni
25		*Aśva-nābha*	α Andromedae
26		**Maghā*	α Leonis
27		*Samudra-pakṣa* (°*kṣī*)	ι Ceti
28	*Kaff al-Khaḍīb*	*Karati-kara* (*Kartita-kara*)	β Cassiopeiae

PLATES

Beneath the rete are stacked four plates, which are designed for the eight latitudes 21°-33°, 23°-24°, 26°-32°, 27°-28°. There is no plate bearing the plate of ecliptic coordinates and the plate of horizons.

On these plates, the equal altitude circles are drawn for each degree, and are numbered for each group of 5° in *Abjad* notation. In one case (on the plate face for 24°) every group of 6° is numbered. There are no azimuth lines, except in the plate for 24°. In the lower half, in the segment between the oblique horizon and the tropic of Cancer, the latitude of the plate is mentioned in *Abjad* notation to the right of the meridian line, but not the duration of the longest day. In a few cases, the degrees of the latitude are also added in Devanagari script, to the left of the meridian. In the lower half, lines are

drawn for seasonal hours and equal hours, starting from the western horizon. In some plates, these hour lines are numbered consecutively; in other plates there are no numbers.[571]

The most interesting feature of these plates is that in the spaces between the hour lines, on both sides of the meridian, either just above or just below the equator circle, are engraved the names of some places (in Arabic/Persian script) and their latitudes in degrees and minutes (in *Abjad* notation). These are the names of the places which lie close to the latitude of the plate and where this plate can be used for astronomical observations.[572]

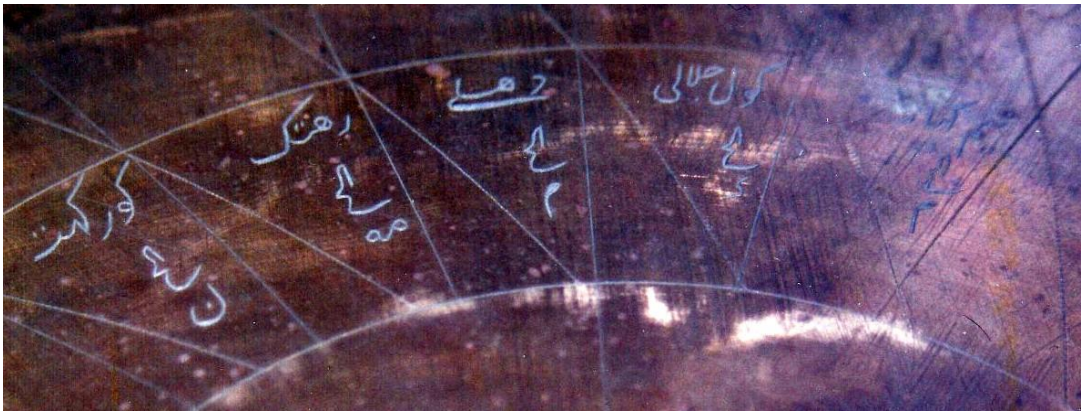


Figure B002.5 – Detail of the plate for 28° (photo by S. R. Sarma)

The proximate places and their latitudes, from left to right, Kūrkhayt 28;50, Rahtak 28;45, Dihlī 28;40, Kūl Jalālī 28;20, Nimkher 28;40, Kaṃpilā 28;10.

Geographical Gazetteer in Persian

In the present astrolabe, a geographical gazetteer in Sanskrit is engraved on the inner surface of the mater. This gazetteer will be discussed later. But the geographical data engraved on the eight faces of the four plates can also be treated as a gazetteer, as the Persian gazetteer.

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571 Normally all the plates should have uniform configurations and labels. The wide divergence seen in the plates of this astrolabe shows that maker is a novice.

572 In Sarma 2011a, I argued that this feature belongs to an astrolabe tradition which is different from the Lahore school. But it occurs also in the astrolabe A041 made by Muḥammad Muqīm of the Lahore family. The only example for such a practice outside India which I could trace occurs in an unsigned, undated astrolabe from Andalusia, now in the British Museum at London. Here on each side of the plate, the names of several towns are mentioned where the same plate can be used, e.g. 30˚ Miṣr, Kirman, Siraf; 38;30˚ Cordova, Tudmir, Ibiza. Cf. King 2005, p. 951.

Table B002-2 Geographical Gazetteer in Persian

	Latitude of the plate face	Place Name	φ	Modern Name
1	21°	Nawsārī	21;0	Navsari, Gujarat
2		Makkah	21;20	Mecca, Saudi Arabia
3	23°	Ratnaur	[23]	Ratanpur, MP
4		Raipūr	23;0	Raipur, MP
5		Mandāran	23;30	Mandasur, MP ?
6		Karah	23;25	Kara, UP
7		Ujjayn	23;30	Ujjain, MP
8		Dhār	23;30	Dhar, MP
9	24°	Ahlan Patan	24;0	Patan, Gujarat
10		Sūrkachah	24;10	In Kutch distict, Gujarat
11		Sārankpūr	24;25	Sarangpur, MP
12	26°	Ajmer	26;0	Ajmer, Rajasthan
13		Alahbās	26;10	Allahabad, UP
14		Tirhut	26;15	Tirhut = Muzaffarpur, Bihar
15		Banāras	26;20	Varanasi, UP
16		Kālbī	26;30	Kalpi, UP
17		Qannawj	26;35	Kannauj, UP
18	27°	Akrah	27;5	Agra, UP
19		Jaknāt	27.5	Puri Jagannath, Orissa
20		Jājnagar	27.5	Puri, Orissa
21		Kawaliyar	27.8	Gwalior, MP
22		Narwar	27;10	Narwar, MP
23		Awadh	27;45	Ayodhya, UP

24		Tahbatah	27;20	Tibet
25	28°	Kūrkhayt	28;50	Kurukshetra, Haryana
26		Rahtak	28;45	Rohtak, Haryana
27		Dihlī	28;40	Delhi
28		Kūl Jalālī	28;20	Aligarh and Jalali, UP
29		Nīmkher	28;40	Nimkher, UP
30		Kaṃpilā	28;10	Kampil, UP
31	32°	Lahūr	[32]	Lahore, Pakistan
32		Yazd	[32]	Yazd, Iran
33		Wāsit	[32]	now in ruins, Iraq
34	33°	Qandahār	33;0	Kandahar, Afghanistan
35		Baghdād	33;25	Baghdad, Iraq

The temple town of Puri or Puri Jagannath in Orissa on the coast of the Bay of Bengal is mentioned twice on plate for 27°, first as ‘Jaknāt’ and then as ‘Jājnagar’, a name by which it is known in Persian writings. In both cases, the latitude value is highly inflated as 27;05 as against the actual value of 19;48.

The latitude of Mecca is given here as 21;20 while the traditional value on astrolabes is 21;40. No. 24, Tahbatah, a mis-writing for Tubbat (i.e. Tibet), is given a very low latitude at 27.20. This error probably stems from the *Ā’īn-i Akbarī* where it is mentioned twice, once in the second climate at 27;30°[573] and a second time in the fifth climate at 40°.[574] What is actually meant is not the entire country, but the capital Lhasa which lies at 29;39° N, 91;07° E.

573 Abū al-Faḍl 3, p. 69.

574 Abū al-Faḍl 3, p. 103.

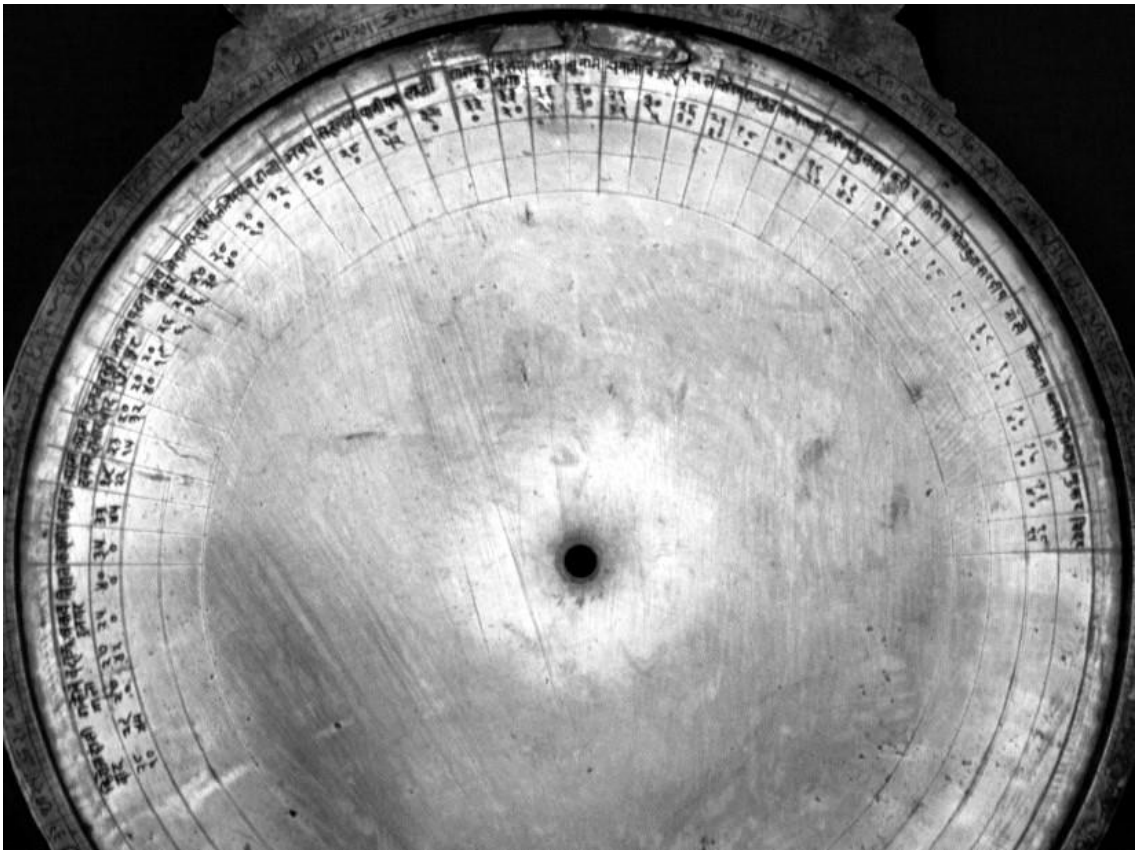


Figure B002.6 – Geographical Gazetteer in Sanskrit (photo by P. S. Prakasa Rao)

GEOGRAPHICAL GAZETTEER IN SANSKRIT

On the inner surface of the mater, a geographical gazetteer is engraved in Devanagari. Near the outer periphery, four circles are drawn, and in the resulting three annular rings are written respectively the place names, the degrees, and the minutes of the latitude. Below these, two more circles were drawn, presumably for degrees and minutes of the longitude but these were not filled in. Nor was the entire circle filled with place names and latitudes. The gazetteer starts 30° below the east point and reaches up to the west point, thus making an arc of about 210°. In this arc are given the names and latitudes of 45 towns. The place names are highly corrupt. In column 4 of the table below, an attempt is made to identify as many places as possible.

Table B002-3 Geographical Gazetteer in Sanskrit

	Place Name	φ	Modern Name
1	Phirojābāda	28;10	Firozabad, UP
2	Hāṃsī	29;45	Hansi, Haryana
3	Ḍhāko Vaṃgālā	27;00	Dhaka, Bangladesh

	Place Name	φ	Modern Name
4	Vadāmū	27;42	Badaun, UP
5	Akabaranagara	25;00	Another name for Rajmahal, West Bengal
6	Nihāta	40;00	?
7	Kaśmīra	35;00	(Kashmir) Srinagar
8	Kābula	33;45	Kabul, Afghanistan
9	Ahamadanagara	19;22	Ahmadnagar, Maharashtra
10	Ahamadābāda	23;15	Ahmedabad, Gujarat
11	Dolatābāda	20;32	Daulatabad, Maharashtra
12	Burahaṃpūra	20;40	Burhanpur, MP
13	Jālanāpūra	20;19	?
14	Paṭanā	26;06	Patna, Bihar
15	Jovanapūra	26;36	Jaunpur, UP
16	Mevata	27;30	Mewat region in the states of Haryana and Rajasthan
17	Sūrasvaraha	28;40	?
18	Tālesara	30;10	Thanesar, Haryana
19	Vaṭālā	32;00	Batala, Panjab
20	Avadha	28;00	Ayodhya, UP
21	Sūranapura	28;00	?
22	Pānīpatha	28;52	Panipat, Haryana
23	Lūtī	32;00	?
24	Śālakūṭha	33;00	Sialkot, Pakistan
25	Kilerājagaṭha	33;20	Qila Rajgadh?
26	Palādura	31;25	?

	Place Name	φ	Modern Name
27	Sunāma	30;30	Sunam, Panjab
28	Dhamālo	31;32	?
29	Vejū	30;05	?
30	Devala	26;30	?
31	N/Taherama	26;20	?
32	Rājakuḍa	18;00	Rajkot, Gujarat?
33	Isavadakhālī	32;00	?
34	Mihirāvara	29;50	?
35	Mulatāna	29;40	Multan, Pakistan
36	Karora	31;00	Karor, Pakistan
37	Siroja	24;10	Sironj, MP
38	Golaku[ṃ]ḍā	18;00	Golconda = Hyderabad, AP
39	Sara[n]dīpa	10;00	Sri Lanka
40	Tāsai	19;20	?
41	Somanāta	17;40	Somnath, Gujarat
42	Kalavarage	17;40	Gulbarga, Karnataka
43	Vijāpura	17;20	Bijapur, Karnataka
44	Mukara	16;40	?
45	Vidara	18;15	Bidar, Karnataka

One place is common in both the gazetteers: Ayodhya (Sanskrit: Avadha, lat. 28°; Persian: Awadh, lat. 27;45°). It is noteworthy that the Persian gazetteer has very few towns from outside India proper, unlike the astrolabes of the Lahore family.

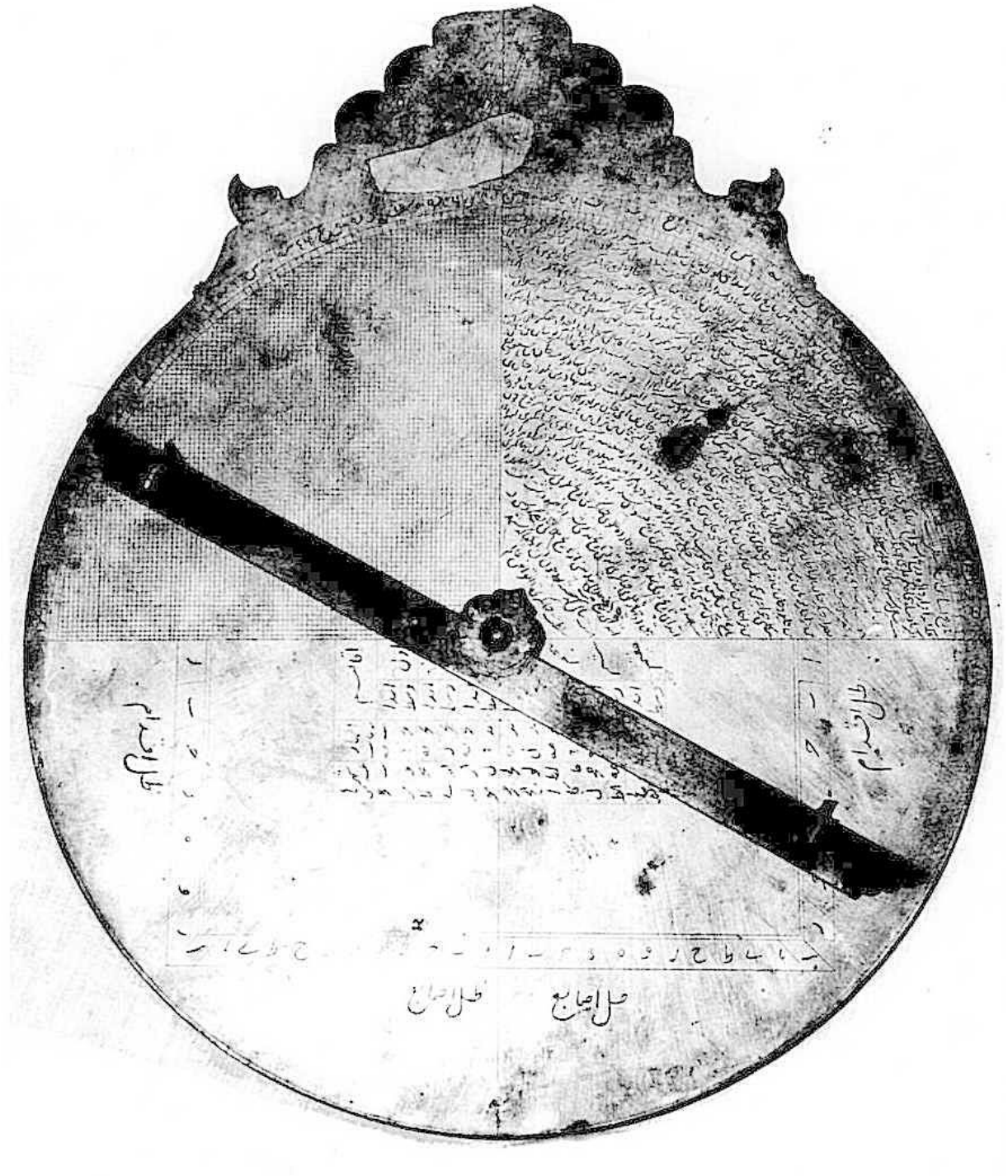


Figure B002.7 – Back of the astrolabe (photo by P. S. Prakasa Rao)

BACK

On the back of the astrolabe, the upper half of the rim is graduated in 1° and 5° and numbered as 5—90; 90—5 in *Abjad* as well as in Devanagari. The lower half of the rim is blank. The upper left quadrant contains a sine-cosine graph with 90 vertical and

90 horizontal equidistant parallel lines. The lines are drawn carefully, but not numbered. The upper right quadrant contains a long inscription, which will be discussed in the next section.

In the lower half, there is a double shadow square which extends almost up to the circumference. The vertical and horizontal scales on the left are each divided into 7 units to measure the shadow thrown by a gnomon of 7 feet, while the vertical and horizontal scales on the right are each divided into 12 parts for measuring the shadow thrown by a gnomon of 12 digits. The divisions are numbered correctly in *Abjad* notation, but the labels are incomplete and incorrect. The two vertical scales on the left and right are designated as *ẓill aqdām* ('shadow in feet') and the two horizontal scales *ẓill aṣābiʿ* ('shadow in digits').

In the middle of the shadow squares, just below the central hole is engraved a table of climates, with the arguments in Arabic, the hours and latitudes in *Abjad*.

Table B002-4 Table of Climates

Climates		Hours of the Longest Day	Latitudes
First	beginning middle	12;45 13;0	12;43 16;47
Second	beginning middle	13;15 13;30	20;31 24;10
Third	beginning middle	13;45 14;0	27;34 30;46
Fourth	beginning middle	14;15 14;30	33;43 36;28
Fifth	beginning middle	14;45 15;0	39;1 41;21
Sixth	beginning middle	15;15 15;30	43;30 45;29
Seventh	beginning middle end	15;45 16;00 16:15	47;38 48;59 50;31

ALIDADE

At the centre of the back is pivoted a straight-bar alidade, having a length of 402 mm, a width of 13 mm below and 12 mm above and a thickness of 4.5 mm. The alidade is ornate, with a lobed centre piece and terminals. The edge of the alidade is bevelled. One half of this edge is divided in 30 equal divisions and the other in six unequal divisions.

A 34 mm long pin with a broad head passes through the hole at the centre of all the parts. Through the hole at the tip of the pin, a wedge is inserted to hold tight the pin and the whole assemblage of the astrolabe.

INSCRIPTION

The entire upper right quadrant is filled with a long inscription engraved in 21 lines of progressively diminishing length. This is the longest inscription ever engraved on any astrolabe. It begins with the statement that the astrolabe was produced in the eleventh regnal year of the Mughal emperor Jahāngīr (i.e. 1616-17), and then goes on to compute the number of years that have elapsed at this point since the accession of Jahāngīr's father Akbar, his father Humāyūn, his father Bābur, and so on and so forth. In this *tour de force* of dynastic chronology, it is annoying that very little is said about the man who made the astrolabe. Professor Irfan Habib has kindly prepared an English translation which is reproduced below.

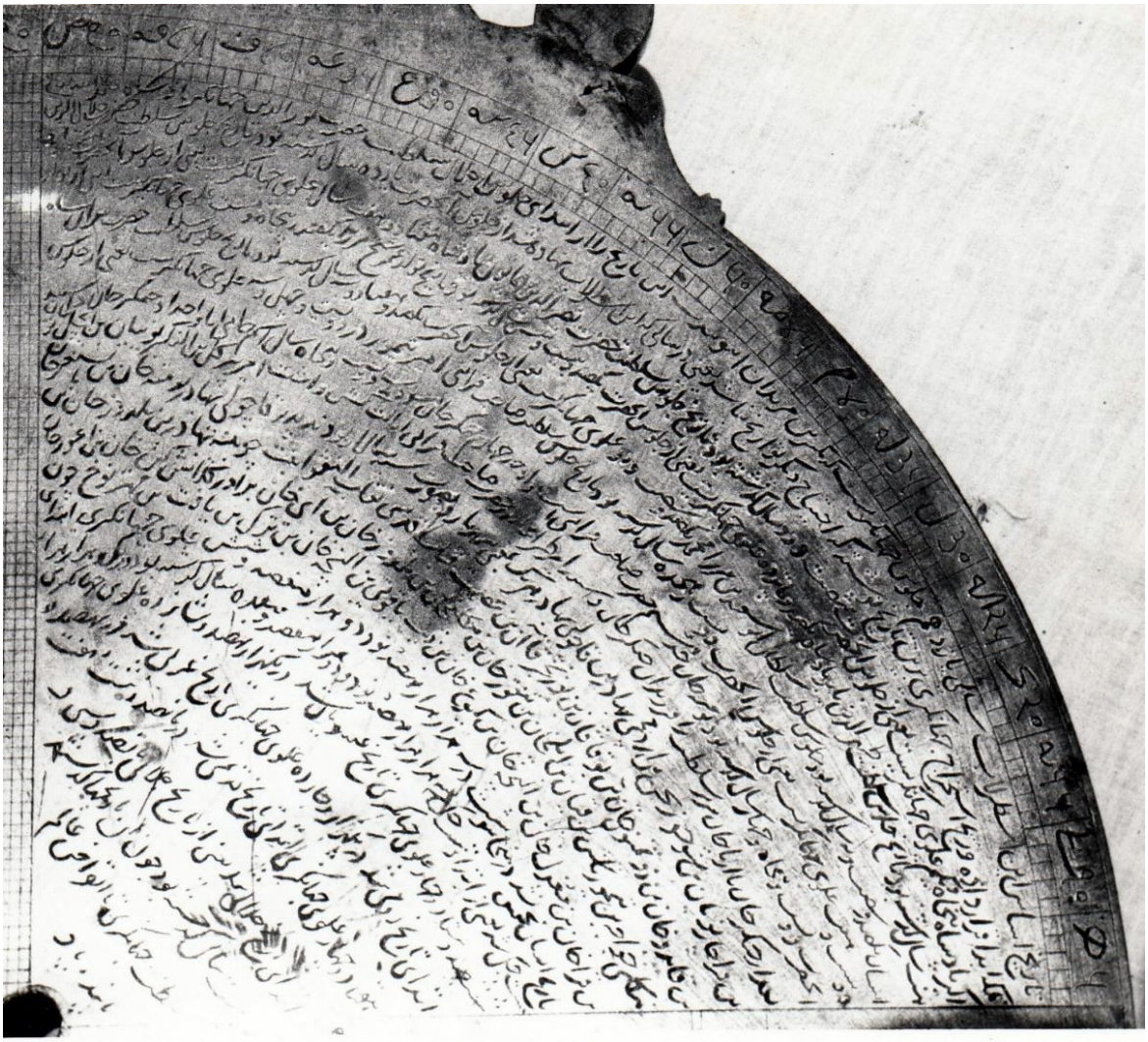


Figure B002.8 – Inscription on the back (photo by P. S. Prakasa Rao)

The date of the making (*asās*) of this astrolabe is the eleventh regnal year of Jahāngīr (*julūs-i Jahāngīr*), when the lowliest of 'disciples' [of His Majesty] (*kamtarīn murīdān*), A…ū[575] Pandit, has prepared the *tārīkh* from the beginning of the reign of His Majesty Nūr al-Dīn Jahāngīr Pādshāh—may His reign last for ever!—and written the table for calculation (*istikhrāj*) of the Jahāngīrī [era] on this *tārīkh,* so that there be no need of other *tārīkhs.* That is: from the year that this astrolabe was prepared, eleven years had passed after His Majesty's accession.

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575 Only the letters *alif* and *wāw* are engraved without any diacritical points; it can be Attū/Appū/Abīv, etc.

The date (*tārīkh*) of accession of His Majesty Jalāl al-Dīn Akbar Pādshāh was fifty-one years[576] before Jahāngīr's accession; that is, from His Majesty [Akbar's] accession sixty-two years had passed [till now].

The date of accession of Naṣīr al-Dīn Humāyūn Pādshāh was seventy-seven years from (=before) the accession of Jahāngīr; that is, from His Majesty [Humāyūn's] accession, eighty-eight years had passed [till now].[577]

The date of accession of Zahīr al-Dīn Bābur Pādshāh was one hundred and fifteen years earlier than Jahāngīr's accession; that is, from His Majesty [Bābur's] accession, one hundred and twenty-six years had passed.

The date of birth of ᶜUmar Shaykh Mirzā was one hundred and fifty-eight years prior [to Jahāngīr's accession]; that is, from his birth one hundred and sixty-nine years had passed.

The accession of Abū Sa'īd, son of Mirzā Muḥammad, is [to be placed] one hundred and sixty-two years before Jahāngīr's [accession]; that is, from His Majesty [Abū Sa'īd's] accession one hundred and seventy-three years had passed.

The date of accession of Mīrān Shāh is two hundred and seven years before Jahāngīr's [accession]; that is, from His Majesty [Mirān Shāh's] accession two hundred and eighteen years had passed.

The date of accession of Ṣāhib Qirānī Amīr Tīmūr is two hundred and forty-three years before Jahāngīr's [accession]; that is, from His Majesty [Timūr's] accession, two hundred and forty-four years had passed.

Yomina (?) Khān was the eighth-generation ancestor of His Majesty Ṣāhib Qīrānī. His was also the fourth-generation ancestor of Chingīz Khān. For a period of two hundred and fifty years, the ancestors of Chingīz Khān bore

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576 Professor Irfan Habib notes that, while *jahāngīrī* regnal years were solar, the period of Akbar's reign given here is in lunar years. Accordingly the year of Akbar's coronation would be 1605 - 51 = AD 1554, whereas the actual year is 1556. Akbar ruled from 1556-1605, thus the duration of his reign is 49 solar years. This shortage of two years repeats itself in the next paragraph.

577 Thus the year of Humāyūn's accession to the throne would be 1605 - 77 = 1528; the correct year is 1530. Humāyūn ruled from 1530 to 1556. The period of his reign is correctly given here as 26 years.

the title of *khān.* After Chingīz Khān till Arnā (?) Khān, the descendants (lit. children) of Chingīz Khān held the throne of government …'

[Mongol ancestors listed and then linked with Noah; this part is omitted in this translation.]

In three thousand thousand, nine hundred ninety-two thousand, seven hundred and six (*se hazār hazār nah sad nawad do hazār haft sad wa shash,* 3,992,706) [years] before Jahāngīr's [accession] the *Sat Jug* began;[578] that is, since the beginning of the *Sat Jug* three thousand thousand, nine hundred ninety-two thousand, seven hundred and seventeen (3,992,717) years had passed [till now].[579]

In one thousand thousand, six hundred and eighty-four (1,000,684) before Jahāngīr's [accession] lies the epoch of the Christian era (*tārīkh-i ʿīswī*).[580]

In one thousand, nine hundred and sixteen (1916) before Jahāngīr's [accession] lies the epoch of the Roman era (*tārīkh-i rūmī*).[581]

In one thousand and fourteen (1014) before Jahāngīr's [accession] lies the epoch of the Arabic era (*tārīkh-i ʿarabī*).[582]

In nine hundred and seventy-four (974) before Jahāngīr's [accession] lies the epoch of the ancient era (*tārīkh-i qadīmī*).[583]

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578 Thus from the commencement of the *Sat Jug* (= *Satyayuga, Kṛtayuga*) up to Jahāngīr's accession in AD 1605, it is said to be 3,992,706 years. There is an error in the second digit from the left.

duration of the *Satyayuga* =	1,728,000 years
duration of the *Tretāyuga* =	1,296,000 years
duration of the *Dvāparayuga* =	864,000 years
Kali years before Christian era =	3,101years
from the commencement of the Christian era up to Jahāngīr's accession=	1,605 years
Total=	3,892,706years

579 Likewise, this should be 3,892,717 and not 3,992,717.

580 In the figure 'one thousand thousand, six hundred …,' the second 'thousand' must be a scribal error. The correct figure is 1604 if expired years are meant.

581 Rūmī or Syro-Macedanian era commencing from 1 October 312 BC.

582 Hijrī era.

583 Yazdegird era.

> In five hundred and twenty-seven (527) before Jahāngīr's [accession] lies the epoch of Jalālī era (*tārīkh-i jalālī*); that is, of the Jalālī era five hundred and thirty-eight (538) had passed.[584]
>
> [Even] when [all] these [years of] eras have elapsed, may the reign of Jahāngīr last till the end of the Universe.

The inscription mentions that the astrolabe was produced, or more correctly the production of the astrolabe was completed, in the eleventh regnal year of Jahāngīr. It is the common practice at Jahāngīr's court to date events in terms of the emperor's regnal years, which are solar years. According to Jahāngīr's own memoirs,[585] his eleventh regnal year commenced on Sunday, 19 March 1616, and the twelfth regnal year on Monday, 20 March 1617. Thus the astrolabe was completed between 19 March 1616 and 19 March 1617.

Pandit had the high ambition to mention the time of the manufacture of his astrolabe also in terms of years before Jahāngīr's accession reaching up to his ancestors in India and in Central Asia, a chain which he tries to carry up to Noah. Here he enumerates the years that elapsed since the accession of each of Jahāngīr's ancestors separately. In this connection he uses the expressions *julūs-i jahāngīrī* and *ʿulwī jahāngīrī* respectively for years from Jahāngīr's coronation onwards and for years that elapsed before coronation, in a manner analogous to AD and BC. Professor Irfan Habib agrees that *ʿulwī Jahāngīrī* refers to the years preceding the accession of Jahāngīr, but adds that such usage is unusual. Also this method of mentioning the time of an event in terms of the years of accession of each previous ruler appears to be unusual.

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584 Jalālī or Mālikī era, founded by Sulṭān Jalāl al-Dīn Mālik Shāh Seljuqi in AD 1079 with the help of ʿUmar Khayyām.

585 Jahāngīr's Memoirs are so arranged that each chapter corresponds to a particular regnal year which commences with the sun entering the zodiac sign Aries. The eleventh regnal year commenced when 'Fifteen gharis of day had passed on Sunday, the last day of Isfandārmuz̲, corresponding with the 1st Rabī'u-l-awwal [= 19th March, 1616], when from the mansion of Pisces the sun cast the ray of prosperity on the palace of Aries,' cf. Jahangir, p. 317. About the commencement of the next regnal year, the Memoirs state: 'One ghari of day remained of Monday, the 30th of the aforesaid (Isfandiyār) month, corresponding to the 12th Rabī'u-l-awwal, 1026 [= 20 March 1617], when the sun changed from the constellation of Pisces into the pleasure-house of Aries, which is his abode of honour and good fortune,' cf. Jahangir, p. 370.

In addition to these periods, Pandit attempts to mention the year of the astrolabe production also in the Indian mythical era of *Sat Yug,*[586] and five other eras, and carries the narration to a crescendo, where he wishes, with a rhetorical flourish, that, even when all these eras have elapsed, Jahāngīr's reign itself may last till the end of the Universe. This is no doubt quite an eloquent finale, but the chronology is marred by several errors.

While enumerating the regnal years of the Mughal rulers, Pandit mixes up solar and lunar years. He gives Jahāngīr's regnal years and Humāyūn's period of rule in solar years, but Akbar's in lunar years. The years elapsed prior to Jahāngīr's accession are given in five different eras, namely, Christian era (*tārīkh-i ʿīswī*), Rūmī or Syro-Macedonian era (*tārīkh-i rūmī*), Arabic era (*tārīkh-i ʿarabī*), Yazdegird era (*tārīkh-i qadīmī*) and Jalālī era (*tārīkh-i jalālī*). Here Pandit is obviously emulating the *Akbarnāma,* where the date of birth of Jahāngīr's father, Akbar, is also given in five different eras, namely Jalālī, Yazdegird, Hijrī, Hindu (= Saṃvat or Vikrama Saṃvat) and Rūmī.[587]

It is surprising that in a bilingual astrolabe where Pandit endeavous to combine the Muslim and Hindu traditions of astronomy, he omits to mention the Vikrama Saṃvat era, which was commonly employed in the contemporary Hindu society and also in the *Akbarnāma* as shown above, and employs instead the mythical *Satya-yuga*, that too with an error of 100,000 years!

BIBLIOGRAPHY

Dvivedi 1923.

Sarma 2011a.

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586 Sanskrit *Satya-yuga* or *Kṛta-yuga.* That the durations of the four *yugas* are in the ratio of 4:3:2:1 is a fact well known in Sanskrit epic and astronomical literature. Cf. *Akbarnāma*, I, p. 151: '… the revolutions of the world consist of four Ages. First, the period which is 1,728,000 years, they call the *Sat Yug.* …The second Age is called *Tretā* and lasts 1,296,00 years. … The third Age is called *Dwāpar* and lasts 864,000 years. … The fourth Age is the *Kal yug.* Its period is 432,000.'

587 *Akbarnāma,* I, pp. 54-56.

ᶜABD AL-QĀDIR AL-MUḤIBB AL-ASṬURLĀBĪ

ᶜAbd al-Qādir al-Muḥibb al-Asṭurlābī is known through four astrolabes, only one of which is dated 1034 AH (AD 1621-22).[588] An undated celestial globe made by his son Luṭf Allāh ibn ᶜAbd al-Qādir al-Muḥibb al-Asṭurlābī is with the Institut du Monde Arabe, Paris.[589] The Museum of the History of Science, Oxford, holds an astrolabe made in 1647 by Ibn Muḥibb Ḥaqīqa, who may be the son of ᶜAbd al-Qādir Muḥibb.[590]

Nothing is known about Muḥibb's place of origin or the place of work. But from the fact that three plate faces in his undated astrolabe at Frankfurt B006) are designed for latitudes 27°, 29° and 32° which pertain to the three Mughal imperial cities Agra, Delhi and Lahore and from the fact that his son Haqīqa's astrolabe carries sigmoid curves for the sun's midday altitude at latitudes 27° and 32°, it can be safely concluded that the father Muḥibb and the sons Luṭf Allāh and Ḥaqīqa lived somewhere in Panjab.

Of the four astrolabes made by Muḥibb, details are available only of two astrolabes B005 and B006 which display excellent workmanship with their elegantly designed *kursīs* and retes. Again of these two, B006 is the most ambitious astrolabe with the largest number of star pointers on the rete, largest geographical gazetteer and several other features which are not found in any other Indian astrolabe.[591]

The son Ibn Muḥibb Ḥaqīqā's astrolabe is more modest in comparison; he is familiar with the astrolabes of the Lahore family; the back of his astrolabe closely resembles several small astrolabes made by his contemporary Ḍiyā' al-Dīn Muḥammad of the Lahore family.

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588 The CCA lists under 1123 a Sanskrit astrolabe with a diameter of 181. This is clearly based on a misunderstanding, for no Muslim is known to have produced a Sanskrit astrolabe. Probably the lost rete in this astrolabe may have been replaced by a Sanskrit rete. No other details are available.

589 Savage-Smith 1985 No. 67, p. 251; Mouliérac 1989, pp. 84-85.

590 Gunther 1932, no. 73, pp. 200-201, Figs. 100, 101; CCA 73.

591 Schmidl 1994.

B003 ASTROLABE BY ᶜABD AL-QĀDIR MUḤIBB, 1031 AH (AD 1621-22)

Diameter 178 mm

London, PC

Répertoire 1

This entry is based on Répertoire 1.

RETE

The ecliptic ring is divided in 12 signs. There are 25 named star pointers.

BACK

Sine graph in the upper left quadrant; in the upper right quadrant, declination arcs with graphs of the azimuths of *qibla* for Baghdād, Iṣfahān and Ṭūs; astrological tables in the lower half.

INSCRIPTION

The Répertoire provides a French translation of the inscription, which is rendered into English below. Muḥibb inserted his signature between two lines of some unknown poem. We separate the signature from the poem.

> All the difficulties of the heavens, I have solved with the astrolabe of wisdom — table after table —, and at night the stars are observed by calculating the distance and the degree of the passage.
>
> The work of the humblest of men, ᶜAbd al-Qādir Muḥibb. In the year 1031 [Hijrī].

B004 ASTROLABE BY ᶜABD AL-QĀDIR MUḤIBB, NOT DATED[592]

Diameter 317

PLU, ex-London, Sotheby's

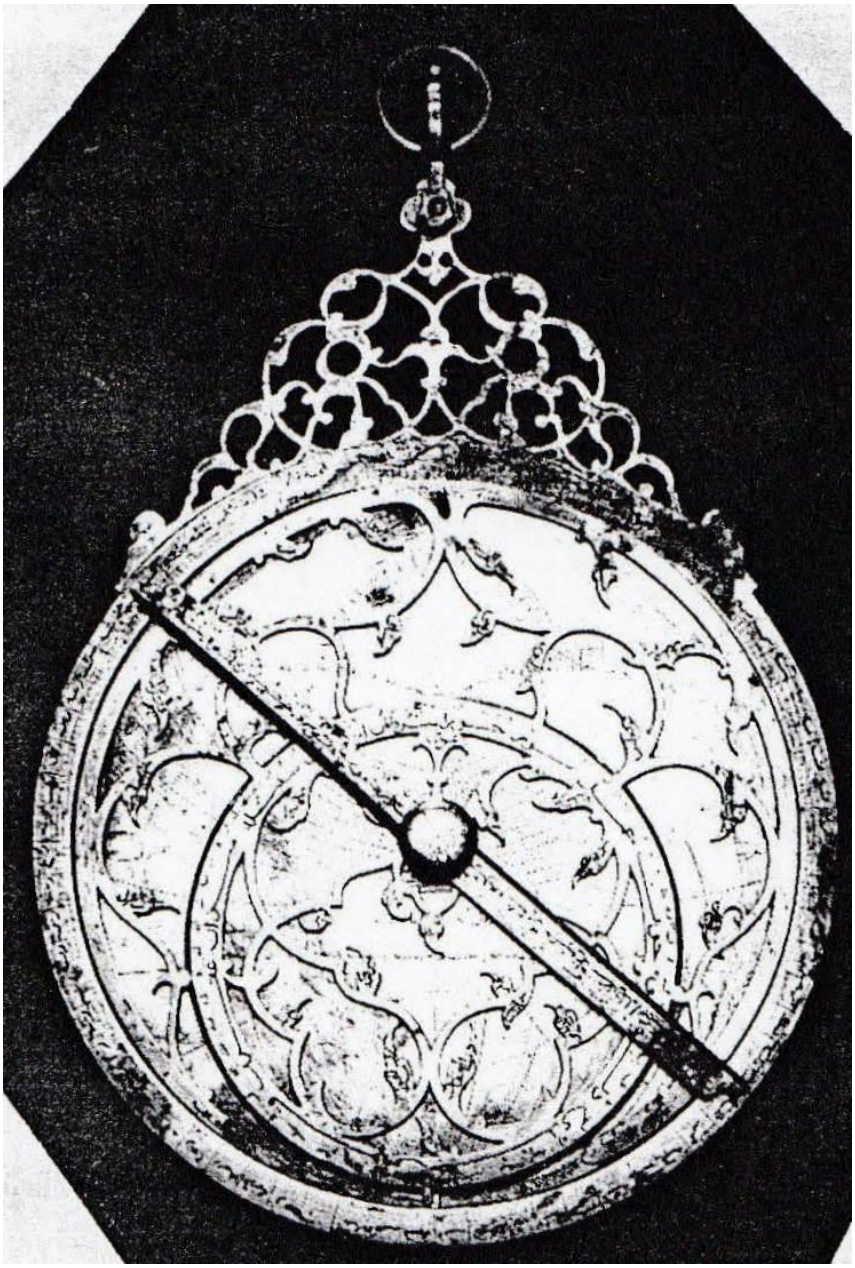


Figure B004.1 – Front of the astrolabe (photo from Sotheby's catalogue)

This large astrolabe is signed by ᶜAbd al-Qādir Muḥibb, but is not dated. The original rete is lost; it is replaced by a rete made by the famous Safavid instrument maker ᶜAbd al-A'imma in 1116/1704-5, who is known through some twenty-six astrolabes, a

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592 This entry is based on Sotheby's catalogue of 25 April 1996, lot 156.

compass and a *qibla*-indicator. Interestingly, the present rete bears the earliest date on his creations.

Components

Body with *kursī* (d. 317), ring and shackle, 5 plates, alidade, pin and horse. The rete is a replacement.

Front

The ring is rather large and the shackle trifoliate with ornate bases. The *kursī* is intricately and elegantly reticulated and resembles the *kursī* in Ḍiyā' al-Dīn's astrolabe of 1650 at the Brooklyn Museum (A064). In the available photo, it is difficult to discern how the limb is divided.

Rete

As mentioned above, the rete is the earliest dated work of ᶜAbd al-A'imma. Here the two rings of the Tropic of Capricorn and the ecliptic are held together by an almost symmetric floral tracery. The equinoctial and the solstitial bars are not represented.

Plates

There are five plates engraved with altitude circles, azimuth arcs and hour lines.

Geographical Gazetteer

In two concentric circles, the gazetteer provides the names, longitudes, latitudes, *inḥirāf* and *jihat* of 102 localities.

Back

In the upper half of the back, there are a sine quadrant and a solar quadrant with three graphs of the meridian altitude of the sun at latitudes 27°, 30° and 36°. The rim of the lower half is occupied by the cotangent scales. Within these are one shadow square, a table with the names of the 29 lunar mansions, and other astrological tables.

Alidade

There is a graduated alidade with ornate ends.

Inscription on the astrolabe

'Work (*ᶜamal*) of the least of men, ᶜAbd al-Qādir Muḥibb.'

INSCRIPTION ON THE RETE

‘Made by (*sanaᶜahu*) ᶜAbd al-A’imma in the year 1116 [AH = AD 1704-5].’

PROVENANCE

Said to be from the estate of Ralph Yahe.

B005 ASTROLABE BY ᶜABD AL-QĀDIR MUḤIBB, NOT DATED[593]

Diameter 146 mm

PLU

CCA 3677; Répertoire 2



Figure B005.1 – Front of the astrolabe (from Linton 1980)

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593 Entry based on Linton 1980, no. 164.

COMPONENTS

Body with *kursī* (d. 146), ring and shackle, rete, 6 plates, alidade, pin and horse. The ring and shackle are not original. The horse is missing. The astrolabe in a good condition despite some wear on the back.

FRONT

The ring and the shackle are not original. The *kursī* is very elegantly reticulated and its surface is decorated on both sides with ornate lines and flowers in low relief. The finial of the *kursī* is circular.

The limb is divided in 1° and 5° and numbered clockwise as 5, 10, 5, 20, … 5, 350, 5, 360.

RETE

The slender Capricorn ring and the much wider ecliptic ring are held together by a narrow equinoctial bar which has a counter change at the centre. A segment of equatorial ring is shown below the ecliptic ring; it is held in position by two transversal bars which run from the Capricorn ring to the ecliptic ring. The ecliptic ring is divided into the 12 signs of the zodiac; each sign is subdivided into units of 6°; these are numbered anti-clockwise from 6 to 30 in each sign. The edge of the ecliptic ring is divided in 3°. Some construction lines are visible on the back.

The star pointers are joined by a tracery of tendrils and flowers with flared petals. The tracery consists of several loops arranged symmetrically on either side of the meridian. On the meridian, there is an arch-like frame just below the ring of the ecliptic in the south and a reversed arch just below the equator ring in the north. Some 21 star pointers carry names, but not all of them can be deciphered in the available photo.

PLATES

There are six plates of which four are designed for latitudes between 22° and 39°, one plate with the plate of ecliptic coordinates and the plate of horizons, and one plate with multiple projections. On the first four plates, altitude circles are drawn for every 3° and azimuth arcs for every 10° above and below the local horizon. There are lines for seasonal hours and lines for equal hours, drawn for every 6 minutes, sometimes from the western horizon and other times from both the western and eastern horizons.

GEOGRAPHICAL GAZETTEER

The inner surface of the mater carries just three concentric circles, and is otherwise quite empty. Inserted there is a circular piece of parchment (obviously added later) with handwritten names of 73 localities with their longitudes, latitudes, *inḥirāf, jihat* and *masāfat.*

BACK

On the back, the rim of the upper half carries two altitude scales which are divided and numbered as in the front 5, 10, 5, … 5, 90; 90, 5, … 5, 10, 5. In the upper left is a trigonometric quadrant with 60 horizontal lines with each fifth highlighted by dots. The solar quadrant on the upper right is engraved with declination arcs for each 6° of the solar longitude. Here also every fifth arc which forms the boundary between zodiac signs is dotted. The names of the corresponding signs are engraved along the two radii. There are no other graphs in this quadrant.

In the lower half, shadow squares are drawn immediately below the horizontal diameter. The square on the left is for shadow lengths measured in feet. The vertical scale is accompanied by the label *ẓill sullam aqdām maᶜkūs* and the horizontal scale has the label *ẓill sullam aqdām mustawī.* The scales on the right is for shadows measured in digits. Here the horizontal scale is accompanied by the label *ẓill sullam aṣābiᶜ mustawī* and the vertical scale by *ẓill sullam aṣābiᶜ maᶜkūs.*

The rim of the lower half carries cotangent scales. The scale on the left is divided in feet; the unequal divisions are numbered clockwise from the meridian onwards as 1, 2, 3, … 9, 10, 15, 20, 25, …, followed by the label *ẓill aqdām.* The scale on the right is divided in digits; the unequal divisions are numbered anti-clockwise from the meridian onwards as 1, 2, 3, … 10, 11, 12, blank, 20, 25, 30 … 55, 60, followed by the label *ẓill aṣābiᶜ*.

The space between the cotangent scales and the shadow squares is occupied by 6 semi-circular rows carrying astrological tables. Rows 1 and 2 (as counted from the outside) are filled with the names of the 28 lunar mansions and the names of the 12 zodiac signs; the next two rows carry the table of limits, while the last two rows are occupied by the table of the decans and their regents. In the plate of horizons, half horizons are arranged in eight sets.

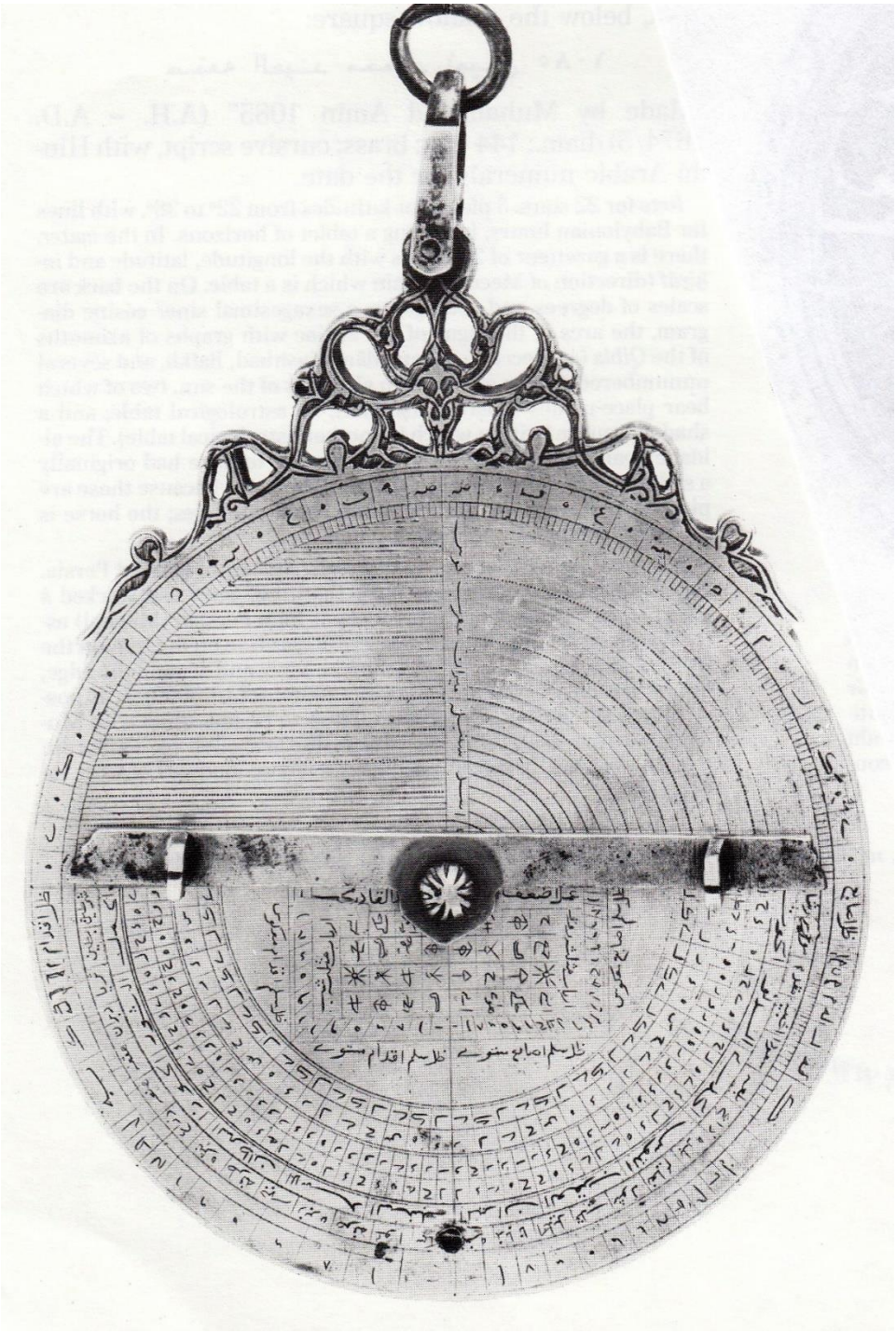


Figure B005.2 – Back of the astrolabe (from Linton 1980)

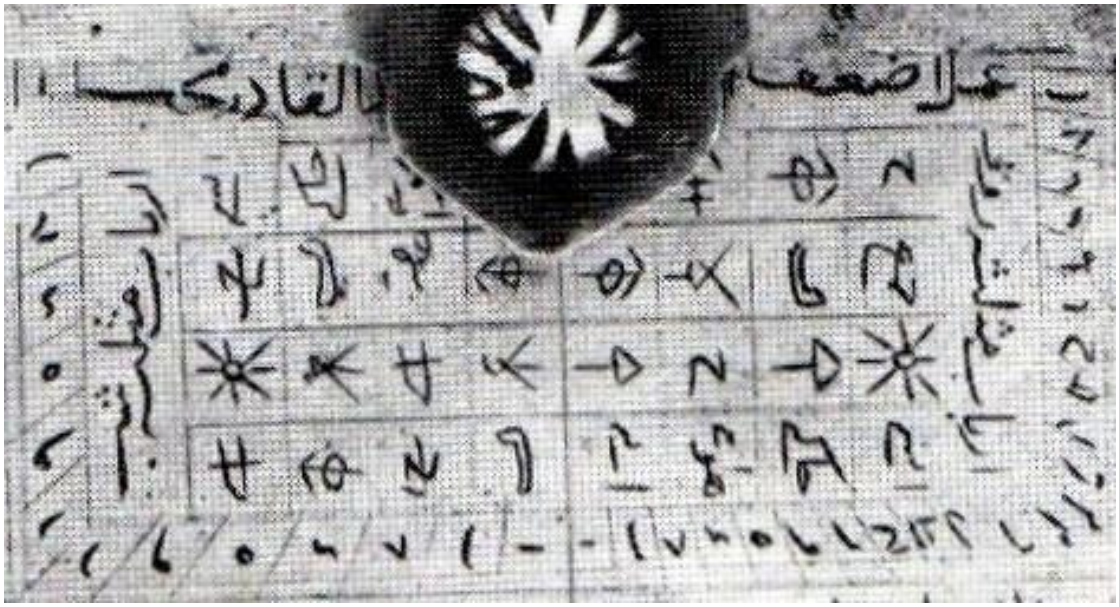


Figure B005.3 – Astrolabe maker's signature at the top and the table of triplicities below (detail of Figure B005.2)

Inside the shadow squares are two rectangular tables; on the left is the table of the nocturnal regents of the triplicities with the label *arbāb muthallath shab* and on the right the table of diurnal regents of the triplicities with the label *arbāb muthallath rūz*.

Table B005-1 Table of Triplicities

Nocturnal Regents					**Diurnal Regents**			
fiery *ātishī*	earthy *khākī*	airy (*hawā'ī*)	watery (*ābī*)		fiery *ātishī*	earthy *khākī*	airy *hawā'ī*	watery *ābī*
Jupiter	Moon	Mercury	Mars		Sun	Venus	Saturn	Venus
Sun	Venus	Saturn	Venus		Jupiter	Moon	Mercury	Mars
Saturn	Mercury	Jupiter	Moon		Saturn	Mars	(Jupiter)	(Moon)

In these tables the planetary lords are represented by symbols partly derived from the standard Greek symbols. However, it is quite strange that Muḥibb uses different kinds of symbols for the same planet. In the following Figure B005.4, the standard Greek symbols are shown in the second row, the symbols used in the table of diurnal regents in the third row and those used for nocturnal regents in the fourth row. Thus Jupiter, Venus and Saturn have different symbols for the day and for the night. In the case of Mercury, both symbols are used in nocturnal table.

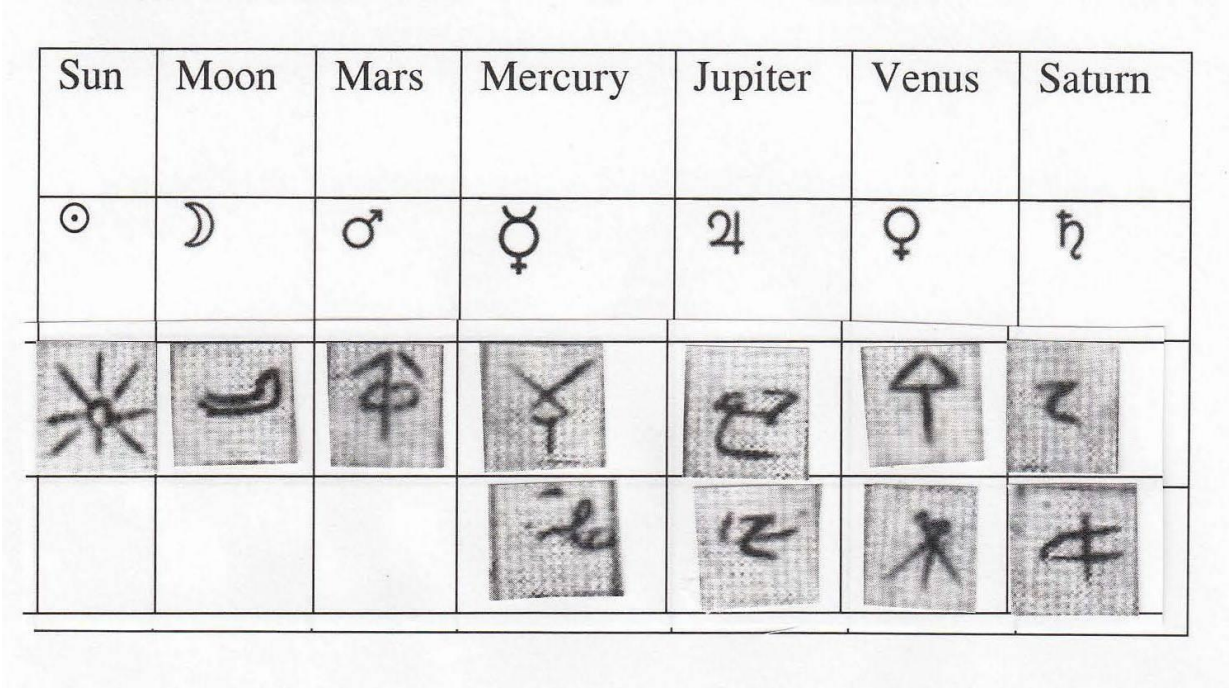


Figure B005.4 – Planetary symbols in the table of triplicities

This is not an isolated attempt by Muḥibb to create planetary symbols akin to the Greek symbols. The Sulṭān of Yemen, al-Mālik al-Ashraf ᶜUmar (r. 1295-1297) composed a treatise on the astrolabe and also constructed an astrolabe in 1290, which is now with the Metropolitan Museum of New York. In the treatise as well as on the astrolabe, the Sulṭān employs similar planetary symbols.[594]

Alidade

The straight bar alidade is not graduated; pin has a star-shaped round head.

Inscription

Engraved above the shadow squares is the signature of the astrolabe maker.

ᶜamal aḍaf al-ᶜibād ᶜabd al-qādir muḥibb

'The work of the weakest of the servants [of God], ᶜAbd al-Qādir Muḥibb.'

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[594] Cf. King 2005, pp. 615-657: 'An Astrolabe made by the Yemeni Sultan al-Ashraf', esp. p. 626, Fig. 2. 2 (back of the astrolabe) and p. 635, Fig. 3.2 (illustration of the back of the astrolabe in the treatise by al-Ashraf). On an exact replica of this astrolabe, see Sezgin 2003, II, p, 105; Sezgin 2011, II, p. 105. The Sulṭān also composed another treatise called *Kitāb al Tabṣira fi ᶜilm al-nujūm* on astrology, medicine and magic. Here also similar planetary symbols are used. Cf. Schmidl 2012, esp. pp. 49-52.

PROVENANCE

Collection Devlay, Cairo; Alain Brieux Collection, Paris; Collection Leonard Linton, Point Lookout, New York; Paris sale at Drouot on 9 and 10 October 1980 lot 164; auctioned again in Paris on 7 December 2015. Its present location is not known.

BIBLIOGRAPHY

Alain Brieux, *Histoire des Sciences..., Catalogue*, Paris, nd [ca. 1972], No. 6658.

Linton 1980, no. 164, pp. 92-93.

B006 ASTROLABE BY ᶜABD AL-QĀDIR MUḤIBB, NOT DATED

Diameter 306 mm

Frankfurt, Museum für Angewandte Kunst

CCA 3700 = 3923

Répertoire 1



Figure B006.1 – Front of the astrolabe
(courtesy Institut für Geschichte der Arabisch-Islamischen Wissenschaften, Frankfurt)

This is the most ambitious astrolabe produced in Mughal India.[595] The rete accommodates 63 star pointers, which is the largest number among the Indo-Persian astrolabes. On the inner surface of the mater is engraved a geographical gazetteer of 285 localities, again the largest number for Indo-Persian astrolabes. Besides the geographical gazetteer, the inner surface of the mater carries a circular table of declinations and mediations of 93 fixed stars and a rectangular table of maximum length of daylight for each degree of latitude from 13° to 52°. These two tables occur in no other Indo-Persian astrolabe. Again on the back of the astrolabe, there are some astrological tables which do not occur in any other Indo-Persian astrolabe. There are new features in the plates as well. On one plate, one half carries the projection for latitude 66;30° while the other half is engraved with the projection of the complement 23;30°. Lahore astrolabes have occasionally triple projections for latitudes 0°, 72° and 90°. A plate in this astrolabe displays a quadruple projection for 0°, 18°, 72° and 90°; the astrolabe maker is quite proud of this accomplishment and proclaims that it is his invention: *min ikhtirāᶜ al-sāniᶜ*.

From the viewpoint of workmanship also it is well made with meticulously drawn lines, especially the altitude circles for each degree on the plates. The *kursī* and the rete are very elegantly fashioned, although Muḥibb's other astrolabe B005 is a shade more beautiful in this respect. The thick edge of the astrolabe is decorated with a Persian poem in embossed letters and the remaining space is filled with a frieze of undulating tendrils and flowers.



Figure B006.2 – Floral decoration on the edge of the astrolabe
(courtesy Institut für Geschichte der Arabisch-Islamischen Wissenschaften, Frankfurt)

Furthermore, the astrolabe became somewhat notorious, because somebody made additional engravings on the back of the *kursī* and on the edge of the astrolabe to suggest

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595 This entry is based on Schmidl 1994 and a comprehensive astronomical, astrological and linguistic study of this astrolabe under preparation by Dr Petra G. Schmidl. I am deeply indebted to her for generously allowing me to make use of her two papers. I am also highly grateful to the Institut für Geschichte der Arabisch-Islamischen Wissenschaften, Frankfurt, for the photos included in this entry.

that this astrolabe was made by or for the famous Naṣīr al-Dīn al-Ṭūsī in 1269-70 and that it was priced 100 *mithqāl* of gold and 208 *mithqāl* of silver.[596]

COMPONENTS

Body with *kursī* (d. 306), shackle, ring and cord, rete for 63 stars, 4 plates, alidade, pin, horse and ruler. The shackle, ring, cord and ruler are not original.



Figure B006.3 – *Kursī* of the astrolabe with the signature of the astrolabe maker (detail of Figure B006.1)

FRONT

The plain ring and shackle and the blue cord are modern replacements. The *kursī* is elaborately reticulated with a cartouche in the middle. The profiles are made up of ogees and series of lobes; the finial is trifoliate with the two petals on the sides slightly curved downwards. A similar motif is repeated immediately below. The entire surface is decorated with embossed flowers and tendrils. The astrolabe maker's signature is engraved on the cartouche in relief and reads *ᶜamal ᶜabd al-qādir muḥibb* (the work of ᶜAbd al-Qādir Muḥibb). On the reverse side of the cartouche, there was probably the

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596 Influenced by this false attribution to the great al-Ṭūsi, the Institute of the History of Science, Johann Goethe University, of Frankfurt, acquired this astrolabe for the high price 21,500 DM in 1960. Schmidl 1994 convincingly argues that these inscriptions are clear forgeries.

date of manufacture or another related engraving. This was crudely altered to *yā muḥammad naṣīr al-dīn wa-d-dunya* (O Muḥammad, Support of the religion and of the world), which is employed by the Sūfīs as one of the 99 names of God. But it also creates the impression that the astrolabe is related to or made by the famous polymath and astronomer Naṣīr al-Dīn al-Ṭūsī (1201-1294), the director of the Marāgha observatory.

The limb is divided in 0;30°, 1° and 5° and numbered clockwise in 5s from 5 to 360.

RETE

The rete is reticulated very elegantly and very delicately. The rings of the Tropic of Capricorn, of the ecliptic and the partially represented equator are held together by the slender equinoctial bar which has a counter change at the centre and by the floral tracery. The design of the rete is almost the same as that in Muḥibb's other astrolabe B005, but with greater elaboration and with more loops. One major difference is the following: in B005 only one segment of the equator ring is represented below the equator ring in the north; here there are two segments both inside the ecliptic ring and below it. Both segments are interrupted in the middle for the lobed arches.

The ecliptic ring is divided into the 12 signs of the zodiac and their names are engraved in the respective divisions. Each sign is divided in 5° and numbered accordingly anti-clockwise. The edge of the ring is calibrated in 1°. There are 63 star pointers, the exact positions of the stars being marked by a dot.

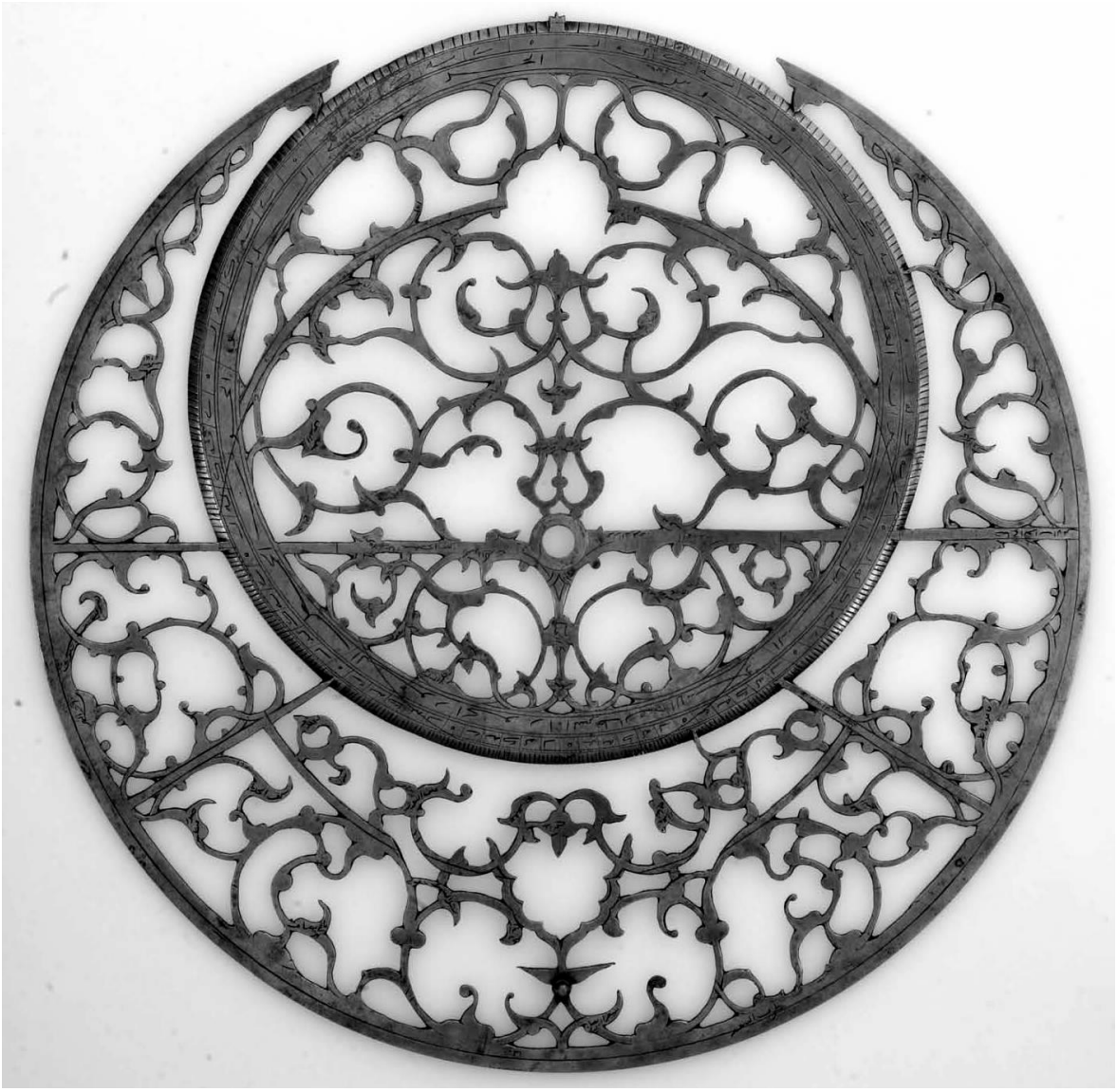


Figure B006.4 – Rete of the astrolabe (courtesy Institut für Geschichte der Arabisch-Islamischen Wissenschaften, Frankfurt)

Table B006-1 Stars on the Rete

	φ	Identification
1	*Dhanab Qayṭus Janūbī*	β Ceti
2	*Baṭn al-Ḥūt*	β Andromedae
3	*Ākhir al-Nahr*	θ Eridani
4	*Rās al-Muthallath*	α Trianguli
5	*Rukbat Dhāt al-Kursī*	δ Cassiopeiae
6	*Nāṭiḥ*	α Arietis

	φ	Identification
7	*Ṣadr Qayṭus*	π Ceti
8	*Rās al-Ghūl*	β Persei
9	*Kaff al-Judhmā'*	α Ceti
10	*Mirfaq al-Thurayya*	α Persei
11	*Munīr*	?
12	*Riǰl al-Musalsala*	γ Andromedae
13	*Tālī Masāfat Nahr*	γ Eridani
14	*ᶜAyn al-Thawr, Dabarān*	α Tauri
15	*ᶜAyyūq*	α Aurigae
16	*Riǰl al-Yusra Jawzā'* (?)	β Orionis
17	(no name)	
18	*Haqᶜa Saḥābī*	λ / φ Orionis
19	*Riǰl al-Yumnā*	κ Orionis
20	*Mankib Dhī al-ᶜInān*	β Aurigae
21	*Yad al-Yumna*	α Orionis
22	*Shiᶜrā Yamānī*	α Canis Majoris
23	*Shiᶜrā Shāmī*	α Canis Minoris
24	*Ṭaraf al-Safīna*	ρ Puppis
25	*Baṣruhu* (?) *Mughallaf* (?) *Saḥābī*	κ Cancri / λ Leonis
26	*Fard al-Shujāᶜ*	α Hydrae
27	*Qalb al-Asad Malikī*	α Leonis
28	*Ẓahr al-Dubb al-Akbar* (?)	α Ursae Majoris
29	*Qāᶜidat Bāṭiya*	α Crateris
30	*Kabid* (?) *al-Asad*	?

	φ	Identification
31	*Zubra*	δ / θ Leonis
32	*Ṣarfa*	β Leonis
33	*Al-Qāʾid*	η Ursae Majoris
34	*Janāḥ al-Ghurāb al-Ayman*	γ Corvi
35	*Simāk Aᶜzal*	α Virginis
36	*Anwar al-Farqadayn*	β Ursae Minoris
37	*ᶜAnāq*	ζ Ursae Majoris
38	*Simāk Rāmiḥ*	α Bootis
39	*Kiffa Janūbī*	α Librae
40	*Kiffa Shamālī*	β Librae
41	*Nayyir Fakkah*	α Coronae Borealis
42	*ᶜUnuq Ḥayyah*	α Serpentis
43	*Rāqiṣ*	μ Draconis
44	*Rās al-Jāthī*	α Herculis
45	*Rās al-Ḥawwā*	α Ophiuchi
46	*Kabid* (?) *al-Ḥawwā*	β Serpentis (?)
47	*Rās al-Tinnīn*	α Draconis
48	*Nasr Wāqiᶜ*	α Lyrae
49	*Dhanab al-ᶜUqāb*	ζ Aquilae
50	*Minqār Dajājah*	β Cygni
51	*Nasr al-Ṭā'ir*	α Aquilae
52	*Dhanab al-Dālfīn*	ε Delphini
53	*Ridf*	α Cygni
54	*Rukba Dajājah*	ω Cygni (?)

	φ	Identification
55	*Fam al-Faras*	ε Pegasi
56	*Dhanab al-Jadī*	δ Capricorni
57	*Sāq Sākib al-Mā'*	α Aquarii
58	*Matn al-Faras*	α Pegasi
59	*Mankib al-Faras*	β Pegasi
60	*Rāᶜī*	γ Cephei
61	*Surrat al-Faras*	δ Pegasi
62	*Janāḥ al-Faras*	γ Pegasi
63	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are four plates with the following particulars.

Table B006-2 Plates

	φ	Longest Day	(Locality)
1a	27°	13;45 hours	(Agra)
1b	29°	13;53 hours	(Delhi)
2a	32°	14;8 hours	(Lahore)
2b	36°	14;30 hours	(middle of the fourth climate)
3a	22°	13;22 hours	(Mecca)
3b	0°+18°+72°+90°		
4a	23;30°+66;30°		
4b	Plate of horizons		

On all the latitude plates, altitude circles are drawn for every single degree, and each fifth circle is numbered. On plate 3b, however, they are drawn for every 3°. The azimuth arcs are drawn for every 5° and numbered along the local horizon. They are drawn mostly above and below the horizon, but on some plates like 1b, they are drawn only above the horizon. On all plates lines for seasonal hours are drawn and numbered from the western horizon onwards from 1 to 12 below the circle of the equator.

The lines for equal hours are unusual. They are drawn for every 4 minutes, on some plates from the western horizon and on some other plates from both the western and the eastern horizons. In either case, the plates are all completely filled with the altitudes lines in the upper half and the lines for equal hours in the lower half.

On plates for 27° and 29°, *al-mashriq* and *al-maghrib* are written below the horizon in the east and west. Immediately above the altitude circle for 28°, there are two different labels in the east and west; these could not be deciphered in the available photo.



Figure B006.5 – Plate 1b for latitude 29°
(courtesy Institut für Geschichte der Arabisch-Islamischen Wissenschaften, Frankfurt)

GEOGRAPHICAL GAZETTEER

On the inner side of the mater, a geographical gazetteer with names, longitudes and latitudes of 285 localities is engraved in three circles, each consisting of 3 rows. Inside these three circles, there are three more rows carrying the names, declinations and mediations of 93 fixed stars. Thereafter are engraved the captions of these two lists in the two upper quadrants. On the left is the caption of the geographical gazetteer: *jadwal atw[ā]ll buldān az jazā'ir khālidāt wa ᶜarḍ* (*ᶜurūḍ*) *az istiwā rawā zīj kayūmarthī shahriyārī īlkhānī* (table of the longitudes of localities from the Fortunate Isles and latitudes from the equator after the *Zīj Īlkhānī.* In the upper right quadrant is the caption of the star list: *jadwal abᶜād kawākib az muᶜaddil al-nahār wa darajat mamarr mintaqat*

al-burūj (the table of distance of the stars from the celestial equator and the degrees of mediation of the ecliptic).

In the middle of the plate is a rectangular table with the heading: *jadwal sāᶜāt bilād az ᶜarḍ 13 darjah tā ᶜarḍ 52 darjah* (table of hours [of the longest day] at towns on latitude 13 degrees to latitude 52 degrees).

The table of stars with their declinations and mediations and the table of hours of the longest day are unique here and do not occur in any other Indo-Persian astrolabe.[597]

This geographical gazetteer is said to be based on the *Īlkhānī* tables, but there are several repetitions, which are shown in the fifth column of the following table. It appears likely that the astrolabe maker did not use the *Īlkhānī* tables directly, but some other geographical table based on the *Īlkhānī* tables, where these repetitions may have occurred.

Although this is the largest geographical gazetteer in the Indo-Persian astrolabes, it contains less than 30 localities in the Indian subcontinent.[598] The only new place which is not listed in any other Indo-Persian astrolabe is Kālanjar (no. 283) or Kālinjar, a fortress city in Central India (80;29° E, 24;59° N).[599]

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597 For the two tables, see the forthcoming paper by Petra Schmidl.

598 I am, of course, pleased that Aligarh is mentioned under the old name Kūl (no. 270).

599 Kennedy 1987a, s.v. Kalanjar.



Figure B006.6 – Geographical Gazetteer
(courtesy Institut für Geschichte der Arabisch-Islamischen Wissenschaften, Frankfurt)

Table B006-3 Geographical Gazetteer

	Place Name	L	φ	Comments
	Outer Circle			
1	Makka Mubārak	77;10	21;40	
2	Madīnat Rasūl Allāh	75;20	25;0	
3	Ṭā’if	77;30	23;0	
4	Sūs Aqṣā	15;30	32;0	

	Place Name	L	φ	Comments
5	Fāra Qaṣba Ṭanja	18;0	22;0	
6	Tāhart ᶜUlyā	35;30	29;0	
7	Sufla az Farniqiya	36;0	29;0	
8	Silikhmāya	37;0	31;30	
9	Qayrawān	41;0	31;40	
10	Mahdiyya	42;0	32;30	
11	Ṭarābulus Maghrib	45;0	32;0	
12	Qurṭuba Andalus	38;27	35;0	
13	Taza az Barbar	65;0	14;0	
14	Jarmī az Ḥabash	65;0	9;30	
15	Durqula Shar Nūba	53;40	14;30	
16	Qūsh Miṣr	61;30	24;30	
17	Iskandariyya	61;54	30;58	
18	Miṣr	63;20	30;20	
19	Damiyāṭ	63;30	31;25	
20	Qulzum Kanār Daryā	64;0	29;30	
21	ᶜAdan	76;0	11;0	cf. 255, 284
22	Ṣanᶜā’ Dār al-Malikīn (?)	77;0	14;30	cf. 285
23	Zabīd	74;20	14;10	
24	Ṣuḥār	14;0	14;20	cf. 26

	Place Name	L	φ	Comments
25	Yamāma	82;30	23;0	cf. 256
26	Ṣuḥār Baḥrayn	83;0	24;30	cf. 24
27	Laḥsā	83;30	24;0	
28	Qaṭīfa Baḥrayn	74;0	25;0	
29	Bayt al-Maqdis	66;30	31;50	
30	ᶜAsqalān	66;30	32;15	
31	Ramla	77;50	32;10	
32	Qaysāra	66;30	32;30	
33	Ṭabariyya	68;0	32;0	
34	Ṣūr	68;30	32;40	
35	Ṣaydā	68;30	32;40	
36	Ṭarābulus	69;40	34;0	
37	Dimashq	70;0	33;15	
38	Baᶜlbak	70;45	33;15	
39	Khimṣ	70;45	34;0	
40	Anṭākiyya	71;26	35;30	
41	Sarfīn	71;7	34;15	
42	Qīrbīn	72;0	35;30	
43	Ḥalab	72;10	35;50	
44	Mābij	72;15	34;10	
45	Raḥba	74;35	34;10	
46	Ṭarsūs	68;40	36;42	
47	Qaṣqaṣiyya	69;15	36;45	

	Place Name	L	φ	Comments
48	Malaṭya	71;0	37;0	
49	Ṣiqilliya	65;0	37;10	
50	Rūmiya	85;27	41;50	
51	Athīniya Madīnat Ḥikmā’	69;40	37;20	
52	Qusṭanṭiyya	59;50	45;0	
53	Maqīdūnya	60;0	41;0	
54	ᶜAmmūriya	64;0	43;0	
55	Arzāna Rūm	77;0	39;40	
56	Arzankān	76;0	38;0	
57	Sīwās	71;40	39;0	
58	Sahimāṭ	72;35	42;0	
59	Qālīqalā	73;25	39;0	
60	Qūnya	66;30	41;0	
61	Ḥarrān	73;0	36;40	cf. 245
62	Raqqā	73;15	36;0	cf. 165, 251
63	Rās al-ᶜAyn	74;0	36;50	
64	Masārdīn	74;0	37;15	
65	Qarqarsiya	74;40	37;20	
66	Niṣībīn	75;20	36;0	
67	Sinjār	76;0	36;0	
68	ᶜĀna	76;30	34;0	
69	Mawṣil	77;0	34;30	
70	Irbīl	77;20	35;0	

	Place Name	L	φ	Comments
71	Takrīt	78;20	34;30	
72	Amid	73;40	38;0	
73	Malādjird	75;0	38;45	
74	Akhlāṭ	75;50	39;20	
75	Arjīsh	77;0	38;30	
76	Abī	79;0	41;0	
77	Salmās	79;15	37;40	
78	Khuway	79;40	37;40	
79	Ūrmiya	79;45	37;0	
80	Mawand	80;45	37;50	
81	Najwān	81;15	38;40	
82	Marāgha	82;0	38;0	
83	Tabrīz	82;0	38;0	
84	Ardabīl	82;30	38;0	
85	Mūqān	83;0	38;0	
86	Bardhaᶜa (?)	83;0	40;30	
87	Jankza	83;0	41;20	cf. 247
88	Shamkūra	83;0	41;50	
89	Tiflīs	83;0	43;0	
90	Alān	83;0	44;0	
91	Baylaqān	83;30	39;50	
92	Bākawiya	84;30	39;30	
93	Shamākhī Qaṣba	84;30	40;50	
94	Bāb al-Abwāb	85;0	43;0	

	Place Name	L	φ	Comments
95	Balanjar Dār al-Mulk	85;20	46;30	
	Middle Circle			
96	Kirya Madinat Rūs	87;0	53;0	
97	Safīn	86;30	43;0	
98	Bulfār	90;0	49;30	
99	Bukhyār	83;0	44;0	
100	Sarra Manra’ā	79;0	34;0	
101	Kūfa	79;30	31;30	
102	Al-Madā’in	72;0	33;10	
103	Baghdād	80;0	33;25	
104	Wāsiṭ	81;30	32;20	
105	Baṣra	84;0	30;0	
106	Ubulla	84;0	30;15	
107	ᶜAbādān	84;30	30;0	
108	Jundnīshābūr	84;5	31;55	
109	Tustar	84;30	31;30	
110	ᶜAskar	84;30	31;15	
111	Ahwāz	85;0	31;0	
112	Rāmhurmuz	85;45	31;0	
113	Arrajān	86;30	31;55	
114	Shābūr	86;55	30;0	
115	Kāzirūn	87;0	29;15	
116	Nawbandajān	87;15	37;10	

	Place Name	L	φ	Comments
117	Fīrūzābād	87;30	28;10	
118	Shīrāf	88;0	29;0	
119	Shīrāz	83;0	29;36	
120	Iṣṭakhr	88;30	30;0	
121	Yazd	89;0	32;0	
122	Sahrazūr	82;20	32;30	
123	Ḥulwān	82;15	34;0	
124	Farmāsīn	83;0	34;30	
125	Dīnawar	83;0	35;0	
126	Suhraward	83;20	36;0	
127	Nahāwand	83;45	34;20	
128	Zankān	83;40	36;30	cf. 226 Zanjān
129	Abhar	84;30	36;45	
130	Hamadān	83;0	35;10	
131	Karkh	84;45	34;0	
132	Sāwa	105;0	36;15	
133	Qazwīn	105;0	37;15	
134	Aba	105;0	34;40	
135	Jurbādaqān	105;30	30;15	
136	Samīrum	105;40	32;15	
137	Iṣfahān	106;40	32;25	
138	Kāshān	106;0	34;0	
139	Qumm	85;40	34;45	
140	Rayy	86;20	35;0	

	Place Name	L	φ	Comments
141	Khwārizm	87;10	35;40	cf. 187
142	Alamūt	85;37	36;21	
143	Ṭāliqān	85;45	37;10	
144	Jīlān	85;10	37;0	
145	Kajūr Kalār	86;50	36;25	
146	Dumāwand	87;20	37;10	
147	Āmul	88;20	36;15	
148	Sārina	58;0	37;0	
149	Askar Qaṣba Jurjān	89;30	37;15	
150	Jurjān	90;0	36;50	
151	Samnān	88;0	36;0	
152	Dāmwān	88;55	36;20	Dāmghān ?
153	Bisṭām	89;30	37;10	
154	Tiyār	89;50	35;0	
155	Farāwa	90;0	39;0	
156	Mazīnān	90;30	37;0	
157	Sabzawār	91;30	36;05	
158	Nīshābūr	92;30	36;21	
159	Ṭūs	92;30	36;0	
160	Tūrshīz	92;0	35;0	
161	Ṭabas	92;0	33;0	cf. 164, 167
162	Tūn	92;30	34;30	
163	Fābīn (?)	93;20	33;40	cf. 166
164	Ṭabas Kilakī	94;15	33;15	cf. 161, 167

	Place Name	L	φ	Comments
165	Raqqā	92;30	34;30	cf. 62, 251
166	Qā'īn (?)	93;20	33;40	cf. 163
167	Ṭabas Masīnā	94;15	33;15	cf. 161, 164
168	Zūzan	93;30	35;20	
169	Būshanj	94;5	34;50	
170	Harāt	94;20	37;30	
171	Bādhghīn	97;30	34;20	
172	Sarakhs	94;30	37;0	
173	Marw	97;0	36;30	
174	Jūzajān	98;0	35;30	
175	Fāriyāb	99;0	34;45	
176	Ashūrḥān	100;0	36;45	
177	Balkh	101;0	36;41	
178	Bāmiyān	102;0	34;35	
179	Samankān	102;0	36;0	
180	Qabadhiyān	102;0	37;45	
181	Walwā[li]j	102;20	36;55	cf. 228
182	Ṭāliqān	102;50	37;25	
183	Andabāt	103;45	37;0	
184	Badakhshān	104.24	37;10	
185	Bulūr	108;0	37;0	
186	Būkurkānj	93;45	42;35	
187	Khwārizm	94;30	42;17	cf. 141
188	Hazār Asb	90;0	41;0	

	Place Name	L	φ	Comments
189	Kāt	95;0	41;36	
190	Darqān	94;15	39;30	
	Inner Circle			
191	Bukhārā	97;30	39;50	
192	Samarqand	99;16	39;34	
193	Nasaf	98;0	39;0	
194	Lishn	99;30	39;30	
195	Mashhad	99;50	43;36	
196	Ṭarāz	99;50	44;31	
197	Usrūshana	180;0	40;0	
198	Ṣaghāniyān	180;30	38;47	
199	Khujand	75;35	41;55	
200	Shāsh	81;0	43;0	
201	Tūnka Qaṣba	81;0	43;25	
202	Marghāna	101.20	42;25	
203	Ūzland	102;50	44;0	
204	Ūsh	102;20	43;20	
205	Kāshghar	106;30	44;0	
206	Jāj	109;0	42;30	
207	Khutan	107;0	42;0	
208	Al-Māligh	102;30	44;0	
209	Qabāligh	108;0	44;0	
210	Uwīn	110;0	46;0	
211	Bīsh Basāliᶜ	111;0	45;50	

	Place Name	L	φ	Comments
212	Qarāqurūm	95;0	46;0	
213	Khān Bāligh	124;0	46;0	
214	Nanknās	130;0	39;0	
215	Mahdiyya	140	30;0	
216	Sirjān	90;20	29;30	
217	Hūrmūz	92;0	25;0	
218	Bardsīr	92;30	29;50	
219	Jīruft	93;0	27;0	
220	X-m-n (?)	73;20	15;10	
221	Bamar (?)	94;0	28;30	
222	ᶜAskar	86;8	30;40	
223	Narmāshīr	94;20	29;0	
224	Kāzirūn	87;8	29;50	
225	Khabīs	93;0	31;0	
226	Zanjān	88;8	38;8	cf.128
227	Zaraᶜ	97;0	32;30	
228	[Wa]lwāliḥ (?)	102;4	16;40	cf. 181
229	Bust	100	33;0	
230	Ṭ-r-h-x-ā (?)	86;28	33;50	
231	Talisābād	101;55	32;30	
232	Haraql[a] (?)	88;04 !	46;45 !	
233	Maymand	101;55	33;20	
234	Qardār	120;25	38;35	
235	Ghazna	104;20	33;35	cf. 236

	Place Name	L	φ	Comments
236	Ghaznayn	104;8	35;8	cf. 235
237	Banjahir	104;40	35;0	
238	Ribāṭ Amīr	105;0	34;0	
239	Maghān	108;36	37;8	Dāmghān?
240	Tir (?) Qaṣba Makrān	98;0	26;15	
241	Qā'in	120;15	38;15	
242	Kīj	99;0	28;0	
243	Jiruft	98;8	32;14	
244	Ḥālik az Makrān	99;0	30;0	
245	Ḥarrān	75;08	37;45	cf. 61
246	Daybul	102;30	14;20!	
247	Kanja	81;4	41;8	cf. 87
248	Māfa az Hind	82;0	19;20	corrupt for Tāna?
249	[Di]his[t]ān (?)	91;50	36;45	
250	Nahlawara	102;30	22;0	
251	Daqqa (?)	78;15	34;8	corrupt for Raqqā (cf. 62, 165)?
252	Sawmnāt	106;0	17;0	
253	Bamm	98; -	32;8	
254	Qandahār	107;40	33;0	
255	ᶜAdan	74;3	18;3	cf. 21, 284
256	Tamata (?)	82;30	24;10	corrupt for Yamāma (cf. 25)?

	Place Name	L	φ	Comments
257	Mūltān	107;35	29;40	
258	Lahāwar	109;20	31;50	
259	Kashmīr	108;0	35;0	
260	Tubbat	110;0	40;0	
261	Kābul	104;40	34;30	
262	S-w-r-x-w-r (?)	89;4	33;4	
263	X-d-m-x-r-h-ā	112;8	30;0	
264	Bānībat	113;20	28;52	
265	Dihlī	113;35	28;19	
266	Akra	115;0	27;0	
267	Kawaliyar	114;0	26;29	
268	Safhal	115;0	28;4	Sanbhal
269	Barāwan	117;19	26;32	Badā’ūn
270	Kūl	114;39	28;0	
271	Banāras	117;20	26;15	cf. 269
272	Jawnbūr	119;6	26;36	
273	Sarandīb	130;0	10;0	
274	Bunḥābūr (?)	120;4	20;0	cf. 277
275	Ajīr	102;0	25;0	cf. 280
276	Aḥmadābād	118;40	23;15	
277	Burhānbūr	119;--	22;0	cf. 274
278	Dawlatābād	111;0	20;30	
279	Kahbayāt	109;4	24;0	Kanbayāt
280	Ajmīr	111;5	24;0	cf.275

	Place Name	L	φ	Comments
281	Qannawj	115;50	26;35	
282	Hā[n]sī	112;25	29;45	
283	Kālanjar	120;5	28;25	
284	ᶜAdana	75;03	18;3	cf. 21, 255
285	Ṣaᶜā’n	77;20	16;04	cf. 22

BACK

On the back, there are altitude scales on the upper half of the rim, divided in 0;30°, 1° and 5° and numbered in 5s as 5—90; 90— 5.

In the trigonometric quadrant on the upper left are drawn sixty horizontal lines at equal distances and fifteen vertical lines at intervals gradually decreasing towards the circumference, but neither set is numbered. Moreover, a bundle of 60 arcs are traced from the east point up to the upper vertical radius where they merge with the 60 parallel lines. Of these every fifth is drawn as a thicker arc. These arcs are numbered in 5s from 5 to 60, starting from the horizontal diameter and reaching vertically up to the arc of the quadrant. The purpose of these 60 arcs is not known, so also the significance of a small half circle engraved on the vertical radius.

The 60 horizontal lines in the upper left quadrant are extended into the solar quadrant in upper right as declination arcs for each 3° of solar longitude. Each tenth arc which forms the boundary between zodiac signs is drawn as a thicker line. The names of the corresponding zodiac signs are inscribed along the two radii.

In the lower half are drawn the shadow squares. The one on the left is for a base of 7; here the vertical horizontal scales are divided in 7 parts each and numbered accordingly. The shadow square on the right is for bases of 12 and 60; the scales are first divided in 12 parts and numbered from 1 to 12. Then each part is divided in 5 so that there are 60 divisions in each scale. The four scales are given the following labels:
Vertical scale on the left: *ẓill aqdām al-maᶜkūs* (direct shadow in feet)
Horizontal scale on the left: *ẓill aqdām al-mustawī* (reverse shadow in feet)

Horizontal scale on the right: *ẓill sittaynī al-mustawī* (direct shadow in 60 divisions)
Vertical scale on the right: *ẓill sittaynī al-maᶜkūs* (reverse shadow in 60 divisions).

On the lower half of the rim are engraved cotangent scales. The scale on the left is divided in feet and the unequal divisions are numbered in 5s clockwise from the meridian, followed by the label *ẓill aqdām.* The scale on the right is divided in digits and the unequal divisions are numbered in 5s anti-clockwise from the meridian, followed by the label *ẓill aṣābiᶜ*.

Between the cotangent scales on the rim and the shadow squares, there are eight semi-circular rows; the first two are filled with the names of the 28 lunar mansions and the names of the 12 zodiac signs; the next two rows carry the table of the limits and the following two rows the decans and their regents.[600]

The last two rows contain, as the labels engraved immediately thereafter inform us, the sun's declination of the sun in each sign of zodiac (*mayl al-shams fī-l-burūj*) and a scale of shadows (*al-raqā'im al-mustawat*).

Inside the shadow squares are engraved four astrological tables. Starting from the left, these are the diurnal and nocturnal regents of the triplicities (*arbāb muthallathāt rūz, arbāb muthallathāt shab*), novenaries (*nuhbaharr*), exaltations and deteriorations of the planets (*sharaf* and *hubūṭ*), apogees and perigees of the planets. The tables of triplicities are well known. The other three are new.

In the novenaries, each zodiac sign is divided into 9 equal parts of 3;30° which are assigned to planets in their domiciliary order. The arrangement is the same for all the four signs in a trigon. This table is derived from the *navāṃśa* (lit. ninth part) of Sanskrit astronomy.[601] The *zarqālī* astrolabe by Ḍiyā' al-Dīn Muḥammad of the Lahore family also carries this table of novenaries (A091).

The table of the exaltations and deteriorations show the degrees of the signs where a particular planet is most effective or the reverse.[602]

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600 Here and in the tables engraved inside the shadow squares, the astrolabe differs a few times from the standard tables, owing to scribal errors or other reasons. An analysis of these differences will appear in the forthcoming paper by Dr. Schmidl.

601 Cf. Kaye 1918, p. 124; Türstig 1980, p. 57-57.

602 Analogous to *paramocca* and *paramanīca* of Sanskrit astrology; cf. Türstig 1980, p. 161.

On the table of the apogees and perigees, Schmidl remarks that the position of the apogees and perigees of planets depends on the time when the observation is made; but the astrolabe does not mention any time of observation; however, a comparison with the table in al-Bīrūnī's *Kitāb al-Tafhīm* does not show any significant differences.



Figure B006.7 – Back of the astrolabe
(courtesy Institut für Geschichte der Arabisch-Islamischen Wissenschaften, Frankfurt)

ALIDADE

The alidade is straight without any counter change; it has ornate ends and an ornate centre-piece. The edge and the upper rim on the both sides carry sexagesimal scales. On the upper register on the right hand side, the sexagesimal scale is divided in 5s and numbered from 5 to 60 the mid-point of the astrolabe to the tip. The lower register on this side is marked for unequal hours to be used when the alidade is employed as a sundial.

On the left-hand side of the alidade are drawn declination arcs as on the upper right quadrant on the back and the signs are faintly marked by their serial numbers.

The ruler attached in front is ungraduated and must be a replacement. The pin is original and bears an ornate tip which projects out on the front side when the astrolabe is fully assembled. The wedge is shaped like the head of a horse with un upright ear and with an eye and a nostril indicated by small holes.



Figure B006.8 – Alidade, ruler, pin and horse
(courtesy Institut für Geschichte der Arabisch-Islamischen Wissenschaften, Frankfurt)

INSCRIPTIONS

1. On the front side of the cartouche in the *kursī* is the original inscription which reads

   ᶜamal ᶜabd al-qādir muḥibb

   The work of ᶜAbd al-Qādir Muḥibb.



Figure B006.9 – Astrolabe maker's signature (detail of Figure B006.1)

2. On the reverse side of the cartouche, somebody later engraved *yā muḥammad naṣīr al-dīn wa-d-dunya* (O Muḥammad, Support of the religion and of the world), which is employed by the Sūfīs as one of the 99 names of God. But it also creates the impression that the astrolabe is made by or for the famous astronomer Naṣīr al-Dīn al-Ṭūsī, the director of the Maragha observatory.



Figure B006.10 – Engraving on the back of the *kursī* (detail of Figure B006.7)

3. In order the enforce the notion that the astrolabe is associated with Naṣīr al-Dīn al-Ṭūsī and thus to increase its age and the monetary value, two other inscriptions are engraved on the edge of the astrolabe. On the right hand side is the inscription *yazdigird sanata 638* (1269-70) and *talā yeksod mithqāl* (100 *mithqal* gold).



Figure B006.11 – Engraving on the edge of the astrolabe (courtesy Institut für Geschichte der Arabisch-Islamischen Wissenschaften, Frankfurt)

4. On the left-hand side of the edge is engraved *noqreh duwīst wa hasht* (?) (208 *mithqāl* silver). *Mithqāl* is a unit of weight in Arabic and is equal to 4.25 grams.



Figure B006.12 – Engraving on the edge of the astrolabe
(courtesy Institut für Geschichte der Arabisch-Islamischen Wissenschaften, Frankfurt)

PROVENANCE

The astrolabe was formerly in the possession of Jamileh Yeganeh, Teheran; in 1960 it was acquired by the Institute of History of Science, Johann Goethe University, Frankfurt. After the closure of this institute in 2007, it was given on long term to the Museum für Angewandte Kunst, Frankfurt.

BIBLIOGRAPHY

Schmidl 1994.

B007⊙ ASTROLABE BY IBN MUḤIBB ḤAQĪQA, 1057 AH (AD 1647-48)

Diameter 77 mm

Oxford, Museum of the History of Science (# 52066)

CCA 73; Répertoire 1

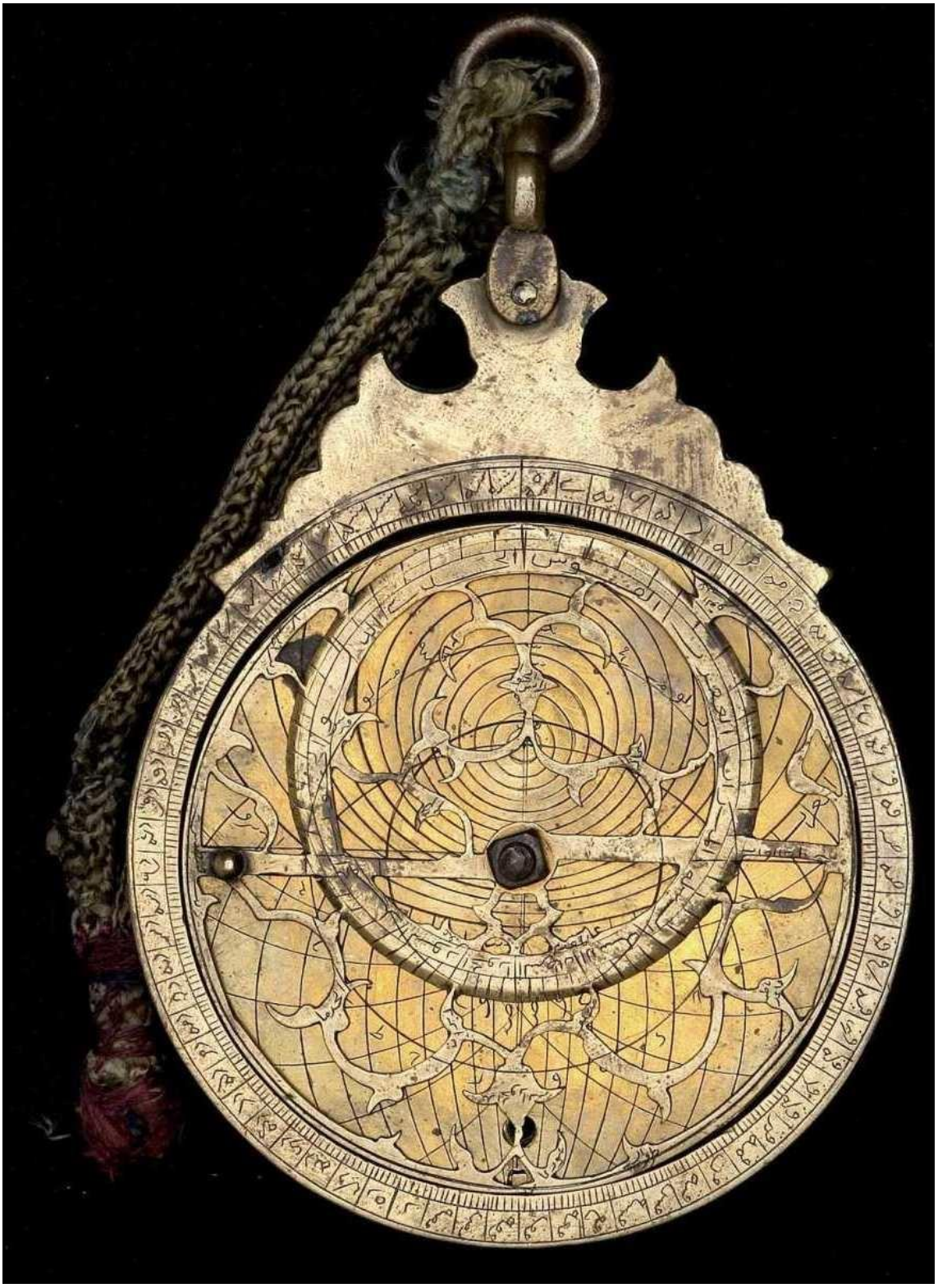


Figure B007.1 – Front of the astrolabe (© Museum of the History of Science, Oxford)

Ibn Muḥibb Ḥaqīqa must be the son of ᶜAbd al-Qādir Muḥibb; he is known through just this one astrolabe. As on the majority of Lahore astrolabes, there are two sigmoid curves on this astrolabe also for the sun's midday altitude at latitudes 27° and 32°. Chronologically, Ḥaqīqa is a contemporary of Ḍiyā' al-Dīn Muḥammad of Lahore and employs exactly the same symbol for zero as Ḍiyā' al-Dīn does, the symbol which looks like a small pair of scissors.

Components

Body with *kursī* (d. 77, h. 109, t. 7), ring, shackle and cord, rete, 6 plates and alidade; the pin and wedge are lost; the ensemble is held together by a bolt and a nut. Inside the rim of the main body, there is a small peg at the north point to hold the plates in position. There is a notch at the corresponding place in all the plates. Moreover, just above the peg, a pin appears to have been attached to the mater originally. It is gone now and just the hole remains. There is a hole at the corresponding place in all the plates.

Front

The ring is large with an octagonal cross-section; the shackle also has an octagonal cross-section and the shape of a trefoil. A green cord is attached to the ring. The *kursī* was made separately and soldered to the main body. It is solid; in each profile, there is a highly exaggerated mango-shaped scallop.

The limb is divided in 1° (not uniformly) and 5° and numbered in 5s clockwise from 5 to 360. In the very first cell, the engraver made an error; he first inscribed 360, scratched it over and added 5 above it.

Rete

The very slender Capricorn ring and the much wider ecliptic ring are held together by the equinoctial bar which has a counter change at the centre. The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names. Each sign is subdivided into five parts, but these parts are not numbered. The star pointers are joined by an almost symmetrical tracery. On the surface of the rete, there are traces of the circles of equator and of the Tropic of Cancer. A knob to rotate the rete is affixed to the equinoctial bar near the east point. The Capricorn index is not well defined. There are 17 star pointers. Because of the small size of the astrolabe, the star names engraved on the rete are starkly abbreviated.

Table B007-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab Qayṭus*	β Ceti
2	*[Kaff] al-Jadhmā*	α Ceti
3	*Ghūl*	β Persei
4	*Dabarān*	α Tauri
5	*Yad al-Jawzā' Yusrā*	γ Orionis
6	*Shiᶜrā [Yamānī]*	α Canis Majoris
7	*Muqaddam*	α Geminorum
8	?	
9	*Ṭarfat …*	ρ Puppis
10	*Qāᶜidat Bāṭiya*	α Crateris
11	*Simāk [Rāmiḥ]*	α Bootis
12	*Qalb al-ᶜAqrab*	α Scorpii
13	*Rās al-Ḥawwā*	α Ophiuchi
14	*Ṭā'ir*	α Aquilae
15	*[Fam] Faras*	ε Pegasi
16	*Dhanab al-Jadī*	δ Capricorni
17	*Kaff Kaḍīb* ?	β Cassiopeiae

PLATES

There are six plates; the first five serve 10 different latitudes from 18;14° to 36°. It is not clear which locality is indicated by the first latitude 18;14°; no locality with this latitude is listed in the geographical gazetteer.

Table B007-2 Plates

	φ	Longest Day	(Locality)
1a	18;14°	13;9 hours	?
1b	29°	13;52 hours	(Delhi)
2a	21;40°	13;22 hours	(Mecca)
2b	25;0°	13;35 hours	(Medina)
3a	26°	13;43 hours	
3b	28°	13;44 hours	
4a	27°	13;43 hours	(Agra)
4b	32°	14;8 hours	(Lahore)
5a	34°	14;20 hours	
5b	36°	13;32 hours	
6a	Plate of ecliptic coordinates		
6b	Plate of horizons		

On plates 1, 2, 3 and 5, altitude circles are drawn for every 6°, azimuth arcs for each 10° below the local horizon, and lines for seasonal hours. There are no lines for equal hours. On plate 4, latitude circles are traced for every 3°, azimuth arcs for each 10° below the horizon, and plain lines for seasonal hours and dotted lines for equal hours from the western horizon.

Geographical Gazetteer

The gazetteer provides the names, longitudes and latitudes of 34 localities in two circles. Strangely, Delhi is not mentioned here, although plate 1b is designed for latitude 29°.

Table B007-3 Geographical Gazetteer

	Place Name	L	φ
	Outer Circle		
1	Makka Muᶜẓẓam	77;10	21;40
2	Madīnat Musharrafa	75;20	25;0
3	Kufa	79;30	31;30
4	Al-Rūm	77;0	39;50
5	Dimashq	70;0	33;15
6	Tabrīz	82;0	38;0
7	Baghdād	80;30	33;25
8	Yazd	89;0	32;30
9	Iṣfahān	86;40	32;25
10	Ṭūs	94;30	37;0
11	Balkh	101;0	36;41
12	Bukhārā	97;30	39;50
13	Hamadān	83;0	35;10
14	Harāt	94;33	34;30
15	Harmūz	92;0	35;0
16	Qandahār	107;40	33;0
17	Kābul	104;40	34;30
18	Kashmīr	103;0	35;0
19	Lāhūr	109;20	31;50
20	Mūltān	107;35	29;40
21	Mashhad Maqdis	92;30	36;0
22	Sabzawār	91;30	36;5

	Place Name	L	φ
23	Shīrāz	108;0	29;36
	Inner Circle		
24	Bījāpūr	115;30	17;20
25	Burhānpūr	113;0	20;30
26	Dawlatābād	111;0	20;30
27	Ajmīr	111;0	26;0
28	Kawāliyār	114;0	26;29
29	Qannawj	115;50	26;35
30	Jawnpūr	119;6	26;36
31	Akbarābād	114;0	26;43
32	Dhākā Bankālā	130;0	27;0
33	Patna	120;45	26;40
34	Ahmadābād	108;40	28;15

BACK

The rim of the upper half is engraved with two latitude scales which are divided in 1° and 5° and numbered in 5s as 5—90; 90—5. The upper left quadrant carries 30 horizontal lines; these are numbered in 6s along the vertical radius from the centre up to the south point. The solar quadrant in the upper right is divided by 5 declination arcs into 6 zones, each of which represents a pair of zodiac signs. The names of the signs are engraved along the two radii. Two curves of the midday altitude of the sun throughout the year at latitudes 27° and 32° are plotted in this quadrant with the labels *khaṭṭ niṣf al-nahār bi-ᶜarḍ 27* (line of midday at the latitude of 27°)[603] and *khaṭṭ niṣf al-nahār bi-ᶜarḍ 32* (line of midday at the latitude of 32°).

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603 Gunther 1932, p. 202 and Répertoire read this latitude erroneously as 37°.



Figure B007.2 – Back of the astrolabe (© Museum of the History of Science, Oxford)

Shadow squares are drawn in the lower half, on the left for a base of 7 and on the right for a base of 12. The scales are divided and numbered accordingly, and are accompanied by the following labels:

In the inner corner on the left: *ẓill sullam aqdām* (scale of shadows in feet)

Vertical scale on the left: *ẓill aqdām maᶜkūs* (reverse shadows in feet)
Horizontal scale on the left: *ẓill aqdām mustawī* (direct shadows in feet)
In the inner corner on the right: *ẓill sullam aṣābiᶜ* (scale of shadows in digits)
Horizontal scale on the right: *ẓill aṣābiᶜ mustawī* (direct shadows in digits)
Vertical scale on the right: *ẓill aṣābiᶜ maᶜkūs* (reverse shadows in digits).

The rim of the lower half carries cotangent scales. The scale on the left is in feet. The outer row is divided in groups of six unequal units and numbered in 6s from the vertical diameter clockwise as 6, 7, 12, 18, 24 … 60, followed by the label *ẓill aqdām* (shadows in feet). The inner row is divided in single units. The scale on the right is in digits. The outer row here is also divided in groups of 6 and numbered in 6s from the vertical diameter anticlockwise as 6, 7, 12, 18, 24 … 60, followed by the label *ẓill aṣābiᶜ* (shadows in digits).

Between the cotangent scales and the shadow squares are two semi-circular rows engraved with the names of the 12 signs of the zodiac and the names of the 28 corresponding lunar mansions.

Alidade

The alidade has ornate ends and an ornate centre-piece. The upper register of the right arm carries a sexagesimal scale, numbered in 6s, from 6 to 60, starting from the centre and reaching up to the tip. The lower register on this side is marked with the serial numbers of seasonal hours for measuring time when the alidade is used as a sundial. The left arm is divided as in the solar quadrant on the upper right quadrant on the back and is marked with the serial numbers of the zodiac signs.

Inscription

The maker's signature is engraved upside-down inside the shadow squares:

ibn muḥibb haqīqa
ghafr allāh dhunūbah sanah 1057
'Ibn Muḥibb Ḥaqīqa
May God forgive his sins; year 1057 [Hijrī = AD 1647-48].'

Bibliography

Gunther 1932, no. 73, pp. 201-202, figures 101-102.

MUḤAMMAD ṢĀLIḤ TATAWĪ [604]

Muḥammad Ṣāliḥ Tatawī (*fl.* 1659-1666) is known from four astrolabes and three celestial globes; besides, three unsigned astrolabes and one unsigned celestial globe can be attributed to him on stylistic grounds. He is the only instrument maker outside the Lahore family who produced so many instruments in the seventeenth century. He signs his creations with a short inscription *ʿamal muḥammad tatawī,* followed by the year. In the globe of 1659, he writes *tatahwī* in stead of *tatawī.* On this Emilie Savage-Smith remarks as follows: 'It is unlikely that the maker was from Tatta in the Sind (the delta of the Indus river) since the name of the town is written with slightly different letters and should more accurately be transliterated as T'hat't'hā.'[605] Actually the name is written to day in English as Thatta, in the local language Sindhi as ٺٽو and in Urdu as ٹھٹہ . At the time of Muḥammad Ṣāliḥ, Urdu was still in the stage of formation and Ṣāliḥ may have spelt his name according to the Sindhi usage. In the geographical gazetteer of his astrolabe of 1666 (B011), he lists the town as Tatah (تتہ) with a longitude of 102;30° and latitude of 25;10° (the modern values are 67;55,28 E and 24;44,46° N).

It is not known where his workshop lay, at his native place Thatta itself, or elsewhere. On the celestial globe he produced in 1659, he writes that it was made by the order of (*bi-farmāyish*) Shykh ʿAbd al-Khāliq. A unique manuscript of the *Tashil-i Zīj-i Ulugh Begī* of Mullā Chānd Bahā' al-Dīn in the Sawai Mansingh Palace Library at Jaipur bears the seal of ʿAbd al-Khāliq, 'a slave of Shāh Jahān', dated 1030 AH (AD 1628-29).[606] Therefore, Muḥammad Ṣāliḥ's patron ʿAbd al-Khāliq must be a high dignitary at the court of Shah Jahan at Agra.

No other information is available about Ṣāliḥ personal life, save the astrolabes and celestial globes produced by him.[607] His astrolabes can be divided into two broad categories. In the first category are the small astrolabes B009 (Mumbai), B010 (V&A),

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604 Savage-Smith 1985, nos. 25 and 29, pp. 229-232, 304, Fig. 18; Sarma, Ansari & Kulkarni 1993; Maddison & Savage-Smith 1997, I, pp. 235 and 237.

605 Savage-Smith 1985, p. 44; the same wording again on p. 229.

606 Pingree 1999, p. 76, n. 18.

607 His celestial globes will be discussed in section G.

B012 (Patna) and B013 (Karachi); these have diameters between 111 mm and 144 mm. The second category comprises the two large astrolabes B011 (Oxford) and B014 (Salem).

B009, B012 and B013 of the first category contain almost identical *kursīs* and retes. The *kursīs* are solid with profiles made up of two ogees. The shackle is trifoliate like the shackles in the Lahore astrolabes, but has a knob at the top which seems to be a characteristic feature of Ṣāliḥ. In the retes, the three rings of the Tropic of Capricorn, ecliptic and the partially represented equator ring are held together by the complete equinoctial and solstitial bars, both with a counter change at the centre. There is no floral tracery joining the star pointers. These arise from the circular rings and straight bars which have been just mentioned. The star pointers have the simple shape of lobed daggers. Unlike the retes in the Lahore astrolabe makers, Ṣāliḥ's retes are not cluttered with too many star pointers; there are less than 30 named star pointers.

The backs of the astrolabes in this first category also differ from Lahore astrolabes. The solar quadrant on the upper right quadrant carries a universal horary quadrant with two faintly drawn curves of the midday altitude of the sun at latitudes 27° and 32°. The accompanying labels read *niṣf al-nahār bi-ᶜarḍ 27* or 32, while in the Lahore astrolabes the labels read *khaṭṭ niṣf al-nahār bi-ᶜarḍ x.* In the lower half, besides the shadow squares and the cotangent scales, there is just one astrological table with the names of the zodiac signs and the names of corresponding lunar mansions.

The astrolabe B010 broadly shares these features, but has an ornate *kursī* and an indifferent tracery in the rete.

The astrolabe of 1666 (B011) is much larger with a diameter of 194 mm and is very flamboyant with a reticulated *kursī* and a floral tracery in the rete. The astrolabe B014 is still larger with a diameter of 218 mm, its reticulated *kursī* is more ornate than the same in B011, but the rete is closer to the retes in the first category. The backs of these astrolabes are quite similar to the backs of the astrolabes in the first category, but do not have any graphs of solar meridian altitude.

B008 ASTROLABE BY MUḤAMMAD ṢĀLIḤ, 1072 AH (AD 1661-62)

Diameter ?

PLU, ex-Edgerton (Mass), private collection of Eugen Hoffmann

Répertoire 2

The following information is based on Répertoire; no other details are available.

RETE

The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names. There are 21 named star pointers.

BACK

The upper half of the rim carries two altitudes scales, each marked up to 90°. Upper left quadrant with a sine graph; upper right quadrant with two curves for the sun's meridian altitude at latitudes 27° and 32°; in the lower half, shadow squares, astrological tables, and cotangent scales on the rim.

INSCRIPTION

ᶜamal muḥammad ṣāliḥ tatawī sanah 1072

The work of Muḥammad Ṣāliḥ of Thatta, year 1072 [Hijrī = AD 1661-62]

B009⊙ ASTROLABE BY MUḤAMMAD ṢĀLIḤ, 1074 AH (AD 1663-64)

Diameter 131 mm

Mumbai, Chhatrapati Shivaji Maharaj Vastu Sangahalaya (# F 209)



Figure B009.1 – Front of the astrolabe (photo by S. R. Sarma)

COMPONENTS

Body with *kursī* (d. 131, h. 159, t. 7), ring, shackle, rete, 6 plates, alidade and horse. The pin is missing.

FRONT

The ring, made of a darker alloy, is large with a circular cross-section. The shackle has an octagonal cross-section, with straight legs and a knob at the top. The limb and front part of the *kursī* are cast together and riveted to the back plate by a series of 7 nails all along the circumference. The *kursī* is solid without any decorative engraving. The profiles are made up of two ogees, a larger one near the base and a smaller one above.

The limb is graduated in 1° and 6°and numbered in 6s from 6 to 360 clockwise.



Figure B009.2 – Rete of the astrolabe (photo by S. R. Sarma)

RETE

The three rings of the Capricorn, equator and ecliptic are held together by the equinoctial and solstitial bars, both completely represented, both with the counter change at the centre. The equinoctial bar has one more counter change at its intersection with the ecliptic ring in the east. The equator is represented by two large segments, one inside the ecliptic and the other below the ecliptic. The segment below the ecliptic is supported by two transversal bars which stretch from the Capricorn ring to the ecliptic ring. A handle is attached to the transversal bar on the left. Blunt Capricorn index.

The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names; each sign is divided into groups of 6° and numbered accordingly; the bevelled edge is graduated in 3°.

There are 21 named star pointers, 11 to the north of the ecliptic and 10 to the south. They look like leaves, or rather like lobed daggers.

Table B009-1 Stars on the Rete

	Star Names	Identification
1	*Dhanab al-Qayṭus [Shamālī]*	ι Ceti
2	*Rās al-Ghūl*	β Persei
3	*ᶜAyn al-Thawr*	α Tauri
4	*Rijl Jawzā' al-Yusrā*	β Orionis
5	*ᶜAyyūq*	α Aurigae
6	*Shiᶜrā Yamāniyya*	α Canis Majoris
7	*Shiᶜrā Shāmiyya*	α Canis Minoris
8	*Fard Shujāᶜ*	α Hydrae
9	*Ẓahr al-Asad*	δ Leonis
10	*Janāḥ al-Ghurāb*	γ Corvi
11	*Simāk Aᶜzal*	α Virginis
12	*Simāk Rāmiḥ*	α Bootis

	Star Names	Identification
13	*Nayyir al-Fakkah*	α Coronae Borealis
14	*ᶜUnuq al-Ḥayyah*	α Serpentis
15	*Qalb al-ᶜAqrab*	α Scorpii
16	*Rās al-Ḥawwā*	α Ophiuchi
17	*Nasr Ṭā'ir*	α Aquilae
18	*Fam al-Faras*	ε Pegasi
19	*Dhanab al-Jadī*	δ Capricorni
20	*Kaff al-Khaḍīb*	β Cassiopeiae
21	*Janāḥ al-Faras*	γ Pegasi

PLATES

There are six plates in the astrolabe. Those serving specific latitudes are engraved with altitude circles for every 3°, azimuth arcs for each 10° below the horizon, lines for seasonal hours and dotted lines for equal hours.

Table B009-2 Plates

	φ	Longest Day	(Locality)
1a	17;0°	13;2 hours	
1b	21;40°	13;20 hours	(Mecca)
2a	23;0°	13;27 hours	(Tropic of Cancer?)
2b	25;0°	13;35 hours	(Medina)
3a	27;0°	13;44 hours	(Agra)
3b	29;0°	13;53 hours	(Delhi)
4a	32;0°	14;8 hours	(Lahore)
4b	34;0°	14;15 hours	(Baghdad)

	φ	Longest Day	(Locality)
5a	40;0°	14;55 hours	(Samarqand)
5b	Double projection for 72° + 90°		
6a	Plate of ecliptic coordinates		
6b	Plate of horizons		

GEOGRAPHICAL GAZETTEER

The gazetteer provides the names, longitudes and latitudes of 72 localities in two circles.



Figure B009.3 – Back of the astrolabe (photo by S. R. Sarma)

BACK

The rim of the upper half with two altitude scales, divided in 1° and 5° (in the front 1° and 6° !) and numbered from 5 to 90. In the upper left quadrant is a sine graph with 60 horizontal lines, every fifth highlighted with dots.

The upper right quadrant has 18 declination arcs, every third highlighted. The names of the corresponding signs and their subdivisions of 10, 20, 30 are engraved along

the two radii. Upon this is superimposed a universal horary quadrant; the six lines of seasonal hours are numbered, in degrees of arc, as 15, 30, 45, 60, 75, 90 from right to left. There are two labels related to the curves of the midday altitude of the sun at latitudes 32° and 27°: *[khaṭṭ] niṣf al-nahār bi-ᶜarḍ 32* and *bi-ᶜarḍ 27,* but strangely the curves are not drawn.

Shadow squares are drawn in the lower half, on the left for a base of 12 and on the right for a base of 7. At both corners is the label *sullam* (ladder, scale). The four scales are accompanied by the following labels:

Vertical scale on the left: *ẓill aṣābiᶜ maᶜkūs* (umbra versa in digits),

Horizontal scale on the left: *ẓill aṣābiᶜ mustawī* (umbra recta in digits),

Horizontal scale on the right: *ẓill aqdām mustawī* (umbra recta in feet),

Vertical scale on the right: *ẓill aqdām maᶜkūs* (umbra versa in feet).

Cotangent scales are marked on the lower half of the rim. The scale on the left is in digits; the unequal divisions are numbered, clockwise from the meridian, as 5, 10, 15 … 60, followed by the label *ẓill aṣābiᶜ* (shadows in digits). The scale on the right is in feet, it is also numbered in 5s, but anti-clockwise from the meridian, followed by the label *ẓill aqdām* (shadows in feet). The two semi-circular rows above these cotangent scales are engraved respectively with the names of the 12 signs of the zodiac and the names of the 28 corresponding lunar mansions.

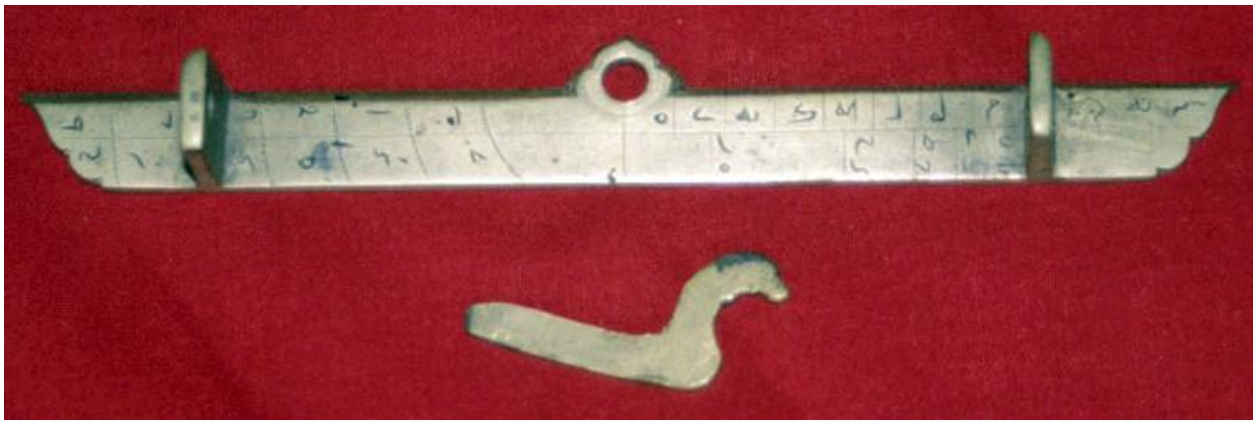


Figure B009.4 – Alidade and horse (photo by S. R. Sarma)

ALIDADE

The astrolabe is straight without any counter change. The two ends are each decorated with an ogee and a lobe, with a matching centre piece. The right-hand side of the alidade carries a sexagesimal scale in the upper register; it is divided in units of 5 and numbered in 5s from 5 to 60, from the centre to the tip. In the lower register are

markings for seasonal hours when the alidade is used as a sundial. On the left-hand side the alidade bears a zodiac scale, divided by declination arcs and the signs marked by their serial numbers. The wedge has the crude shape of a horse's head.

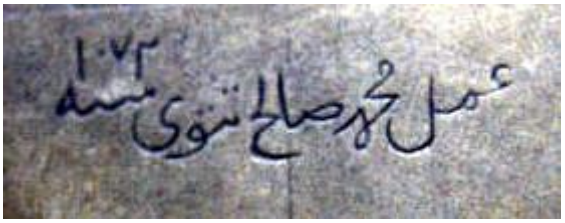


Figure B009.5 – Signature (detail of Figure B011.3)

INSCRIPTION

The astrolabe maker's signature is engraved upside down inside the shadow squares:

ᶜamal muḥammad ṣāliḥ tatawī sanah 1074

Made by Muḥammad Ṣāliḥ, year 1074 [Hijrī = AD 1663-64].

B010⊙ ASTROLABE BY MUḤAMMAD ṢĀLIḤ, 1076 AH (AD 1665-66)

Diameter 111 mm

London, Victoria and Albert Museum (# IM 408-1924; IPN 2467)[608]

CCA 23; Répertoire 4

This astrolabe was studied and published as early as 1856 by William H. Morley in his celebrated *Description of the Persian Astrolabe constructed for Shah Husain Safavi,* where he gave a complete list of the plates and of the stars on the rete, and reproduced the entire geographical gazetteer, together with line drawings of the rete, back, Plate of ecliptic coordinates and alidade.[609]

COMPONENTS

Mater with *kursī* (d. 111, h. 148, t. 7), ring and shackle, rete (d. 94) for 29 stars, 6 plates (d. 94), alidade (l. 96), pin and horse.

FRONT

Large ring with a circular cross-section; trifoliate finial with trowel-shaped bases. Beautifully crafted *kursī* with lobed profiles and a trifoliate finial. The front of the *kursī* is divided into two halves by the prominently marked vertical ridge, on both sides of which are identical floral motifs symmetrically placed. The motif consists of a larger and a smaller flower with leaves and tendrils in bas relief. The petals of the flowers are meticulously executed. The back of the *kursī* is blank.

The limb is graduated 1° and 6° and numbered in 6s clockwise from 6 to 360.

RETE

In the rete, the two rings of Capricorn and ecliptic are held together by the equinoctial bar which has counter changes at its two intersections with the ecliptic ring and at the centre. The part inside the ecliptic ring to the right of the centre is broken and mended. The ecliptic ring is engraved with the names of the 12 signs of the zodiac and

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608 Victoria and Albert Museum wrote to me to say that they do not permit publication of private photography of their objects. Therefore, I cannot, regretfully, include my photos with this entry.

609 Morley 1856, pp. 37-39, plates xix-xxi.

each sign is divided in 6° and numbered 6 to 30 anti-clockwise. There are 29 star pointers, joined by an indifferent tracery. A little above the north point is a lobed handle to rotate the rete around the centre. Slightly projecting out of the south point is the *al-mūri,* the Capricorn index.

Table B010-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab Qayṭus*	β Ceti
2	*Janb Mar'at*	β Andromedae
3	*Fam al-Qayṭus*	γ Ceti
4	*Kaff al-Jadhmā'*	α Ceti
5	*ᶜAyn al-Thawr*	α Tauri
6	*Rijl al-Jawzā al-Yusrā*	β Orionis
7	*Yad al-Jawzā'*	α Orionis
8	*Shiᶜrā Yamānī*[610]	α Canis Majoris
9	*Dhanab Kalb Akbar*	η Canis Majoris
10	*Shiᶜrā Shāmī*[611]	α Canis Minoris
11	*Fard al-Shujāᶜ*	α Hydrae
12	*Qalb al-Asad*	α Leonis
13	*Ẓahr al-Asad*	δ Leonis
14	*Ṣarfa*	β Leonis
15	*Al-Qā'id*	η Ursae Majoris
16	*Simāk Aᶜzal*	α Virginis
17	*Simāk al-Rāmiḥ*	α Bootis

610 Wrongly named *Shiᶜrā Shāmī.*

611 Wrongly named *Shiᶜrā Yamānī.*

	Star Name	Identification
18	*Nayyir al-Fakkah*	α Coronae Borealis
19	*Qalb al-ᶜAqrab*	α Scorpii
20	*Rās al-Jāthī*	α Herculis
21	*Nasr Wāqiᶜ*	α Lyrae
22	*Nasr Ṭā'ir*	α Aquilae
23	*Ridf*	α Cygni
24	*Fam al-Faras*	ε Pegasi
25	*Mankib [al-Faras]*	β Pegasi
26	*Surrat Faras*	δ Pegasi = α Andromedae
27	*Kaff Kh[aḍīb]*	β Cassiopeiae
28	*Janaḥ [al-Faras]*	γ Pegasi
29	*Ḍafdaᶜ*	α Piscis Australis

PLATES

There are six plates with the following specifications.

Table B010-2 Plates

	φ	Longest Day
1a	22°	13;22 hours
1b	24°	13;31 hours
2a	27°	13;46 hours
2b	30°	13;38 hours !
3a	32°	14;8 hours
3b	36°	14;32 hours
4a	38°	14;42 hours

	φ	Longest Day
4b	40°	14;54 hours
5a	35°	14;25 hours
5b	Double projection 0° + 90°	
6a	Plate of ecliptic coordinates	
6b	Plate of horizons	

On plates 1a to 5a, altitude circles are traced for every 6°; azimuth arcs for each 10° below the horizon, those for 30° are extended above the horizon. In the lower half are drawn plain lines for seasonal hours and dotted lines for equal hours.

GEOGRAPHICAL GAZETTEER

The geographical gazetteer is engraved on the inner side of the mater in two concentric circles, providing the names, longitudes and latitudes of 34 localities.[612]

Table B010-3 Geographical Gazetteer

	Place Name (*al-bilād*)	**L (*al-ṭūl*)**	**φ (*al-ᶜarḍ*)**
	Outer Circle		
1	Miṣr	63;20	30;20
2	Madīnat Rasūl	75;20	25;0
3	Makka Muᶜazzam	77;10	21;40
4	Bayt al-Maqdis	66;31	31;50

612 It is surprising that Morley reads the gazetteer from the left to the right against the usual convention of writing in Arabic/Persian. Moreover, the arguments are engraved in the cells to the left of the vertical diameter, clearly indicating that the gazetteer should be read leftwards, starting from Miṣr, followed by the holy cities of Medina and Mecca. Morley does not record the zeros in the coordinates.

	Place Name (*al-bilād*)	**L** (*al-ṭūl*)	**φ** (*al-ᶜarḍ*)
5	Dimaskq	70;0	36;15
6	Ḥalab	72;10	35;50
7	Marāgha	82;18	37;20
8	Tabrīz	82;0	38;0
9	Bulghār[613]	90;0	49;30
10	Kūfa	79;30	31;30
11	Baghdād	80;30	33;25
12	Basra	84;0	30;0
13	Shīrāz	88;0	29;36
14	Yazd	89;0	32;0
15	Isfahān	86;40	32;25
16	Mashhad	92;30	37;0
17	Balkh	102;0	36;41
18	Badakhshān	104;24	37;10
19	Bukhārā	97;30	39;50
20	Samarqand	99;36	44;0
21	Kāshghar	106;30	44;0
22	Khutan	107;0	42;0
23	Hurmūz	92;0	26;50
	Inner Circle		
24	Kābul	104;40	34;30
25	Kashmīr	108;0	35;0

[613] Morley reads Bulqār which is not right.

	Place Name (*al-bilād*)	L (*al-ṭūl*)	φ (*al-ᶜarḍ*)
26	Tubbat	110;0	40;0
27	Qandahār	107;40	33;0
28	Mūltān	107;35	29;40
29	Lahāhūr	119;20	31;50
30	Haḍrat Dihlī	113;35	28;15
31	Akra	114;0	27;13
32	Ajmīr	112;0	26;0
33	Qannawj	115;50	26;29
34	Bānārasī[614]	117;20	26;55

BACK

The rim of the upper half carries altitude scales, which are divided in 1° and 6° and labelled in 6s as 6—90; 90—6. In the upper left quadrant is a sine graph with 60 horizontal lines, where each sixth line is emphasized. The upper left quadrant is divided by five declination arcs, creating six zones, each related to a pair of zodiac signs. The signs are marked by their serial numbers along the two radii. On this is superimposed a universal horary quadrant; the six hour lines are numbered from 1 to 6 along the arc of the quadrant from the horizontal radius to the vertical radius.

In the lower half are shadow squares, on the left for a base of 7 feet and on the right for a base of 12 digits. The vertical and horizontal scales on both sides are divided and numbered accordingly. In the two corners inside are two labels; on the left *ẓill sullam aqdām* (scale of the shadows in feet); on the right *ẓill sullam aṣābiᶜ* (scale of the shadows in digits). The labels outside the squares are as follows:

614 Morley reads Bānāras, but the engraving reads Bānārasī which is phonetically closer to the Sanskrit name.

Vertical scale on the left: *ẓill aqdām maᶜkūs* (reverse shadows in feet),
Horizontal scale on the left: *ẓill aqdām mustawī* (direct shadows in feet),
Horizontal scale on the right: *ẓill aṣābiᶜ mustawī* (direct shadows in digits),
Vertical scale on the right: *ẓill aṣābiᶜ maᶜkūs* (reverse shadows in digits).

The rim of the lower half carries the scales of cotangents, in feet on the left and in digits on the right. The unequal divisions in the scale on the left are numbered, clockwise from the meridian as 6, 12, 18, 24, 30, 36, 42, 48, 54, 60. The divisions on the scale on the right are also numbered in the same manner, but anti-clockwise. The divisions in these two scales are subdivided into single units in the inner band.

The space between the cotangent scales and the shadow scales is occupied by two semi-circular rows engraved with the names of the 12 signs of the zodiac and the names of the corresponding 28 lunar mansions respectively.

Alidade

The straight bar alidade has ornate ends (with lobes and three round holes) and an ornate centre piece. The sighting plates have two apertures and a notch at the top to receive a sighting tube. The upper register on the right arm of the alidade carries a sexagesimal scale and is numbered in 6s from the centre to the tip on the right. On the lower register in the same side are markings for seasonal hours when the alidade is used as a sundial. The numbers 1 to 6 proceed from the sighting plate and the numbers 7 to 12 are in reverse direction up to the sighting plate. The left arm of the alidade is engraved with the declination arcs and the serial numbers of the zodiac signs as in the upper right quadrant on the back.

The pin has a broad head and nicely shaped tip on the other end. In the wedge, the horse's head is clearly delineated with ears, eye and pouting lips.

Inscription

The astrolabe maker engraved his signature inside the shadow square on the left:

> *ᶜamal muḥammad ṣāliḥ tatawī sanah 1076 [Hijrī]*
>
> Made by Muḥammad Ṣāliḥ of Thatta [in] the year 1076 [Hijrī = AD 1656-57].

PROVENANCE

Collected in India in the first half of the nineteenth century by East India Company officials and preserved in the Museum of the East India Company at London; the Museum was later renamed Indian Museum; after its dissolution, the astrolabe was transferred to the Victoria and Albert Museum.

BIBLIOGRAPHY

Morley 1856, pp. 37-39, plates xix (fig. 14: plate of ecliptic coordinates), xx (fig. 22: rete) and xxi (fig. 27: back; fig. 43: alidade).

B011 ⊙ ASTROLABE BY MUḤAMMAD ṢĀLIḤ, 1077 AH (AD 1666-67)

Diameter 194 mm

Oxford, Museum of the History of Science (# 33474)

CCA 2502; Répertoire 5



Figure B011.1 – Front of the astrolabe (© Museum of the History of Science, Oxford)

This astrolabe is in mint condition. It stands out among Muḥammad Ṣāliḥ's astrolabes with its superior workmanship and elegantly fashioned *kursī* and rete. With a

diameter of 194 mm, it is also much larger than his other astrolabes. The degree scales, however, are not uniform; on the limb, they are numbered in 6s; in the altitude scales on the back in 5s, and on the rete, each sign is divided in 5s. It is also unusual that the maker's signature is engraved on the back, although there is much space on the back.

COMPONENTS

Mater with *kursī* (d. 194, h. 230, t. 9), ring and shackle, rete (d. 180) for 29 stars, 6 plates (d. 180), alidade, pin, washer, wedge.

FRONT

The ring is relatively large; its two ends are not welded together. The shackle is quite small and of a strange shape not met with elsewhere. The *kursī* is rather small; it is elegantly reticulated to produce four intertwining flowers with flared petals, which form the profiles. The finial is circular.

The limb is graduated in 1° and 6° and numbered in 6s from 6 to 360 clockwise.

RETE

The two rings of Capricorn and ecliptic are held together by a very slender equinoctial bar which has a counter change at the centre. The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names. Each sign is divided in 5° and numbered 5, 10, … 30; this division in 5° is unusual. The edge of the ecliptic ring is graduated in 1°. The flower-shaped star pointers and the tracery are reminiscent of Muqīm's astrolabes, but the rete with its limited number of star pointers is more delicately fashioned than any of the Lahore astrolabes. There is a small handle above the western part of the equinoctial bar. The Capricorn index is rather long and slender. The star pointers carry the names of the following 29 stars:

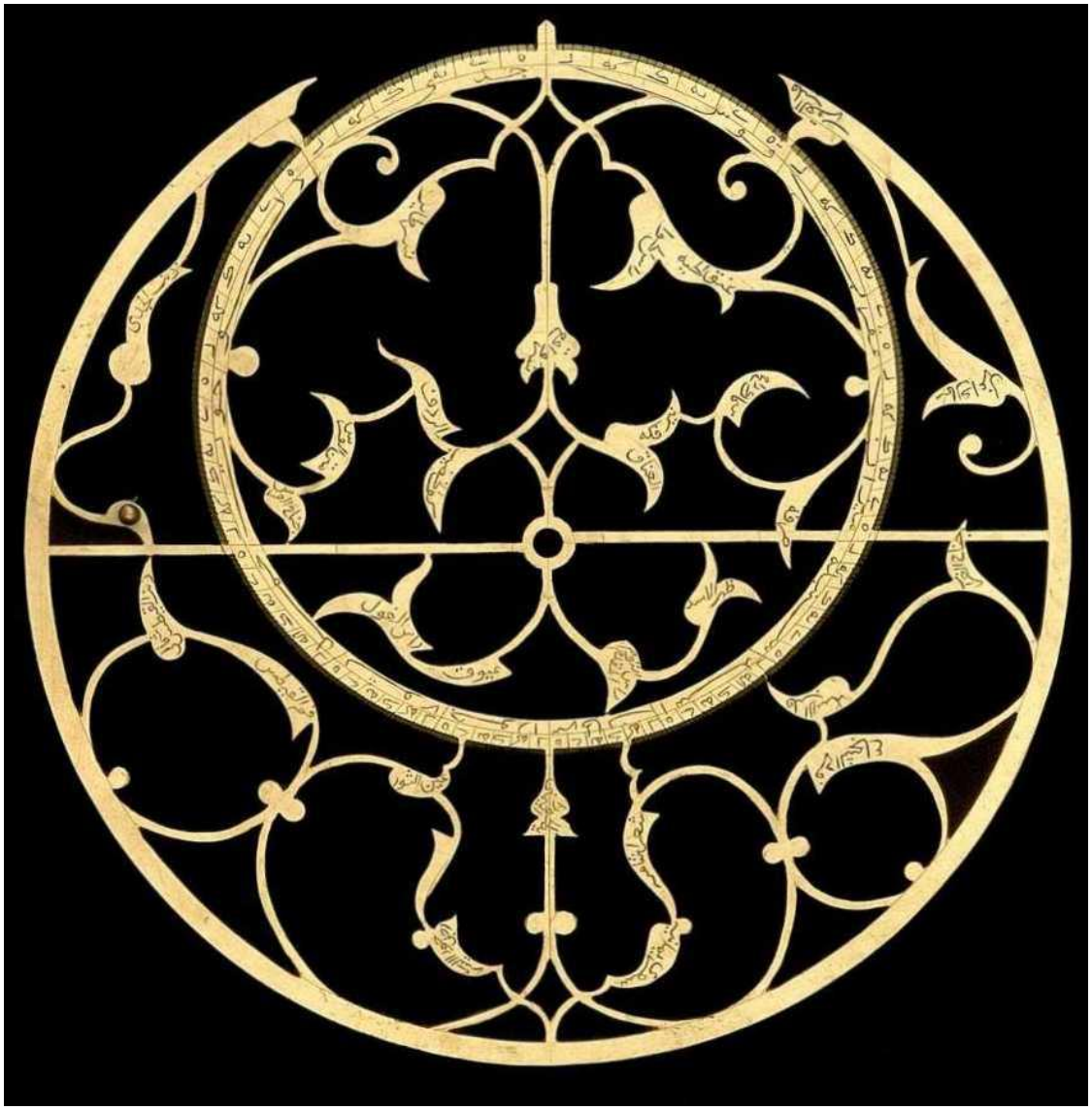


Figure B011.2 – Rete of the astrolabe (© Museum of the History of Science, Oxford)

Table B011-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus Shamālī*	ι Ceti
2	*Fam al-Qayṭus*	γ Ceti
3	*Rās al-Ghūl*	β Persei
4	*ᶜAyn al-Thawr*	α Tauri
5	*ᶜAyyūq*	α Aurigae
6	*Rijl al-Jawzā' al-Yusrā*	β Orionis

	Star Name	Identification
7	*Yad al-Jawzā' al-Yumnā*	α Orionis
8	*Shiᶜrā Yamānī*	α Canis Majoris
9	*Rās al-Taw'am al-Muqaddam*	α Geminorum
10	*Shiᶜrā Shāmī*	α Canis Minoris
11	*Fard al-Shuzāᶜ*	α Hydrae
12	*Qalb al-Asad*	α Leonis
13	*Ẓahr al-Asad*	δ Leonis
14	*Ṣarfa*	β Leonis
15	*Janāḥ al-Ghurāb*	γ Corvi
16	*Al-ᶜAnāq*	ζ Ursae Majoris
17	*Simāk Aᶜzal*	α Virginis
18	*Simāk Rāmiḥ*	α Bootis
19	*Nayyir Fakkah*	α Coronae Borealis
20	*ᶜUnuq al-Ḥayyah*	α Serpentis
21	*Qalb al-ᶜAqrab*	α Scorpii
22	*Rās al-Ḥawwā*	α Ophiuchi
23	*Nasr Wāqiᶜ*	α Lyrae
24	*Nasr Ṭā'ir*	α Aquilae
25	*Al-Ridf*	α Cygni
26	*Dhanab al-Jadī*	δ Capricorni
27	*Matn al-Faras*	α Pegasi
28	*Kaff al-Khaḍīb*	β Cassiopeiae
29	*Janāḥ al-Faras*	γ Pegasi

PLATES

There are 6 plates serving the following latitudes:

Table B011-2 Plates

	φ	Longest Day
1a	18;0°	13;6 hours
1b	20;0°	13;14 hours
2a	21;40°	13;20 hours
2b	25;0°	13 hours!
3a	27;0°	13;44 hours
3b	29;0°	13;53 hours
4a	32;0°	14;8 hours
4b	35;0°	14;25 hours
5a	45;0°	15;30 hours
5b	Triple projection for 0°+72°+90°	
6a	Plate of ecliptic coordinates	
6b	Plate of horizons	

On plates 1a to 5a, altitude circles are drawn for every 1° and labelled for each 2°; every sixth of these circles is highlighted with dots. Azimuth arcs are traced for every 5° below the horizon and those for 30° are extended above the horizon. In the lower half, there are plain lines for seasonal hours and dotted lines for equal hours drawn from the western horizon; both sets are numbered from the western horizon. Above the local horizon in the east is the label *mashriq* and in the west *maghrib.*

Plate 6a is designed for latitude 66;30°. Here the ecliptic circle is the local horizon. Parallel it are traced the latitude circles for every 3°. These are numbered from the ecliptic to the zenith and in the reverse direction from the ecliptic up to the Tropic of Capricorn. The numbers are repeated four times forming four symmetric arcs, two above and two below. The azimuth arcs (= arcs of longitude) are drawn for every 5°,

radiating from the zenith; each fifth which forms the boundary between two signs of the zodiac is dotted. The names of the signs are engraved along the ecliptic circle. The azimuth arcs are numbered from 5 to 30, separately for each sign. The name of the plate is not inscribed.

Plate 6b displays half horizons of latitudes from 6° to 58°, arranged in eight sets at intervals of 4° in the following manner.

6	10	14	18	22	…	46	50	54	58
7	11	15	19	23	…	47	51	55	
8	12	16	20	24	…	48	52	56	
9	13	17	21	25	…	49	53	57	
10	14	18	22	26	…	50	54	58	
11	15	19	23	27	…	51	55		
12	16	20	24	28	…	52	56		
13	17	21	25	29	…	53	57		

It will be noticed that the last four rows are virtually the same as the first four. These half horizons are numbered at both ends. Each set is accompanied by a pair of declination scales to the north and south of the equator; these scales are divided in 24 units and labelled 6, 12, 18 and 23;30. The name of the plate is not inscribed. There are notches at the four points of the compass.

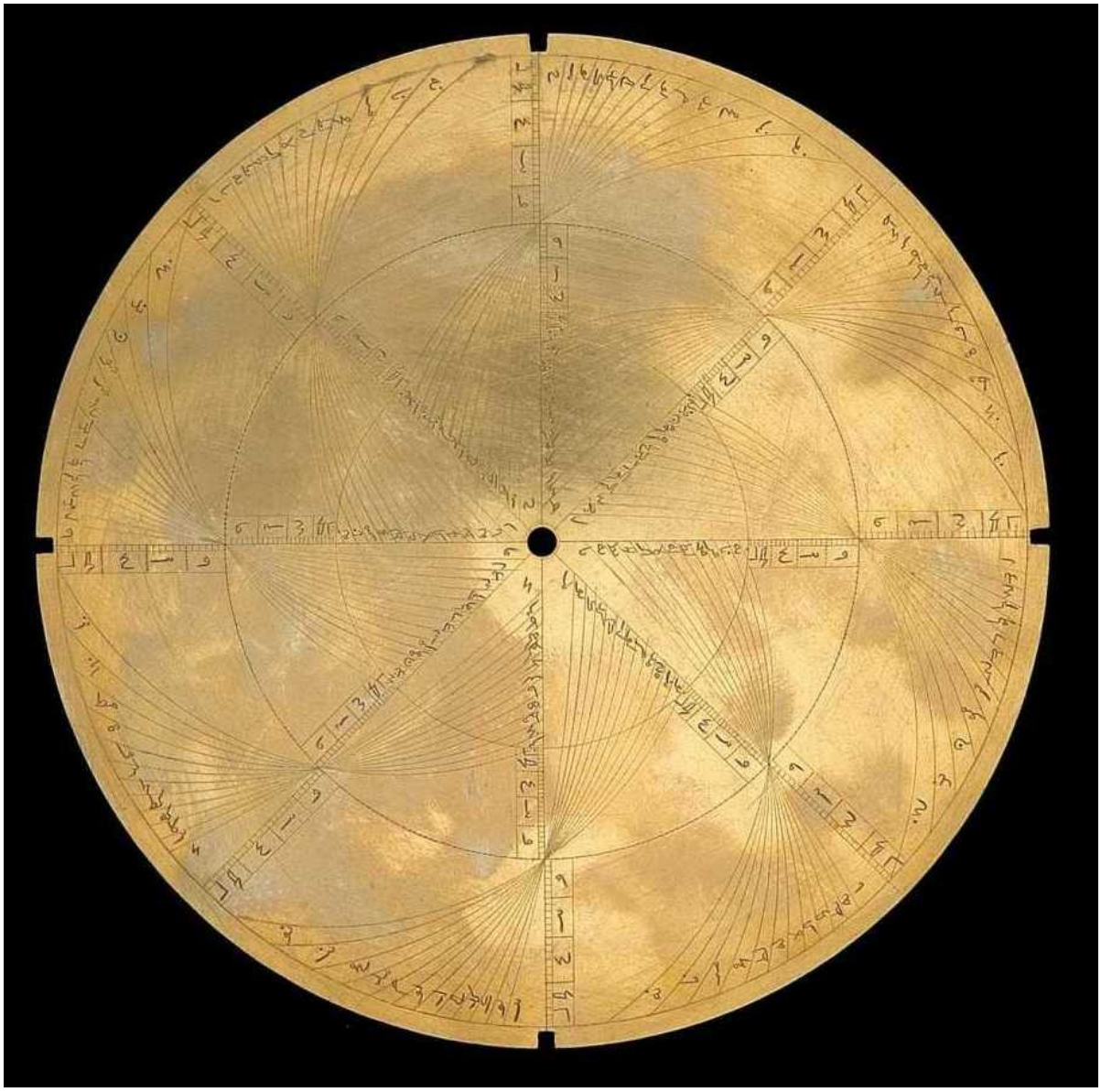


Figure B011.3 – Plate of horizons (© Museum of the History of Science, Oxford)

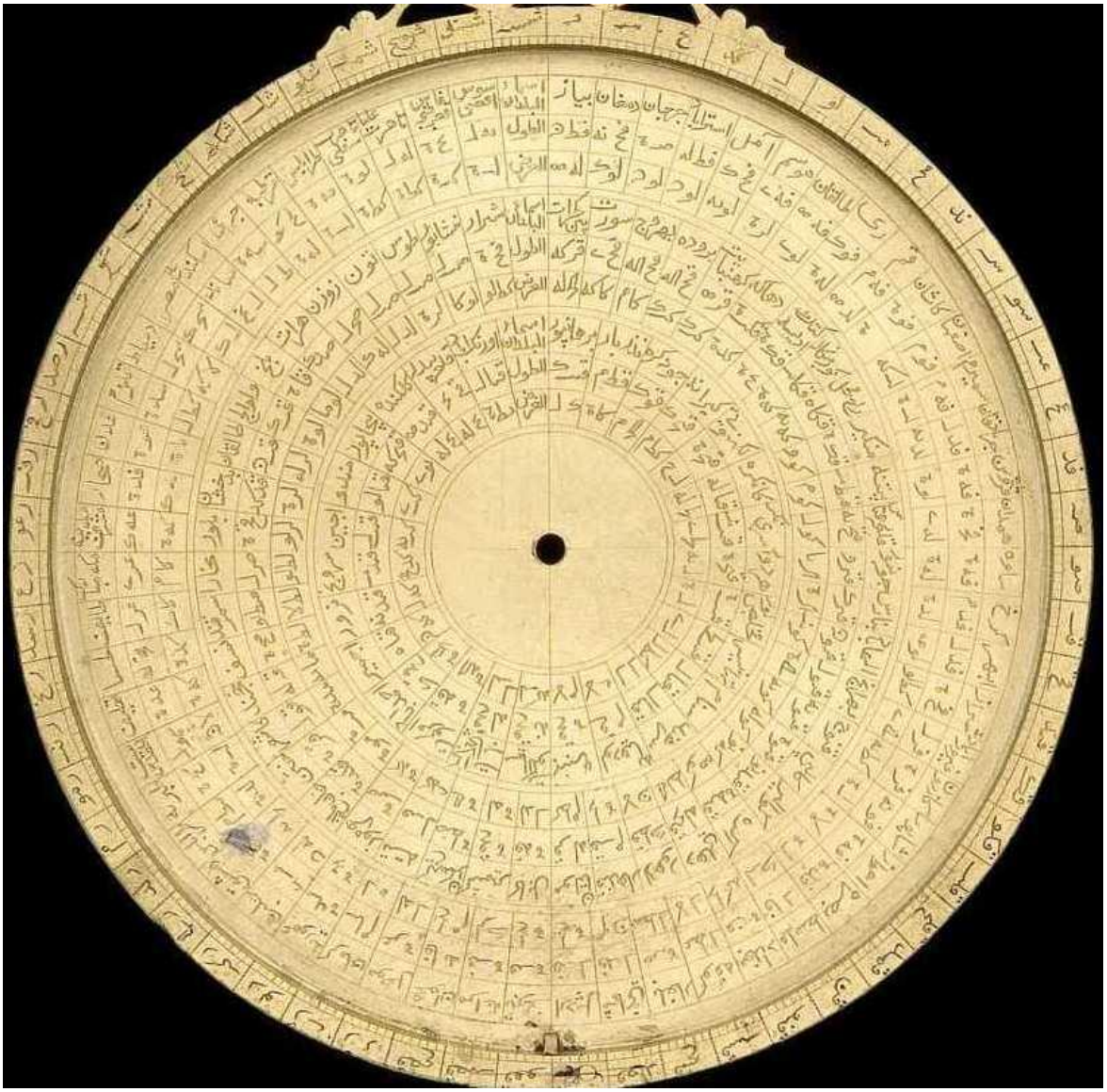


Figure B011.4 – Geographical Gazetteer (© Museum of the History of Science, Oxford)

GEOGRAPHICAL GAZETTEER

The geographical gazetteer, engraved on the inner surface of the mater, provides the names, longitudes and latitudes of 133 localities in three concentric circles. Nearly half of these are from the Indian subcontinent, perhaps the largest number to be found in Indo-Persian astrolabes. Ṣāliḥ's native place Thatta is listed at no. 79. From then on, modern names are added in the fourth column. Shīrāz is repeated at 41 and 60.

Table B011-3 Geographical Gazetteer

	Place Name (*asmā' al-buldān*)	L (*al-ṭūl*)	φ (*al-ᶜarḍ*)	Modern Name
	Outer Circle			
1	Sūs Aqṣā	15;30	32;0	
2	Fās Qaṣba Tanja	18;0	22;0	
3	Tāhart ᶜAlyā'	35;30	29;0	
4	Tāhart Suflis	36;0	29;0	
5	Ṭarābulus (Libya)	45;0	32;0	
6	Qurṭuba	18;26	35;0	
7	Jarmī	65;0	9;30	
8	Iskandariyya	61;54	30;58	
9	Miṣr	63;20	30;20	
10	Damyāṭ	63;30	31;25	
11	Qulzum	64;0	29;30	
12	ᶜAdan	76;0	11;0	
13	Ṣaḥār	84;0	14;20	
14	Madīnat Musharrafa	75;20	25;0	
15	Makka Mubārak	77;10	21;40	
16	Tāᶜif	77;30	21;20	
17	Laḥsā	83;30	24;0	
18	Qaṭīf	74;0	25;0	
19	Bayt al-Maqdis	66;30	31;50	
20	Ṭabariyya	68;0	32;0	

	Place Name (*asmā' al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-ᶜarḍ*)**	**Modern Name**
21	Ṭarābulus[Shām] (Lebanon)	69;40	34;0	
22	Dimashq	70;0	33;15	
23	Ḥalab	72;10	35;50	
24	ᶜAmmūriyya	64;0	43;0	
25	Kirmān	91;40	30;05	
26	Mawṣil	77;0	34;30	
27	Nakhjawān	81;15	38;40	
28	Maragha	82;0	37;20	
29	Tabriz	82;0	37;20	
30	Ardabīl	82;30	38;0	
31	Shamākhī	84;30	40;50	
32	Bulghār	90;0	49;30	
33	Kufa	79;30	31;30	
34	Baghdād	80;0	33;25	
35	Wāsiṭ	81;30	32;20	
36	Basra	84;0	30;0	
37	Ahwāz	85;0	31;0	
38	Shāpūr	86;55	30;0	
39	Kāzirūn	87;0	29;15	
40	Fīrūzābād	87;30	28;10	
41	Shīrāz	88;0	29;36 (repeated at 60)	
42	Abhar	84;30	36;45	

	Place Name (*asmāʾ al-buldān*)	L (*al-ṭūl*)	φ (*al-ʿarḍ*)	Modern Name
43	Karaj	84;40	34;0	
44	Sāwa	85;0	35;0	
45	Hamadān	83;0	35;10	
46	Qazwīn	85;0	36;0	
47	Jurbādqān	84;30	34;15	
48	Semirūm	85;40	32;0	
49	Iṣfahān	86;40	32;25	
50	Kāshān	86;0	---	
51	Qumm	85;40	34;45	
52	Rayy	86;20	35;0	
53	Ṭāliqān[615]	85;45	36;10	
54	Hawsum	85;10	37;0	
55	Āmul	88;20	36;15	
56	Astarābād	89;35	36;50	
57	Jurjān	90;0	36;50	
58	Damghān	88;55	36;20	
59	Biyāz	89;50	35;45	(read Biyār)
	Middle Circle			
60	Shīrāz	88;0	29;36 (see 41)	
61	Nīshābūr	92;30	36;21	
62	Ṭūs	92;30	37;0	

615 Kennedy 1987a, s.v. ‘Region NW Qazwin btw. Qazwin-Abhar’.

	Place Name (*asmā' al-buldān*)	L (*al-ṭūl*)	φ (*al-ᶜarḍ*)	Modern Name
63	Tūn	92;30	34;30	
64	Zūzan	93;30	35;20	
65	Harat	94;20	34;30	
66	Balkh	101;00	36;41	
67	Walwalij	102;20	36;0	
68	Ṭāliqān[616]	102;50	37;35	
69	Badakhshān	104;24	37;0	
70	Bulūr	108;0	37;36	
71	Bukhārā	97;30	39;36	
72	Samarqand	99;16	39;31	
73	Nasaf	98;0	39;0	
74	Khujand	100;35	41;15	
75	Kāshghar	106;30	44;0	
76	Khutan	107;0	42;0	
77	Khān Bāligh	124;0	46;0	
78	Hurmūz	92;0	25;0	
79	Tatah	102;30	25;10	Thatta, Pakistan
80	Kīz-Makrān	99;0	28;0	in Balochistan, Pakistan
81	Kashmīr	108;0	35;0	Srinagar, Kashmir
82	Kābul	105;0	34;30	Kabul, Afghanistan
83	Mūltān	107;35	29;40	Multan, Pakistan

616 Kennedy 1987a, s.v., Tukharistan.

	Place Name (*asmā' al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-ᶜarḍ*)**	**Modern Name**
84	Qandahār	102;40	33;0	Qandahar, Afghanistan
85	Lāhūr	109;20	31;50	Lahore, Pakistan
86	Dihlī	113;35	28;39	Delhi
87	Akra	115;0	26;45	Agra, UP
88	Kawāliyar	114;56	26;56	Gwalior, MP
89	Kālpī	116;0	26;35	Kalpi, UP
90	Qannawj	116;15	26;15	Kannauj,
91	Bahrānj	116;30	28;0	Bahraich,
92	Ilhābād	116;50	26;52	Alahabaad, UP
93	Banāras	117;20	27;0	Varanasi, UP
94	Jawnpūr	117;06	27;11	Jaunpur, UP
95	Qilᶜa Rahtas	118;15	26;30	Rohtasghar Fort, Bihar
96	Patnah	119;12	26;40	Patna, Bihar
97	Mankīr	120;0	26;40	Munger, Bihar
98	Rajmahal	121;05	25;15	Rajmahal, Bangladesh
99	Kawr Bangalah	121;12	25;0	Gaur, Bangladesh
100	Udīsah Katak	120;0	18;0	Cuttack, Orissa
101	Dhākah	122;0	24;0	Dhaka, Bangladesh
102	Khanbāyat[617]	107;45	22;0	Cambay, Gujarat
103	Barūdah	108;25	22;20	Baroda, Gujarat

[617] It is amusing that the gazetteer jumps from the eastern extremity to the west coast!

	Place Name (*asmā' al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-ᶜarḍ*)**	**Modern Name**
104	Bahrūz	108;25	21;40	Bharuch (Broach), Gujarat
105	Sūrat	108;10	21;25	Surat, Gujarat
106	Patan Kujrāt	107;25	23;35	Patan, Gujarat
	Inner Circle			
107	Awrangābād	111;30	19;0	Aurangabad, Maharashtra
108	Qilᶜa Bandapur ?	110;13	18;35	?
109	Kalkanda	114;45	18;35	Golconda = Hyderabad
110	Bījāpūr	113;25	16;10	Bijapur, Karnataka
111	Mandū	111;36	22;10	Mandu, MP
112	Ujjayn	112;30	22;15	Ujjain, MP
113	Sirūnj	114;42	24;48	Sironj, MP
114	Narwar	114;52	25;30	Narwar, MP
115	Ajmīr	111;05	25;50	Ajmer, Rajasthan
116	Aḥmadābād	108;20	23;0	Ahmedabad, Gujarat
117	Amarkot	105;0	25;0	Umarkot, Pakistan
118	Pahāb Kujarat ?	108;35	32;30	?
119	Siyālkūt	108;55	32;25	Sialkot, Pakistan
120	Bahanbarah ?	108;0	31;40	?
121	Lūdhiyānā	110;10	31;10	Ludhiana, Panjab
122	Sirhind	111;30	30;30	Sirhind-Fatehgarh, Panjab
123	Sunām	111;30	29;30	Sunam, Panjab

	Place Name (*asmā' al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-ᶜarḍ*)**	**Modern Name**
124	Tānīsar	112;33	30;10	Thanesar, Haryana
125	Makhlᶜanpūr ?	112;0	30;0	?
126	Hardwār	113;0	30;15	Haridwar, Uttarakhand
127	Sarīnakar	112;52	33;10	Srinagar, Uttarakhand
128	Kānkrah	111;35	33;35	Kangra, Himachal Pradesh
129	Lakhnawtī	113;0	30;8	Lakhnauti, Bangladesh
130	Kīrān ?	113;20	29;40	?
131	Jūnāgarh	106;20	23;40	Junagarh, Gujarat
132	Nanadbād /Nadazbād ?	109;40	21;0	?
133	Burhānpūr	112;20	20;30	Burhanpur,

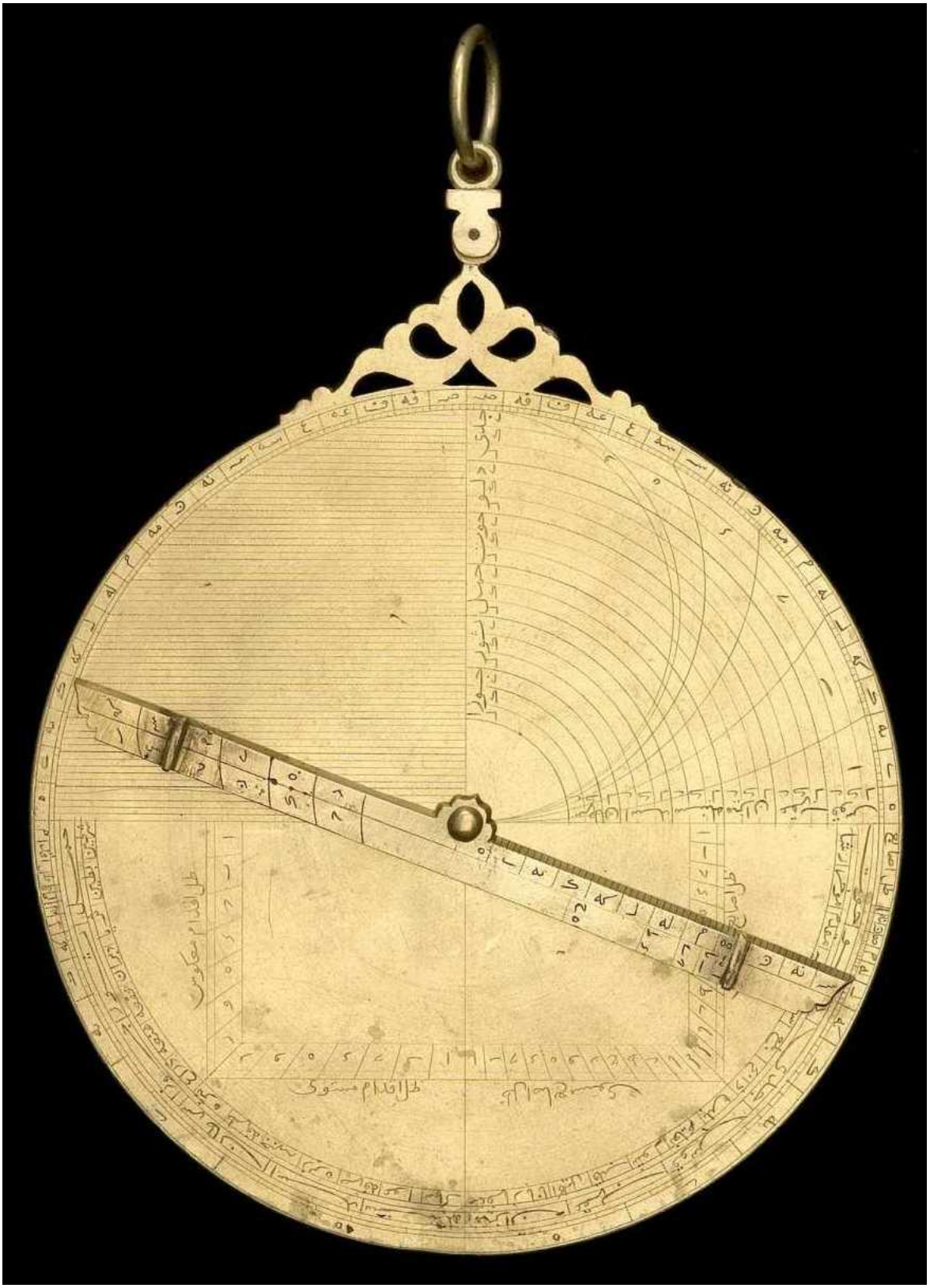


Figure B011.5 – Back of the astrolabe (© Museum of the History of Science, Oxford)

Back

The upper half of the rim carries the two altitude scales which are divided in 1° and 5° and numbered from 5 to 90 as 5—90; 90—5. On the upper left is a trigonometric

quadrant with 60 horizontal lines, each fifth highlighted as darker line. On the upper right is a solar quadrant on which declination arcs are traced for every 10° of solar longitude. The names of the corresponding signs and their subdivisions of 10, 20, 30 are engraved along the two radii. A universal horary quadrant is superimposed on this quadrant; the six curves of the seasonal hours are numbered from 1 to 6 along the arc of the quadrant, starting from the horizontal radius and proceeding towards the vertical radius.

In the lower half, there are shadow squares, on the left for a base of 7 and on the right for a base of 12. The four scales carry the following labels:
Vertical scale on the left: *ẓill aqdām maᶜkūs* (umbra versa in feet),
Horizontal scale on the left: *ẓill aqdām mustawī* (umbra recta in feet),
Horizontal scale on the right: *ẓill aṣābiᶜ mustawī* (umbra recta in digits),
Vertical scale on the right: *ẓill aṣābiᶜ maᶜkūs.*(umbra versa in digits).

Alidade

The straight bar alidade has ornate ends and an ornate centre-piece. The right half of the alidade is designed to match the divisions on the trigonometric quadrant; accordingly, the edge of the right of the right half is divided in 60 units; these are numbered in 5s from 5 to 60 from the centre of the alidade to its tip. The lower register on the right is marked for seasonal hours when the alidade is used as a sundial. The left half of the alidade is divided by declination arcs and by the serial numbers of the zodiac signs, to match the divisions in the solar quadrant. There is a broad-headed pin and a wedge roughly in the shape of a horse's head.

Inscription

Unusually, the astrolabe maker engraved his signature on the edge of the astrolabe, in the upper half on the proper right, although there is adequate space on the back.

> *ᶜamal muḥammad ṣāliḥ tatawī 1077.*
>
> 'Made by Muḥammad Ṣāliḥ of Thatta [in the year] 1077 [Hijrī = AD 1666-67].'

Provenance

Formerly in the Chadenat collection, Paris.

B012⊙ ASTROLABE ATTRIBUTABLE TO MUḤAMMAD ṢĀLIḤ

Diameter 147 mm

Patna, Khuda Bakhsh Oriental Public Library



Figure B012.1 – Front of the astrolabe (photo by S. R. Sarma)

This astrolabe is not signed, nor dated. But it can be attributed to Muḥammad Ṣāliḥ on the basis of the close resemblance between the rete in the present astrolabe and the rete in B011 which is signed by Ṣāliḥ.

Components

Body with *kursī* (d. 147, h. 178, t. 4), shackle, ring, rete for 18 stars, 2 plates; original alidade, pin and wedge are missing. There is a substitute alidade without sighting plates, but with the pin affixed permanently; a twisted wire is used as the wedge.

Front

The ring and shackle appear to made of a darker alloy. The ring is very large with an octagonal cross-section; its two ends are not soldered together. The shackle is thick with short legs and a knob at the top as in B011. The *kursī* and the mater are cast as one piece. Inside the rim, there is a plug at the north point to hold the plates in position.

The *kursī* is somewhat low. The profiles are made up of two ogees. There is a long horizontal slit measuring 41 x 3.5 mm, the purpose of which is not known.

The limb is graduated in 2° and groups of 6° are numbered clockwise from 6 to 90, separately for each quadrant.

Rete

The rete closely resembles the same in the astrolabe B011 signed by Ṣāliḥ. The three rings of the Capricorn, equator and ecliptic are held together by the equinoctial and solstitial bars, both completely represented, both with counter changes at the centre. The equinoctial bar has one more counter change at its intersection with the ecliptic ring in the east. The equator is represented by two large segments, one inside the ecliptic and the other below the ecliptic. Handle at lower right. Blunt Capricorn index.



Figure B012.2 – Rete of the astrolabe (photo by S. R. Sarma)

The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names; each sign is divided into groups of 6° and numbered accordingly; the bevelled edge is graduated in 3°.

The star pointers look like leaves, or rather like lobed daggers.

Table B012-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus Shamālī*	ι Ceti
2	*Rās al-Ghūl*	β Persei
3	*ᶜAyn al-Thawr*	α Tauri
4	*Rijl Jawzā' al-Yusrā*	β Orionis
5	*Shiᶜrā Yamāniyya*	α Canis Majoris
6	*Shiᶜrā Shāmiyya*	α Canis Minoris
7	*Fard al-Shujāᶜ*	α Hydrae
8	*Qalb al-Asad*	α Leonis
9	*Fam* (?) *al-Asad*	λ Leonis ?
10	*Ṣarfa*	β Leonis
11	*Al-ᶜAnāq*	ζ Ursae Majoris
12	*Janāḥ al-Ghurāb*	γ Corvi
13	*Simāk Aᶜzal*	α Virginis
14	*Simāk Rāmiḥ*	α Bootis
15	*Nayyir al-Fakkah*	α Coronae Borealis
16	*ᶜUnuq al-Ḥayyah*	α Serpentis
17	*Qalb al-ᶜAqrab*	α Scorpii
18	*Rās al-Ḥawwā*	α Ophiuchi
19	*Nasr Wāqtᶜ*	α Lyrae
20	*Nasr Ṭā'ir*	α Aquilae
21	*Dhanab al-Jadī*	δ Capricorni
22	*Kaff al-Khaḍīb*	β Cassiopeia
23	*Janāḥ al-Faras*	γ Pegasi

PLATES

Surprisingly there are just are two plates

Table B012-2 Plates

	φ	Longest Day
1a	27;0°	13;42 hours
1b	29;0°	13;53 hours
2a	32;0°	14;8 hours
2b	Plate of horizons	

Plates 1a, 1b, 2b are engraved with altitude circles for every 3°; azimuth arcs are drawn below the horizon for every 10°; there are only lines for seasonal hours.

On the inner side of the mater, there is no geographical gazetteer. As in the latitude plates, it is engraved with the two tropics and the equator and a local horizon; at its two ends there are labels: *al-maghrib* in the west and *al-mashriq* in the east. The Tropic of Cancer and the equator drawn as single lines. On these is superimposed the ecliptic ring with double lines with rows of dots in the middle. It is divided into the 12 signs and labelled with their names. The whole plate is filled with lines, which radiate from the centre to demarcate astrological houses and their subdivisions of 6°. These lines are numbered in common Arabic/Persian numerals from 1 to 60, starting from the east point and proceeding anti-clockwise. It is not stated for which latitude this plate is designed.

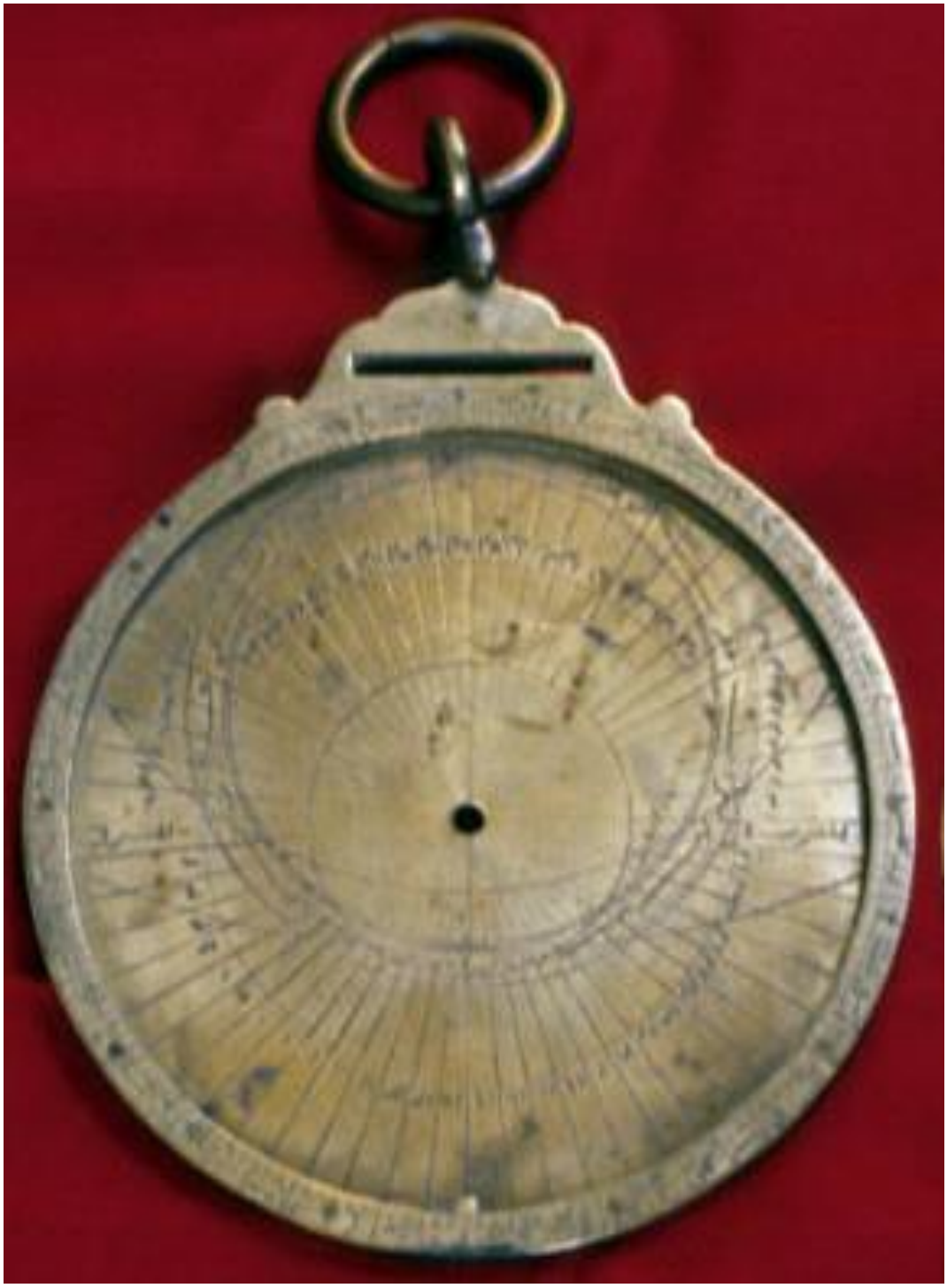


Figure B012.3 – Inner side of the mater with astrological houses (photo by S. R. Sarma)



Figure B012.4 – Back of the astrolabe (photo by S. R. Sarma)

BACK

On the back, the upper half of the rim carries the altitude scales, which are divided in 1° and 5° and numbered in 5s as 5 ---- 90; 90 --- 5. In the upper left quadrant is a sine graph with 29 horizontal lines. The solar quadrant on the upper right is divided by 6

declination arcs and the serial numbers of the corresponding signs are marked along the two radii. Two curves for the sun's midday altitude are drawn for latitudes 29 and 32 with labels [*khaṭṭ*] *niṣf al-nahār bi-ᶜarḍ 29* and [*khaṭṭ*] *niṣf al-nahār bi-ᶜarḍ 32*. There is also universal horary quadrant with six lines of seasonal hours numbered from 1 to 6 from the horizontal radius upwards.

Shadow squares on the lower half; for a base of 7 on the left and for a base of 12 on the right. The scales are appropriately divided and numbered, but there are no labels.

The lower half of the rim is blank. Inside there are two semi-circular rows with the names of the 12 signs and 28 lunar mansions.

ALIDADE

The alidade is an ungraduated straight bar with tapering ends, but without sighting plates. It is not original, nor functional. A pin with a large round head is firmly affixed to the alidade. There is no horse, but a twisted piece of wire passes through the hole of the pin in the front and fastens the whole ensemble. At present, the astrolabe is suspended inside a wooden stand, which is of recent manufacture.

B013 ASTROLABE ATTRIBUTABLE TO MUḤAMMAD ṢĀLIḤ[618]

Not dated; 17th century

Diameter 148 mm

Karachi, National Museum of Pakistan

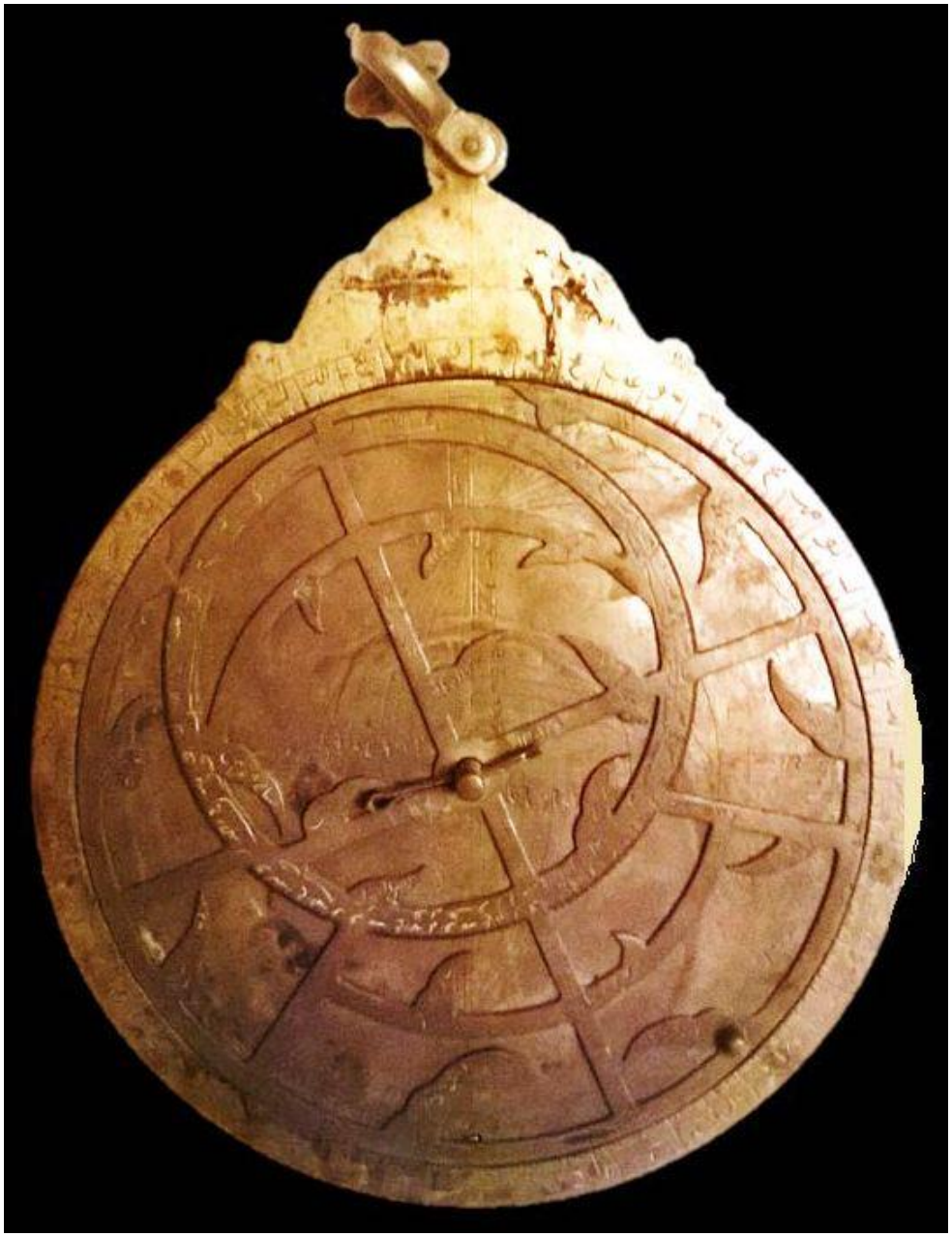


Figure B013.1 – Front of the astrolabe (photo by Mubashir Ul-Haq Abbasi)

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618 Mubashir Ul-Haq Abbasi, who is making a comprehensive catalogue of the astronomical instruments preserved in the museums in Pakistan, has generously provided me the photos and the details about this astrolabe, for which I am highly indebted to him.

This astrolabe is not signed, but the shackle, *kursī*, rete and the back all match so perfectly with the astrolabe B011 made by Ṣāliḥ in 1663 and also with B014. Therefore, this astrolabe can be securely attributed to Ṣāliḥ.

Components

Body with *kursī* (d. 148, h. 178), ring and shackle, rete for 23 stars, 5 plates, alidade with a sighting tube, ruler, pin and wedge. The alidade, ruler and pin are not original.

Front

The ring has an octagonal cross-section; the shackle is circular with straight legs; it has also an octagonal cross-section and carries a knob at the top which is characteristic of Ṣāliḥ's astrolabes. The *kursī* is solid; its profiles are formed by two ogees, one upon the other, followed by a trifoliate finial.

The limb is divided in 1° and 6° and numbered anti-clockwise (which is very unusual!) in 6s from 6 to 90, separately in each quadrant.

Rete

The rete is exactly like the retes in B009 and B012 with both the equinoctial and solstitial bars completely represented, each with a counter change at the centre. The 23 star pointers are also shaped like those in the two astrolabes mentioned above.



Figure B013.2 – Rete of the astrolabe (photo by Mubashir Ul-Haq Abbasi)

Table B013-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus*	β Ceti
2	*Rās al-Ghūl*	β Persei
3	*ᶜAyn al-Thawr*	α Tauri
4	*Rijl al-Jawzā' al-Yusrā*	β Orionis
5	*Shiᶜrā Yamānī*	α Canis Majoris
6	*Shiᶜrā Shāmī*	α Canis Minoris
7	*Ẓahr al-Asad*	δ Leonis
8	*Fard al-Shujāᶜ*	α Hydrae

	Star Name	Identification
9	*Qalb al-Asad*	α Leonis
10	*Janāḥ al-Ghurāb*	γ Corvi
11	*Ṣarfa*	β Leonis
12	*ᶜAnāq*	ζ Ursae Majoris
13	*Simāk Aᶜzal*	α Virginis
14	*Simāk Rāmiḥ*	α Bootis
15	*Nayyir Fakkah*	α Coronae Borealis
16	*ᶜUnuq Ḥayyah*	α Serpentis
17	*Qalb al-ᶜAqrab*	α Scorpii
18	*Rās al-Ḥawwā*	α Ophiuchi
19	*Nasr Wāqiᶜ*	α Lyrae
20	*Nasr Ṭā'ir*	α Aquilae
21	*Dhanab al-Jadī*	δ Capricorni
22	*Kaff al-Khaḍīb*	β Cassiopeiae
23	*Janāḥ al-Faras*	γ Pegasi

Plates

There are five plates with the following particulars.

Table B013-2 Plates

	φ	Longest Day
1a	21;40	13;19 hours
1b	14°	13;20 hours
2a	35°	14;35 hours
2b	25°	13;35 hours

	φ	Longest Day
3a	23°	13;27 hours
3b	32°	14;8 hours
4a	27°	13;44 (?) hours
4b	29°	13;53 hours
5a	Plate of ecliptic coordinates	
5b	Plate of horizons	

Altitude circles are drawn for every 3° with each third highlighted with dots; azimuth arcs for each 10° below the local horizon and lines for seasonal hours. Lines for equal hours are not drawn on any plate. At the middle of the plate, the latitude and the hours of the longest day are written one below the other. Under the eastern horizon is written *mashriq* and under the western horizon *maghrib.* In plate 4, a part of the rim is broken.

On the plate of ecliptic coordinates, circles of latitude are traced for every 6° and numbered four times. Circles of longitude are drawn for every 10° and numbered as 10, 20, 30, separately for each zodiac sign. The names of the signs are inscribed along the ecliptic circle. The name of the plate is not engraved.

On the plate of horizons, half horizons are drawn for each degree of arc from 6° to 69° in four sets at intervals of 6°. Declination scales are drawn along the four radii between the tropics and the equator; these are marked 6, 12, 18, 23;30, the last value being the obliquity. There is no label carrying the name of the plate.

Geographical Gazetteer

The geographical gazetteer is engraved in two circles, separated neatly from one another by double lines. It provides the names, longitudes and latitudes of 74 localities.



Figure B013.3 – Geographical gazetteer (photo by Mubashir Ul-Haq Abbasi)

Table B013-3 Geographical Gazetteer

	Place Names (*asmā' al-buldān*)	**L** (*al-ṭūl*)	**φ** (*al-ᶜarḍ*)
	Outer Circle		
1	Makka Mubārak	77;10	21;40
2	Madīnat Musharrafa	75;20	25;0
3	Ṭā'īf	77;30	21;20
4	Laḥsā	77;30	24;0
5	Qaṭīf Baḥrayn	74;0	25;0
6	Bayt al-Maqdis	66;30	31;30
7	Ṣarya	68;0	32;0
8	Dimashq	70;0	33;15
9	Ḥalab	72;10	35;50
10	Kirmān	91;30	30;5
11	Rās al-ᶜAyn	74;0	36;50
12	Nakhjawān	81;15	38;40
13	Marāgha	82;0	37;20
14	Tabrīz	82;0	38;0
15	Ardabīl	82;30	38;0
16	Bulghār	95;0	49;30
17	Kūfa	79;30	31;30
18	Madā'īn	72;0	33;10
19	Baghdād	80;0	33;25
20	Wāsit	81;30	32;20
21	Baṣra	84;0	30;0
22	Ahwāz	85;0	31;0

	Place Names (***asmā' al-buldān***)	**L** (***al-ṭūl***)	**φ** (***al-ᶜarḍ***)
23	Arjān	86;30	35;30
24	Sābūr	86;15	30;0
25	Kāzerūn	87;0	29;15
26	Fīrūzābād	86;30	28;10
27	Shīrāz	88;0	29;36
28	Zanjān	83;40	36;30
29	Abhar	84;30	36;15
30	Hamadān	83;0	35;0
31	Karkh	84;40	34;0
32	Qazwīn	85;0	35;0
33	Iṣfahān	86;40	32;25
34	Kāshān	86;0	34;0
35	Qumm	85;40	34;45
36	Rayy	86;20	35;0
37	Nayshābūr	92;30	36;20
38	Astarābād	89;35	36;50
39	Amul	88;20	36;15
40	Ṭūs	92;30	37;0
41	Balkh	101;0	36;11
42	Bukhārā	97;30	39;30
43	Badakhshān	84;24	37;0
	Inner Circle		
44	Samarqand	99;36	39;31
45	Nasaf	98;0	39;0

	Place Names (*asmā' al-buldān*)	L (*al-ṭūl*)	φ (*al-ʿarḍ*)
46	Kāshghar	106;30	44;0
47	Khutan	107;0	42;0
48	Hurmūz	92;0	25;0
49	Kīch Makrān	99;0	28;0
50	Daybul wa Hawtattah (?)	102;20	25;10
51	Masūra Qaṣba Sind	105;0	27;40
52	Nahlawāra	107;20	22;0
53	Sawmnāt	106;0	16;0
54	Qandahār	107;40	33;0
55	Lāhūr	109;20	31;50
56	Qannawj Dār al-Mulk Hind[619]	115;50	26;35
57	Banāras	117;20	26;54
58	Sarāndīp	104;0	10;0
59	Tubbat	110;0	40;0
60	Kashmīr	108;0	35;0
61	Kābul	105;0	34;0
62	Dihlī	113;35	28;39
63	Āgra	115;0	27;0
64	Aḥmadābād	108;40	23;15

619 This is how Ulugh Beg's gazetteer describes Kannauj; cf. Sédillot 1853, p. 270. But in the second half of the seventeenth century when Ṣāliḥ engraved this gazetteer, Kannauj was no more the capital of India. Ṣālih copied this from some list derived Ulugh Beg's gazetteer without reflecting on its contemporary relevance.

	Place Names (***asmāʾ al-buldān***)	**L** (***al-ṭūl***)	**φ** (***al-ᶜarḍ***)
65	Burhānpūr	112	20;30
66	Kanbayāt	109;20	22;20
67	Panjapūr	105;30	17;20
68	Ujjayn	112	22;20
69	Amarkūt	107;10	32;50
70	Jamkūt	105;0	25;0
71	Kawāliyar	115;0	26;29
72	Ajmīr	111;5	24;0
73	Sunām	110;25	30;30
74	Badāʾūn	114;39	27;32



Figure B013.4 – Back of the astrolabe (photo by Mubashir Ul-Haq Abbasi)

Back

The back of the astrolabe is designed exactly as in the other astrolabes, with minor variations. The upper half of the rim carries the altitude scales. While the front is divided in 1° and 6°, the altitude scales on the back are divided in 1° and 5° and numbered in

5s as 5—90; 90—5. The trigonometric quadrant on the upper left is engraved with 60 horizontal lines, while the solar quadrant on the upper right is divided by declination arcs into 6 zones, one for each pair of zodiac signs. The names of the corresponding signs are inscribed along the two radii. A universal horary quadrant is superimposed on it and also two barely visible graphs of the meridian altitude of the sun at latitudes 27° and 32°. The related labels, *niṣf al-nahār bi-ᶜarḍ 27* and *niṣf al-nahār bi-ᶜarḍ 32,* are, however, deeply incised.

There are shadow squares in the lower half, on the left for a base of 7 and on the right for a base of 12; the scales are divided and numbered accordingly, but there are no labels accompanying the scales. The rim on the lower is engraved with cotangent scales; on the left for a base of 7 with the label *ẓill aqdām* and on the left for a base of 12 with the label *ẓill aṣābiᶜ*.

In the space between the cotangent scales and the shadow squares are semi-circular rows carrying the names of the 28 lunar mansions and the names of the 12 zodiac signs.



Figure B013.5 – Alidade with the sighting tube (photo by Mubashir Ul-Haq Abbasi)

ALIDADE

The alidade is equipped with a sighting tube, but not graduated. An ungraduated ruler is also pivoted to the centre. Both may be replacements.

B014⊙ ASTROLABE ATTRIBUTABLE TO MUḤAMMAD ṢĀLIḤ

Not dated, 17th century

Diameter 218 mm

Salem, MA, Peabody Essex Museum (# M2560)[620]

CCA 3655

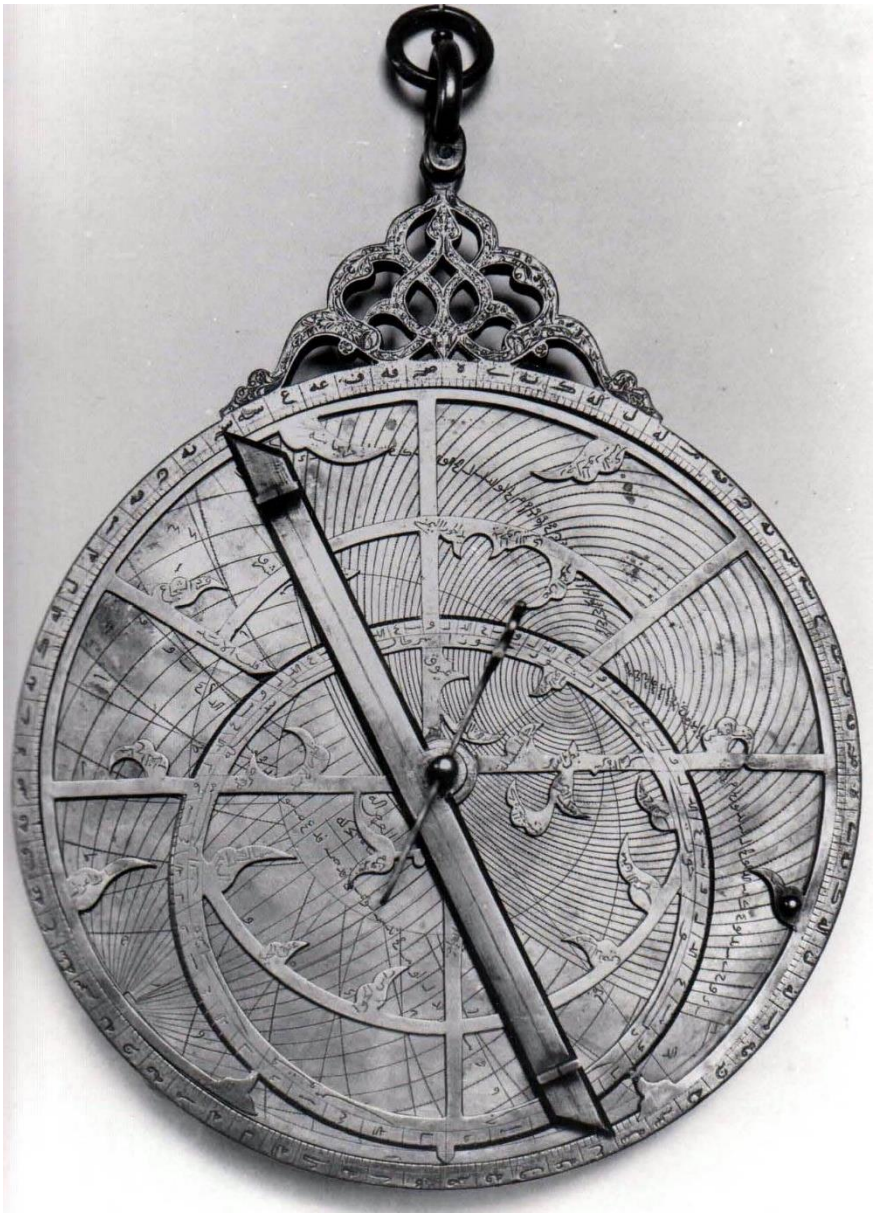


Figure B014.1 – Front of the astrolabe (photo courtesy Professor Takanori Kusuba)

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620 I tried to see this astrolabe in 1993 when I was in the US, but could not because the astrolabe was then sent to the Ota Museum in Tokyo for a special exhibition. At my request, Professor Takanori Kusaba acquired several photos from Tokyo and sent them to me. During my next visit to the US, I had the opportunity to personally examine the astrolabe in June 2005.

CCA 3655 states that this astrolabe is by Muḥammad Muqīm ibn ʿĪsā of Lahore, but it carries no signature or date and no characteristic features which would support the attribution to Muqīm. On the other hand, from the configuration of the back and, more particularly, from the small knob on the shackle which is characteristic of the astrolabes made by Muḥammad Ṣāliḥ, this astrolabe also can be safely attributed to him.

COMPONENTS

Body with *kursī* (d. 218, h. 270) with shackle and ring, rete (d. 203) for 32 stars, 4 plates (d. 203) and pin; the alidade and horse are replacements.

FRONT

The astrolabe is well crafted like B011. The ring and shackle are made of a darker alloy. The ring is simple; the shackle has a circular shape with two oval bases. On the top of the shackle is a small knob, which is characteristic of the astrolabes by Muḥammad Ṣāliḥ. The *kursī* is elegantly reticulated and the surface is decorated with very fine floral engravings which sparkle like jewels. The fine engravings on the surface on both sides may be compared to the same on the unsigned astrolabe A128. The profiles of the *kursī* are formed by ogees at the base and at the top with a lobe in between. The finial circular. The rim is graduated in 1° and 5° and labelled in 5s, from 5 to 90, separately in each quadrant.

RETE

The narrow Capricorn ring and the broader ecliptic ring are held together by the equinoctial bar and the solstitial bar, both of which are counter-changed at the centre. The equator is represented by two large segments, one inside the ecliptic ring and the other below it. This is unusual for the Lahore astrolabes. The ecliptic ring is divided into 12 the signs of the zodiac and is labelled with their names. Each sign is divided into 5 parts and numbered accordingly; these parts are further subdivided into 3 parts each of 2°. A washer was joined to the centre of the rete with two nails. There is a handle affixed to the pointer of the star γ Corvi and a prominent Capricorn index.

There are 32 star pointers, 12 star pointers outside the ecliptic and 20 inside; these are shaped in the form of tiger's claws, some with lobes on the back.

Table B014-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus*	β Ceti
2	*Baṭn al-Ḥūt*	β Andromedae
3	*Rijl al-Musalsala*	γ Andromedae
4	*Ra's al-Ghūl*	β Persei
5	*Mirfaq al-Thurayyā*	α Persei
6	*ᶜAyn al-Thawr*	α Tauri
7	*ᶜAyyūq*	α Aurigae
8	*Rijl al-Jawjā' al-Yusrā*	β Orionis
9	*Yad al-Jawjā' al-Yusrā*	γ Orionis
10	*Yad al-Jawjā al-Yumnā*	α Orionis
11	*Shiᶜrā Yamāniyya*	α Canis Majoris
12	*Shiᶜrā Shāmiyya*	α Canis Minoris
13	*Fard al-Shujāᶜ*	α Hydrae
14	*Qalb al-Asad*	α Leonis
15	*Ẓahr al-Asad*	δ Leonis
16	*Ṣarfa*	β Leonis
17	*Janāḥ al-Ghurāb*	γ Corvi
18	*Simāk Aᶜzal*	α Virginis
19	*Simāk Rāmiḥ*	α Bootis
20	*Nayyir Fakkah*	α Coronae Borealis
21	*ᶜUnuq al-Ḥayyah*	α Serpentis
22	*Qalb al-ᶜAqrab*	α Scorpii
23	*Ra's al-Ḥawwā*	α Ophiuchi
24	*Nasr Wāqiᶜ*	α Lyrae

	Star Name	Identification
25	*Minqār al-Dajājah*	β Cygni
26	*Nasr Ṭā'ir*	α Aquilae
27	*Dhanab al-Dulfīn*	ε Delphini
28	*Matn al-Faras*	α Pegasi
29	*Sāq Sākib al-Mā'*	δ Aquarii
30	*Mankib al-Faras*	β Pegasi
31	*Kaff al-Khaḍīb*	β Cassiopeiae
32	*Janāḥ al-Faras*	γ Pegasi

PLATES

There are four plates; three of these serve six different latitudes.

Table B014-2 Plates

	φ	Longest Day	(Locality)
1a	25°	13;25 hours	(Medina)
1b	29;40°	13;56 hours	(Multan)
2a	27°	13;44 hours	(Agra)
2b	28;20°	13;50 hours	(Delhi)
3a	32°	14;8 hours	(Lahore)
3b	35°	14;25 hours	
4a	Plate of ecliptic coordinates		
4b	Plate of horizons		

Plate 2b for latitude 28;20° is meant for Delhi; the same value is given in the gazetteer for the latitude of Delhi. Plate 2a and 3a are respectively for Agra and Lahore. Plate 1b appears to be for Multan; in the gazetteer this city has the latitude 29;40. It is

interesting that a special plate is made for Multan, besides the three imperial cities of Agra, Delhi and Lahore.

On plates 1 to 3, altitude circles are drawn for each 2° with every third dotted. Azimuth arcs are drawn for each 6° below the horizon. Plain lines are drawn for seasonal hours and dotted lines for equal hours which are drawn from the western horizon as well as from the eastern horizon.

The obverse side of the fourth plate carries the plate of ecliptic coordinates with latitude circles for each 5° and longitude circles for each 6°. The reverse side of this plate carries four sets of half horizons. There is no label on either side.



Figure B014.2 – Geographical Gazetteer (photo courtesy Professor Takanori Kusuba)

GEOGRAPHICAL GAZETTEER

On the inner side of the mater is engraved the geographical gazetteer in three circles with the names, longitudes and latitudes of 113 localities. Ardabīl is listed twice at nos. 22 and 27, but with different coordinates.

Table B014-3 Geographical Gazetteer

	Place Name (*ismā al-baldān*)	**L (*al-ṭūl*)**	**φ (*al-ʿarḍ*)**
	Outer Circle		
1	Makka Muʿaẓẓam	77;10	21;40
2	Madīnat Musharraf	75;20	25;0
3	Lahānū (?)	77;30	21;20
4	Mahadiyya Maghrib	47;0	32;30
5	Sikandariyya	61;54	30;58
6	Miṣr	63;20	30;20
7	Qulzum	94;0	29;30
8	Yaman	77;0	15;30
9	ʿAdan	76;0	11;0
10	Qaṭif Baḥrayn	74;0	25;0
11	Bayt al-Maqdis	66;30	31;50
12	Dimashq	70;0	33;15
13	Baʿālbak	70;55	33;15
14	Himṣ	70;45	37;0
15	Ḥalab	77;10	35;50
16	Qusṭanṭiniyya	59;50	45;0
17	Rūmiyya	85;27	41;50
18	Adhar al-Rūn	77;0	59;40

	Place Name (*ismā al-baldān*)	**L** (*al-ṭūl*)	**φ** (*al-ᶜarḍ*)
19	Adharbaijān	76;0	38;0
20	Rās Alᶜayn	74;0	36;50
21	Mawṣil	77;0	34;30
22	Ardabīl	76;20	35;0 [see #27]
23	Marand	80;45	34;50
24	Nakhjawān	81;15	38;40
25	Maragha	82;0	37;20
26	Tabrīz	82;0	38;0
27	Ardabīl	82;30	38;0 [see #22]
28	Bardaᶜa	83;0	40;30
29	Junkzah ?	83;0	41;20
30	Taᶜnīs (Tiflīs ?)	83;0	43;0
31	Shamākhī	84;30	40;50
32	Bāb al-Abwāb	84;0	43;0
33	Kūyā ?	87;0	43;0
34	Kūfa	79;30	31;30
35	Jadā'ūn ?	72;0	33;10
36	Baghdad	82;0	33;25
37	Wāsiṭ	81;30	32;20
38	Baṣra	84;0	30;0
39	ᶜAylazān ?	84;30	31;0
40	Kāzirūn	87;0	29;55
41	Fīrūzābād	87;30	28;10
42	Shīrāz	88;0	29;36

	Place Name (***ismā al-baldān***)	**L** (***al-ṭūl***)	**φ** (***al-ᶜarḍ***)
43	Aṣfahr ?	88;30	35;0
44	Yazd	89;0	32;0
45	Saharwar	80;20	32;30
46	Farmāsayn ?	83;30	32;30
47	Dīnawar	83;0	35;0
48	Suhraward	83;20	36;0
49	Nayhāwand	83;15	34;20
50	Rankān ?	83;40	36;30
51	Abhar ?	84;30	36;45
52	Hamadān	83;0	35;10
53	Karkh	84;45	34;0
54	Sāwah	85;0	35;0
55	Farwīn	85;0	36;0
	Middle Circle		
56	Āwah	85;0	34;40
57	Jarbādqān	85;30	34;15
58	Samīrmar ?	85;40	30;15
59	Iṣfahan	87;40	32;35
60	Kāshān	86;0	34;0
61	Qumm	85;40	34;40
62	Rayy	86;20	35;0
63	Khawār	87;10	35;0
64	Ṭāliqān	85;45	36;10
65	Hawsam	85;10	37;0

	Place Name (***ismā al-baldān***)	**L** (***al-ṭūl***)	**φ** (***al-ʿarḍ***)
66	Ahal ?	108;20	36;15
67	Astarabad	109;35	36;10
68	Jurjān	90;0	36;50
69	Bisṭām	109;30	36;10
70	Bayāz (read Bayar)	109;50	35;45
71	Sabzawar	91;30	36;5
72	Nishabur	92;30	36;21
73	Tus	92;30	37;0
74	Tun	92;30	32;30
75	Zūzan	93;13	33;40
76	Harāt	94;0	37;30
77	Marw	92;0	36;40
78	Fariyāb	99;0	36;0
79	Bukhārā	107;30	39;50
80	Balkh	101;0	36;41
81	Samarqand	99;36	39;32
82	Khujand	100;35	38;15
83	Kāshghar	106;30	44;0
84	Kābul	104;40	34;30
85	Badakhshān	104;25	37;10
86	Ghaznī	104;27	33;35
87	Khutān	107;0	33;35
88	Hurmūz	92;0	25;0

	Place Name (*ismā al-baldān*)	**L** (*al-ṭūl*)	**φ** (*al-ᶜarḍ*)
89	Kīj Makrān	95;0	28;0
90	Daybul wa Hūtna (?)	102;30	25;10
	Inner Circle		
91	Manṣūra Sind	105;0	27;40
92	Mūltān	107;35	29;40
93	Qandahār	107;40	33;0
94	Lāhūr	109;20	31;50
95	Qannawj	112;50	26;35
96	Banāras	117;20	26;55
97	Sarāndīb	130;0	10;0
98	Tubbat	110;0	40;0
99	Kashmīr	118;0	35;0
100	Tīnīsar	112;25	30;10
101	Dihlī	113;35	28;20
102	Akrah	114	27;0
103	Kawalīyar	115;0	26;25
104	Ajmīr	101;5	24;0 !
105	Aḥmadābād	108;40	23;15
106	Ujjayn	102;0	22;0
107	Amarkot	105;0	25;0
108	Bījābūr	105;30	17;20
109	Rājkarī (?)	109;55	33;20
110	Dawlatābād	101;0	20;30

	Place Name (***ismā al-baldān***)	**L** (***al-ṭūl***)	**φ** (***al-ᶜarḍ***)
111	Aḥmadnakar	107;0	19;0
112	Jawnbūr	109;6	26;36
113	Si[r]hind?	105;0	28;4

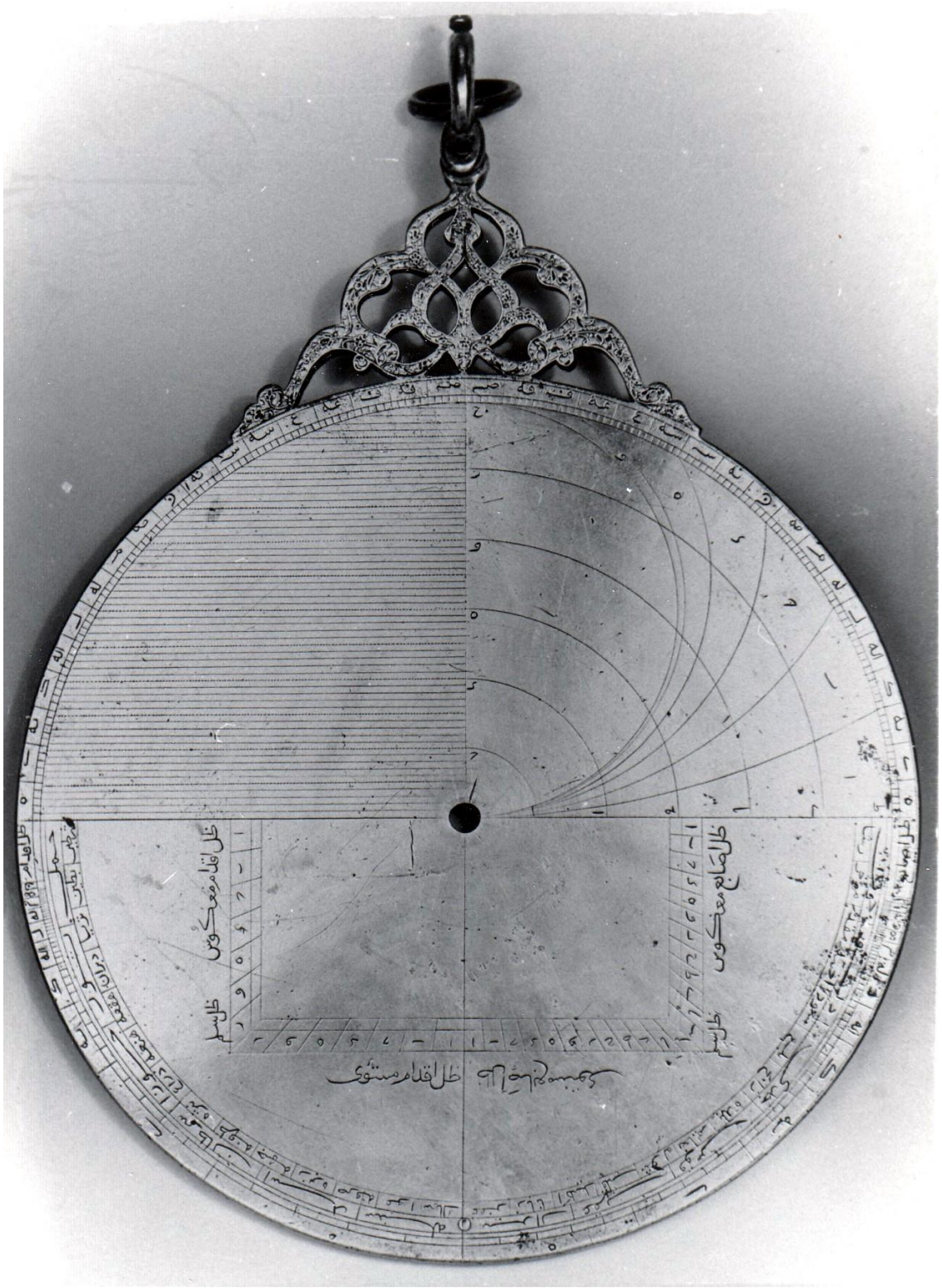


Figure B014.3 – Back of the astrolabe (photo courtesy Professor Takanori Kusuba)

BACK

The upper half of the rim is graduated in 1° and 5° and labelled as 5 ---90; 90---5. Upper left quadrant is engraved with 60 equidistant horizontal parallels; each fifth highlighted with dotted lines. The upper right quadrant is divided into 6 equal segments, each representing a pair of zodiac signs. The signs are marked by their serial numbers

on the vertical and horizontal radii. On this quadrant is superimposed a universal horary quadrant with 6 lines of seasonal hours which are numbered serially.

In the lower half are shadow squares, on the left for the gnomon of 7 feet and on the right for the gnomon of 12 digits. The four scales are divided and numbered accordingly and carry the following labels:

Vertical scale on the left: *ẓill aqdām maᶜkūs*

Horizontal scale on the left: *ẓill aqdām mustawī*

Horizontal scale on the right: *ẓill aṣabiᶜ mustawī*

Vertical scale on the right: *ẓill aṣabiᶜ maᶜkūs.*

In addition, at the two inner corners are written *ẓill sullam* (scale of shadows).

The lower half of the rim carries cotangent scales in the outer row and their subdivisions in the inner row. In the outer row on the left the unequal divisions are numbered in 5s from 5 to 50, followed by the label *ẓill aqdām.* The unequal divisions on the right are also numbered in the same manner, but anti-clockwise from the vertical diameter, followed by the label *ẓill aṣābiᶜ*. Inside the cotangent scales are two rows carrying respectively the names of the 12 zodiac signs and the names of the 28 corresponding lunar mansions.

ALIDADE

The alidade has the unusual form of rhomboid and is ungraduated; it is a late replacement.

B015 UNSIGNED INDO-PERSIAN ASTROLABE[621]

Not dated, 17th Century

Diameter 260 mm

PLU, ex- Milan



Figure B015.1 – Front of the astrolabe (photo courtesy Professor G. L'E. Turner)

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621 Entry based on information and photos kindly provided by the late Professor G. L'E. Turner.

The high openwork *kursī* and the matching floral rete suggest, at first glance, that this astrolabe was produced at the workshop of the Lahore family, but the plate of horizons and the configuration on the back show clearly that this astrolabe is not the product of the Lahore family, but produced outside the family, probably in the seventeenth century.

COMPONENTS

Body with *kursī* (d. 260, h. 335), ring and shackle, rete, 4 plates; alidade, pin and horse are lacking.

FRONT

The shackle appears to be trifoliate with ornate bases. The *kursī* is high and triangular. The profiles are made up of ogees at the base, followed by a series of lobes. The openwork displays a floral pattern with two-petalled flowers and tendrils.

The limb is divided in 1° and 5° and numbered in 5s clockwise from 5 to 90, separately for each quadrant. The *Abjad* letters are written upside down, that is, the tops of the letters are towards the centre of the astrolabe.

RETE

The two rings of Capricorn and ecliptic are held together by the equinoctial bar and the solstitial bar, both completely represented, and both with a counter change at the centre. The equator is also represented by two segments, one within and the other below the ecliptic ring. The ecliptic ring is divided into the 12 signs of zodiac and labelled with their names. Each sign is divided, rather unusually, into 5° and numbered in 5s from 5 to 30. There are arch-like frames at the top of the solstitial bar and also immediately below the ecliptic ring. Similar frames are added to the equinoctial bar at its two intersections with the ecliptic ring. The floral tracery consists of several flowers, each with two petals, one long and one short. The longer petals constitute the star pointers. A bird-like figure straddles the upper segment of the solstitial bar; its beak indicates the position of the star α Lyrae, its plume the position of β Cygni and its tail that of α Coronae Borealis.

A handle for rotating the rete is affixed to the tracery at SW. The Capricorn index is well formed. The 41 stars marked on rete are listed in the order of increasing right ascension in the following table.

Table B015-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus* (?)	β Ceti
2	*Kaff al-Jadhmā'*	α Ceti
3	*Rās al-Ghūl*	β Persei
4	*Al-Dabarān*	α Tauri
5	*ᶜAyyūq*	α Aurigae
6	*Rijl [al-Jawzā'] Yusrā*	β Orionis
7	*Yad al-Jawzā' [Yumnā]*	α Orionis
8	*Rijl [al-Jawzā'] al-Yumnā*	κ Orionis
9	?	
10	*Shiᶜrā Yamānī*	α Canis Majoris
11	*Rās al-Taw'am [al-Muqaddam]* α Geminorum	
12	*Shiᶜrā Shāmī*	α Canis Minoris
13	*Al-Maᶜlaf*	M44 Cancri
14	*Fard Shujāᶜ*	α Hydrae
15	*Qalb al-Asad*	α Leonis
16	*Ẓahr al-Asad*	δ Leonis
17	*Minqār al-Ghurāb*	α Corvi
18	*Al-Ḍifdiᶜ*!	α Piscis Austrini or β Ceti [622]
19	*ᶜAnāq* ?	ζ Ursae Majoris
20	*Janaḥ al-Ghurāb*	γ Corvi

[622] This must be an error for *al-Ṣarfa.* There are two stars named *al-Ḍifdiᶜ*: *al-Ḍifdiᶜ al-Awwal* (α Piscis Austrini) and *al-Ḍifdiᶜ al-Ṭānī* (β Ceti) and both would be on the opposite side of the rete; cf. Kunitzsch 1959, p. 158.

	Star Name	Identification
21	?	
22	*Al-Qā'id*	η Ursae Majoris
23	*Al-Mufrid al-Rāmiḥ*	η Bootis
24	*Al-Simāk al-Rāmiḥ*	α Bootis
25	*ᶜUnuq al-Ḥayyah*	α Serpentis
26	*Al-Nayyir al-Fakkah*	α Coronae Borealis
27	*Rās al-Ḥawwā*	α Ophiuchi
28	?	
29	*Al-Rukbat al-Rāmī*	α Sagittarii
30	?	
31	*Al-Nasr al-Wāqiᶜ*	α Lyrae
32	*Minqār al-Dajājah*	β Cygni
33	*Al-Nasr al-Ṭā'ir*	α Aquilae
34	*Dhanab al-Dālfīn* !	ε Delphini
35	*Fam al-Faras*	ε Pegasi
36	*Dhanab al-Dajājah*	α Cygni
37	*Dhanab al-Jadī*	δ Capricorni
38	*?*	
39	*Kaff al-Khaḍīb*	β Cassiopeiae
40	*Surrat al-Faras*	δ Pegasi
41	*Dhanab al-Qayṭus*	ι Ceti

PLATES

There are four plates with the following features.

Table B015-2 Plates

	φ	Longest Day
1a	24°	13;34 hours
1b	30	14;8 hours
2a	Plate of horizons	
2b	25°	----
3a	27°	13;32 hours
3b	35°	14;28 hours
4a	21;40°	----
4b	32°	14;16 hours

On all plates except 2a, altitude circles are drawn for every 1° with each fifth highlighted by dots. Azimuths arcs are drawn below the horizon for every 3°; here also each fifth circle is dotted. There are two sets of hour lines; one for seasonal hours and the other (dotted) for equal hours; the latter are drawn from both the western and eastern horizons.

On the plate of horizons, the same set of half-horizons are drawn in all the four quadrants, from 3° to 90° at intervals of 3°, which is very unusual. Declination scales are marked along the four radii only to the south of the equator (and not to the north). The divisions on these scales are not discernable in the available photo, but the label reads *al-mayl al-janūbī,* followed by 33 and 30 (!). The plate of ecliptic coordinates is not represented in this astrolabe.

GEOGRAPHICAL GAZETTEER

No information is available.

BACK

On the back, altitude scales are engraved on the upper half of the rim; these scales are divided in 1° and 5° and labelled in 5s as 5—90; 90—5. The two upper quadrants are both filled with 60 horizontal lines at gradually decreasing intervals as in A133.

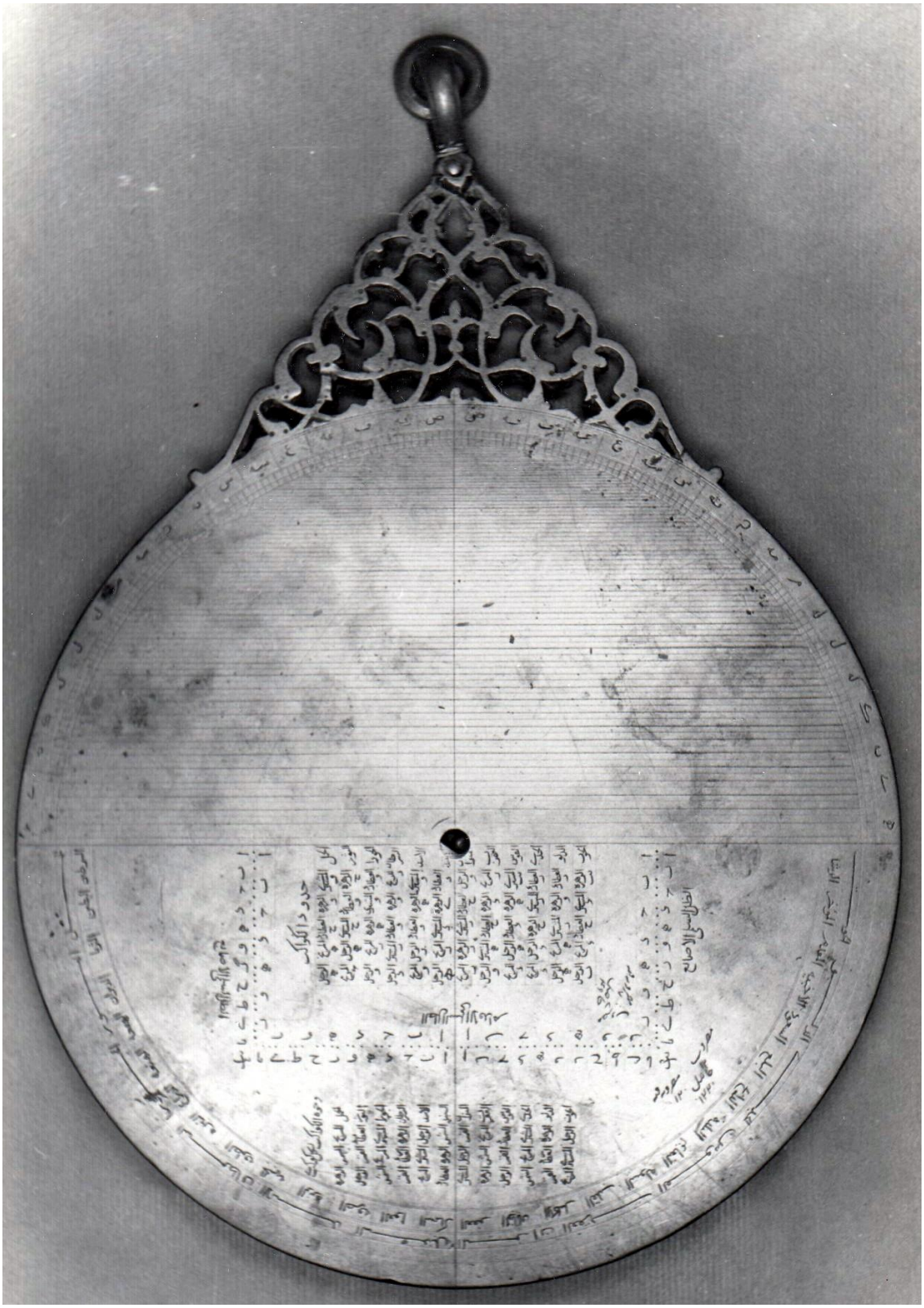


Figure B015.2 – Back of the astrolabe (photo courtesy Professor G. L'E. Turner)

The shadow squares drawn in the lower half are very unusual. There are actually no proper scales as such, but just dotted lines. Numbers 1 to 12 are inscribed outside the vertical and horizontal lines on the left as well as on the right. Numbers 1 to 7 are inscribed inside these four lines. There is an identical label *al-ẓill al-sullī al-aṣābi*$^{c.}$ outside the vertical scales on the left and on the right. On the inner side, there is one common label for the two horizontal scales on the left and right: *al-ẓill al-sullī al-aqdām.* The implication seems to be that the same scale functions as the scale of 7 feet on the inside and as the scale of 12 digits on the outside!

This notion is supported by the short inscriptions, one within and the other without, clearly added by different hand. The one within reads: *maẓrūb 7 maẓrūb fīhi 7 ḥāsil 49* (multiplicand 7, multiplier 7, product 49). The one outside reads: *maẓrūb 12 maẓrūb fīhi 12 ḥāsil 144* (multiplicand 12, multiplier 12, product 144).

Two astrological tables are engraved without any grid lines, one inside the shadow squares and another below them. The table inside the shadow squares is entitled *ḥudūd al-kawākib* (limits of signs) with the names of the zodiac signs and the names of the ruling planets written in full. The second table is the table of faces (*wujūh al-kawākib* -- *kawkab*- ?); here also the names of the signs and the names of the planets are written in full.

There are no cotangent scales in the lower half of the rim; the rim is blank. Inside the rim, the names of the 12 signs of the zodiac and the names of the 28 corresponding lunar mansions are incised.

Provenance

The astrolabe was in a private collection in Milan in August 2006 when Professor G. L'E. Turner sent me the photos. I understand that subsequently the collection was acquired by the Ahuan Gallery of Islamic Art, London; it is not known if the astrolabe is still with this Gallery.

B016 RETE OF AN INDO-PERSIAN ASTROLABE

Not dated, 17th century

Diameter 150 mm

Hastings-on-Hudson, NY, Tesseract[623]



Figure B016.1 – Rete (photo courtesy Dr David Coffeen)

Only the rete of this astrolabe is extant. The two rings of Capricorn and ecliptic are held together by the equinoctial bar which has three counter changes at its two intersections with the ecliptic ring and at the centre. The solsitial bar is also represented, but it is interrupted twice by lobed arches. There are two segments of the equator ring,

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623 Catalogue C-72, lot 3.

one inside the ecliptic and the other below it. The ecliptic ring is divided into the 12 signs of the zodiac and engraved with their names. But the signs are not subdivided. The edge of the ecliptic ring is divided in 2°. In the absence of other components, it is difficult to decide whether this rete belongs to a Lahore astrolabe or to an Indo-Persian astrolabe produced outside the Lahore family. The astrolabes produced in the Lahore family do not show the equator in the retes as is done in this rete. Nor do they represent both the equinoctial and solstitial bars completely. Moreover, the workmanship is quite inferior to that of the Lahore astrolabes. This rete thus belongs to an astrolabe produced outside the Lahore family probably in the seventeenth century.

The lobed arches which interrupt the solstitial bar display some similarity to the rete of the astrolabe B015. There are 26 named star pointers; some carry deeply engraved points at the tips to indicate the precise position of the star; some others (e.g. 5 *Dabarān* and 17 *Simāk Rāmiḥ*) are not completely separated from the main frame. There is a handle on the solstitial bar at its northern intersection with the equatorial ring; there is yet another handle on the tracery at SW, exactly in the same place as in B015. There is no Capricorn index.

Table B016-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus [Janūbī]*	β Ceti
2	*Fam al-Qayṭus*	γ Ceti
3	*Ra's al-Ghūl*	β Persei
4	*ᶜAyyūq*	α Aurigae
5	*Dabarān*	α Tauri
6	*Mankib al-Jawzā'*	α Orionis
7	*Rijl al-Jawzā' Yumnā*	κ Orionis
8	*Shiᶜrā Yamānī*	α Canis Majoris
9	*Shiᶜrā Shāmī*	α Canis Minoris
10	*Fard Shujāᶜ*	α Hydrae

	Star Name	Identification
11	*Qalb al-Asad*	α Leonis
12	*Janāḥ al-Ghurāb*	γ Corvi
13	*al-Ṣarfa*	β Leonis
14	*Simāk Aᶜzal*	α Virginis
15	?	
16	?	
17	*Simāk Rāmiḥ*	α Bootis
18	*Ra's al-Jāthī*	α Herculis
19	*Nayyir al-Fakkah*	α Coronae Borealis
20	*Ra's al-Ḥawwā*	α Ophiuchi
21	*Nasr Wāqiᶜ*	α Lyrae
22	*Nasr al-Ṭā'ir*	α Aquilae
23	*Dhanab al-Jadī*	α Capricorni
24	*Dhanab al-Dulfīn*	ε Delphini
25	*Dhanab al-Dajājah*	α Cygni
26	*Kaff al-Khaḍīb*	β Cassiopeiae

B017⊙ ASTROLABE, NOT SIGNED, 1129 AH (AD 1716-17)

Diameter 151 mm

Delhi, National Museum (# 58.98/9)



Figure B017.1 – Front of the astrolabe (courtesy Anthony J. Turner)

The maker of this astrolabe informs us, quite helpfully, that this is a northern astrolabe (*asṭurlāb shamālī*) and provides the date on both sides of the *kursī*, but does not mention his name.

Components

Body with *kursī* (d. 151, h. 195, t. 10), ring and shackle, rete (d. 135) for 26 stars, 7 plates (d. 136); alidade, pin and horse are missing; the astrolabe is held together by modern bolt and nut.

Front

The ring is very small; the shackle has peculiar shape with the narrow upper part; the *kursī* is solid and not very high, the profiles are made up of two ogees with a lobe between them and a circular finial. The limb is divided in 1° and 5° and numbered in 5s clockwise from 5 to 90, separately in each quadrant.

Rete

The peripheral Capricorn ring is very slender and the ecliptic ring wider. These are held in place by the slender equinoctial bar which has a counter change at the centre. The 26 star pointers are joined by a tracery of tendrils, flowers and leaves.

Plates

There are seven plates with the following particulars.

Table B017-1 Plates

	φ	Longest Day
1a	34°	14;17 hours?
1b	37°	14;32 hours
2a	28°	13;56 hours
2b	31°	14;1 hours
3a	13°	12;46 hours
3b	46°	15;34 hours
4a	19°	13;9 hours
4b	36°	14;57 hours
5a	22°	13;21 hours
5b	25°	13;34 hours

	φ	Longest Day
6a	40°	14;51 hours
6b	43°	15;10 hours
7a	Plate of horizons	
7b	Plate of horizons	

Altitude circles are drawn for every 3° and numbered on both sides of the meridian; there are no azimuth arcs; there are lines for seasonal hours, numbered from 1 to 12 from the western horizon, but not lines for equal hours.

GEOGRAPHICAL GAZETTEER

On the inner surface of the mater is engraved a gazetteer in three concentric circles, providing the names, longitudes and latitudes of 65 localities, from Mecca in the west to Sri Lanka (*Lankā*) in the east. It is interesting that the gazetteer does not use the common Arabic term *Sarandīb,* but the Indian term *Lankā* for Sri Lanka.

BACK

On the back, the upper half of the rim is engraved with altitude scales which are divided in 1° and 5° and numbered as 5—90; 90—90.

The trigonometric quadrant in the upper left carries 30 equidistant horizontal lines and 12 equidistant vertical lines. In the solar quadrant in the upper right 11 declination arcs are drawn partially and the intervening zones are numbered in 5s from 5 to 60 along the vertical radius from the centre upwards. Six curves of the seasonal hours are drawn so that they do not intersect the declination arcs; these are numbered from 1 to 6 starting from the horizontal radius; there is label above the horizontal radius which reads *khaṭūṭ sāʿāt zamāniya* (lines of seasonal hours).



Figure B017.2 – Back of the astrolabe (photo courtesy Anthony J. Turner)

In the lower half are the shadow squares, on the left for a base of 7 and on the right for a base of 12. The vertical and horizontal scales are divided and numbered accordingly. The placement of the labels is somewhat unusual. Near the top of the vertical scale on the left is engraved a label on the inner side which reads *ẓill maᶜkūs bi-aqdām* and near the top of the vertical scale on the right *ẓill maᶜkūs bi-aṣābiᶜ*. For the

two horizontal scales there is a common label engraved across the vertical diameter *ẓill mustawī.* Above this is written on the left *aqdām* and on the right *aṣābiᶜ*.



Figure B017.3 – Inscription on the front of the *kursī* (detail of Figure B017.1)

INSCRIPTION

On the front side of the *kursī,* there is an inscription in four lines:

asṭurlāb shamālī

marṣūdah sanah 1129

'northern astrolabe

inscribed [in] the year 1129'

The Hijrī year translates to AD 1716-1717.

The last two lines contain the Throne Verse (*āyat al-kursī*) from the *Qur'ān* (Surah 2:255).

The first two lines are engraved also on the back of the *kursī.*

B018⊙ ASTROLABE BY SAYYID ᶜABD AL-BĀQĪ IBN SAYYID ḤUSAIN, 1204 AH (AD 1789-90)

Diameter 125 mm

Oxford, Museum of the History of Science (# 50059)

CCA 1022



Figure B018.1 – Front of the astrolabe (photo by S. R. Sarma)

Nothing is known about the maker of this astrolabe. The website of the Museum of the History of Science, Oxford, calls this an Indo-Persian astrolabe, but adds that the place of production is 'Iran/Persia Asia'. But the astrolabe does not show any features of Persian astrolabes of the late eighteenth century. On the other hand, it displays many features of the Lahore astrolabes, such as the mention on the plates of the duration of the longest day in Indian time units of *ghatīs.* There cannot be much doubt that it is an Indo-Persian astrolabe produced in the Indian subcontinent. Interestingly, the rete here is a copy of the same in A104; the two sides of plate 7 in A104 are also copied, although they are somewhat superfluous here. However, the astrolabe cannot be called a mere copy or forgery. The various plates and the back are engraved quite competently.

COMPONENTS

Body with *kursī* (d. 125, h. 152, t. 9), ring and shackle, rete 38 stars, 7 plates, pin and horse; alidade is lacking.

FRONT

The ring and the shackle have diamond cross-sections with sharp edges. The *kursī* is solid; its profiles are made up of ogees at the base, followed by a series of lobes. The limb is divided in 1° and 6° and numbered in 6s clockwise from 6 to 90, separately in each quadrant.

RETE

The rete is a crude imitation of the rete in A104 and carries the same star pointers (see Figure A104.2 and Table A104-1). Here the peripheral Capricorn ring and the wide ecliptic ring are held together by the equinoctial bar which has counter changes at the two equinoxes. From the centre of the disc, twelve radial lines are drawn at intervals of 30°, in order to divide the ecliptic ring into the 12 zodiac signs. The traces of these lines can be seen on the small ring at the centre and on other parts. Traces of the circle of Cancer can also be seen.



Figure B018.2 – Rete of the astrolabe (photo by S. R. Sarma)

Table B018-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab Qayṭus*	β Ceti
2	*Baṭn*	β Andromedae
3	*Fam Qayṭus*	γ Ceti
4	*Ṣadr Qayṭus*	π Ceti
5	*Ghūl*	β Persei
6	*Kaff al-Jadhmā'*	α Ceti
7	*Tālī Masāfat al-Nahr*	γ Eridani
8	*Dabarān*	α Tauri
9	*ᶜAyyūq*	α Aurigae

	Star Name	Identification
10	*Riǰl*	β Orionis
11	*Yad Yusrā*	γ Orionis
12	*Yad Yumnā*	α Orionis
13	*Riǰl Yumnā*	κ Orionis
14	*Shiᶜrā Yamānī*	α Canis Majoris
15	*Shiᶜrā Shāmī*	α Canis Minoris
16	*Ṭarfat al-Safīna*	ρ Puppis
17	*Fard Shujāᶜ*	α Hydrae
18	*Qā'idat al-Bāṭiya*	α Crateris
19	*ᶜAnāq*	ζ Ursae Majoris
20	*Janāḥ Ghurāb*	γ Corvi
21	*Simāk Aᶜzal*	α Virginis
22	*Simāk Rāmiḥ*	α Bootis
23	*Nayyir Fakkah*	α Coronae Borealis
24	*ᶜUnuq Ḥayyah*	α Serpentis
25	*Rās al-Jāthī*	α Herculis
26	*Rās al-Ḥawwā*	α Ophiuchi
27	*ᶜAyn Tinnīn*	α Draconis
28	*Yad Ḥawwā*	δ Ophiuchi
29	*Wāqiᶜ*	α Lyrae
30	*Minqār Dajājah*	β Cygni
31	*Nasr Tā'ir*	α Aquilae
32	*Dhanab al-Dulfīn*	ε Delphini
33	*Dhanab al-Dajājah*	α Cygni

	Star Name	Identification
34	*Fam Faras*	ε Pegasi
35	*Dhanab al-Jadī*	α Capricorni
36	*Sāq Sākib al-Mā'*	δ Aquarii
37	*Surrat Faras*	δ Pegasi
38	*Mankib Faras*	β Pegasi

PLATES

There are seven plates, each with a notch at the north point. Ten plate faces serve latitudes from 11° to 40° and two are designed as the plate of ecliptic coordinates and the plate of horizons respectively. The remaining two are copied from A104.

Table B018-2 Plates

	φ	Longest Day	
		hours	*ghaṭīs*
1a	11;0°	12;48 hours	32 *ghaṭīs*
1b	29°	13;12 hours	34 *ghaṭīs*
2a	27°		34 *ghaṭīs*
2b	32°		35 *ghaṭīs*
3a	30°	13;14 hours	
3b	37°	16;14 hours	?
4a	36°	14;30 hours	
4b	40°	14;12 hours	
5a	34°	14;17 hours	
5b	Plate of ecliptic coordinates		
6a	19°	---	---

	φ	Longest Day hours	*ghaṭīs*
6b	Geographical gazetteer 2		
7a	Plate of horizons		
7b	'Back of the astrolabe'		

The engravings on these plates are not uniform. On the plates calibrated to different latitudes, altitude circles are drawn for every 6° and azimuth arcs are traced for every 10°.

In the lower half, lines for seasonal hours are drawn on all plates; these are numbered from the western horizon onwards from 1 to 12 in *Abjad* notation. Lines for equal hours are varied; these are drawn from the western horizon on some plates and from both horizons on other plates, numbered in *Abjad* on some and in common numerals on others. In the middle of the plates are mentioned the latitudes; the duration of the longest day is stated in hours on most plates, but in four cases also in *ghaṭīs.*

The plate of ecliptic coordinates on plate 5b is engraved with latitude circles for every 6°and longitude circles for every 10°. The ecliptic circle is divided and labelled for each zodiac sign and for each 10°. In the lower half is the label *ṣafīḥat mīzān al-ᶜankabūt.*

The plate of horizons on plate 7a carries four sets of half horizons, together with the declination scales, but no label.

GEOGRAPHICAL GAZETTEER 1

On the inner surface of the mater is engraved a geographical gazetteer in two circles, providing the names, longitudes, latitudes, *inḥirāf* and *jihat* of 46 localities. The gazetteer is nicely arranged with empty spaces enclosed in double lines outside the outer circle, between the two circles and inside the inner circle. The gazetteer commences from Mecca and reaches up to Qandahār. Multān is the only locality from the Indian-subcontinent. It will be shown below that Gazetteer 2 is copied from the Indo-Persian astrolabe A104. Is the present gazetteer then copied from a non-Indian astrolabe? The

engravings in the column of *al-jihat* to indicate the direction in which Mecca is situated are very confusing; here no names of cardinal directions are given, but *Abjad* symbols for the numbers 63 (three times), 360 (once) and 73 (in the rest of the entries)!



Figure B018.3 – Geographical Gazetteer 1 (photo by S. R. Sarma)

Table B018-3 Geographical Gazetteer 1

	Place Names (*al-bilād*)	**L (*al-ṭūl*)**	**φ (*al-ʿarḍ*)**	***al-inḥirāf***	***al-jihat***
	Outer Circle				
1	Makka	77;10	21;40	0;0	0;0
2	Madāna	75;0	25;0	34/37;10	63

	Place Names (*al-bilād*)	**L (*al-ṭūl*)**	**φ (*al-ᶜarḍ*)**	***al-inḥirāf***	***al-jihat***
3	Qayrawān	41;0	31;40	81;47	63
4	Miṣr	63;20	30;20	38;38	63
5	Ṣanᶜā’	77;0	14;30	1;15	360?
6	Laḥsā	43;30	24;0	69;30	73
7	Bayt al-Maqdis	66;30	31;50	45;16	?
8	Dimashq	70;0	33;15	30;5	73
9	Ḥalab	72;10	35;50	18;29	73
10	Mawṣil	87;0	35;30	13;52	73
11	Ardabīl	82;30	38;0	14;13	73
12	Nakhjawān	80;14	38;40	14;15	73
13	Marāgha	82;0	37;20	16;14	73
14	Tabrīz	82; ?	38;0	15;40	73
15	Sardagharī?	79;0	34;0	2;16	73
16	Baghdād	80;0	33;25	12;15	73
17	Wāsit	80;30	32;20	20;14	73
18	Baṣra	84;0	30;0	17;19	73
19	Tustār	84;30	31;30	35;24	73
20	Ahwāz	85;0	31;0	40;30	73
21	Kāzirūn	87;0	29;15	51;14	73
22	Shīrāz	88;0	29;36	13;18	73
23	Yazd	89;0	32;0	48;29	73
24	Hamadān	83;0	35;10	22;17	73
25	Qazwīn	85;0	36;0	17;14	73

	Place Names (*al-bilād*)	**L (*al-ṭūl*)**	**φ (*al-ʿarḍ*)**	***al-inḥirāf***	***al-jihat***
26	Iṣfahān	86;40	32;25	40;28	73
27	Kāshān	86;0	34;0	34;31	73
28	Rayy	86;20	34;0	36;26	73
29	Ṭāliqān	85;45	36;10	25;33	73
30	Astarābād	89;35	36;50	38;48	73
31	Jurbādaqān	85;30	34;15	38;41	73
	Inner Circle				
32	Ṭūs	92;30	37;0	45;6	73
33	Nayshābūr	92;30	36;21	76;25	73
34	Sabzawār	84;30	40;50	20;9	73
35	Turshīz	92;0	35;0	48;11	73
36	Samnān	88;0	36;0	16;14	73
37	Dāmghān	88;55	36;20	38;0	73
38	Tūn	92;30	34;30	50;20	73
39	Qā’īn	93;20	33;40	14;1	73
40	Marw	97;0	37;40	12;30	73
41	Badakhshān	84;25	37;10	64;9	73
42	Kābul	84;40	34;16	69;16	73
43	Harāt	94;20	34;30	14;8	73
44	Kirmān	92;30	29;50	60;51	73
45	Multān	87;35	29;40	80;48	73
46	Qandahār	87;40	33;0	75;5	73

GEOGRAPHICAL GAZETTEER 2

On plate 6b is another geographical gazetteer in three circles, providing the names, longitudes and latitudes of 76 localities, arranged according to climates. This is an exact copy of plate 7b of astrolabe A104 (see Figure A104.6 and Table A104-4), with the minor difference that here one place is omitted, namely Panipat after Hansi (33).



Figure B018.4 – Plate 6b with Geographical Gazetteer 2 (photo by S. R. Sarma)

Table B018-4 Geographical Gazetteer 2

Place Names (*al-buldān*)	L (*al-ṭūl*)	φ (*al-ᶜarḍ*)
Outer Circle		

	Place Names (*al-buldān*)	L (*al-ṭūl*)	φ (*al-ᶜarḍ*)
[-I] *az khaṭṭ istiwā tā iqlīm awwal* (from the line of equator to the first climate)			
1	Jazīrah Qanbulah	21;0	3;0
2	Jamkūt	177;0	5;0
3	Shalā	180;0	5;0
4	ᶜĀna	39;0	10;0
5	ᶜAdan	77;0	11;0
6	Sarāndīp	130;0	10;0
[I] *mabdā iqlīm awwal 12;48* (beginning of the first climate [at latitude] 12;48°)			
7	Jabil	77;0	13;30
8	Janad	77;30	14;30
9	Janīr	110;5	19;48
10	Burhānpūr	113;41	20;30
11	Tāna	114;5/104	19;20
12	Juyūl	106;40	19;0
13	Bīzābūr	115;30	17;20
14	Dawlatābād	111;5	20;30
[II] *mabdā iqlīm dūyum 20;31* (beginning of the second climate [at latitude] 20;31°)			
15	Tā'if	77;30	21;20
16	Makka Musharraf	77;10	21;40
17	Madīnat Tayyiba	75;20	25;0
18	Hurmūz	92;0	25;0

	Place Names (*al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-^{c}arḍ*)**	
19	Akbarābād	114;0	26;43	
20	Qannawj	115;50	26;35	
21	Ajmīr	111;5	26;0	
22	Kawāliyar	130;0	26;29	read 114;0
23	Lakhnaū’	114;13	26;30	
24	Jawnbūr	119;6	36;36 !	read 26;36
25	Awadh	118;6	27;22	
26	Badā’ūn	119;19	27;32	
27	Banāras	117;20	26;55	
28	Aḥmadābād	108;40	23;15	
29	Kanbāyat	109;20	22;20	
[III] *mabdā iqlīm sīwum 27;34* (beginning of the third climate [at latitude] 27;34°)				
30	Kūlkanda	114;19	28;3!	read 18;3
31	Fīrūzābād	117;30	28;10	
32	Dihlī	113;35	28;39	
33	Hānsī	114;25	29;45	
34	Baran	114;5	28;48	
35	Multān	107;35	29;40	
36	Shīrāz	88;41	29;36	
37	Basra	84;0	30;0	
38	Kirmān	91;30	30;5	
	Middle Circle			
39	Tahnīsar	112;33	30;10	

	Place Names (*al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-ʿarḍ*)**
40	Miṣr	63;20	30;20
41	Sunām	112;25	30;30
42	Parshawar	105;55	31;0
43	Kūfa	79;30	31;30
44	Qayrawān	41;0	31;40
45	Bayt al-Maqdis	63;30	31;50
46	Lāhūr	109;20	31;50
47	Yazd	89;0	34;0
48	Iṣfahān	87;40	32;25
49	Qandahār	107;40	33;0
50	Baghdād	82;0	33;25
[IV] *mabdā iqlīm cahārum 33;43* (beginning of the fourth climate [at latitude] 33;43°)			
51	Kāshān	86;0	34;0
52	Harāt	94;20	34;30
53	Sāwa	85;0	35;0
54	Kashmīr	108;0	35;0
55	Ḥalab	72;10	35;50
56	Mashhad	92;30	36;0
57	Balkh	101;0	36;11
58	Mar[ā]gha	82;0	37;20
[V] *mabdā iqlīm panjum 39;1* (beginning of the fifth climate [at latitude] 39;1°)			
59	Samarqand	99;16	39;37

	Place Names (*al-buldān*)	**L (*al-ṭūl*)**	**φ (*al-^{c}arḍ*)**
60	Bukhārā	97;30	39;50
61	Tubbat	110;0	40;0
	Inner Circle		
62	Khutan	107;0	42;0
63	Farghāna	102;0	42;0
64	Īlāq	99;45	43;20
65	Khujand	97;45	43;30
[VI] *mabdā iqlīm shashum 43;30* (beginning of the sixth climate [at latitude] 43;30°)			
66	Kāshghar	106;30	44;0
67	Alān	43;0	44;0
68	Bīsh Bāligh	111;0	45;50
69	Khān Bāligh	124;46	46;0
70	Harqalah	67;20	46;30
[VII] *mabdā iqlīm haftum 47;30* (beginning of the seventh climate [at latitude] 47;30°)			
71	Araq	105;0	48;0
72	Aklah	88;0	49;0
73	Qirqir	65;30	50
[+VII] *khāriz iqlīm haftum* (beyond the seventh climate)			
74	Marīkirmān	64;45	50;40
75	Jazīrah Fard	---	64;41
76	Ṣūdāq	66;0	51;0

Plate 7b

Plate 7b is the most unusual in that it is designed as the back of the astrolabe. It is an almost exact copy of plate 7b of astrolabe A104 (see Figure A104.7). In A104, the main body consists just of the thick limb and the *kursī* and there is no solid back. Therefore, plate 7b can be used as the back of the astrolabe. But in the present astrolabe, there is a solid back and this plate cannot be used at all for observation.

In the plate of A104, in the upper right quadrant, three sigmoid graphs are drawn for the latitudes 19°, 27° and 32°. Here, there are no graphs, but just the numbers 19, 27 and 32!



Figure B018.5 – Plate 7b (photo by S. R. Sarma)

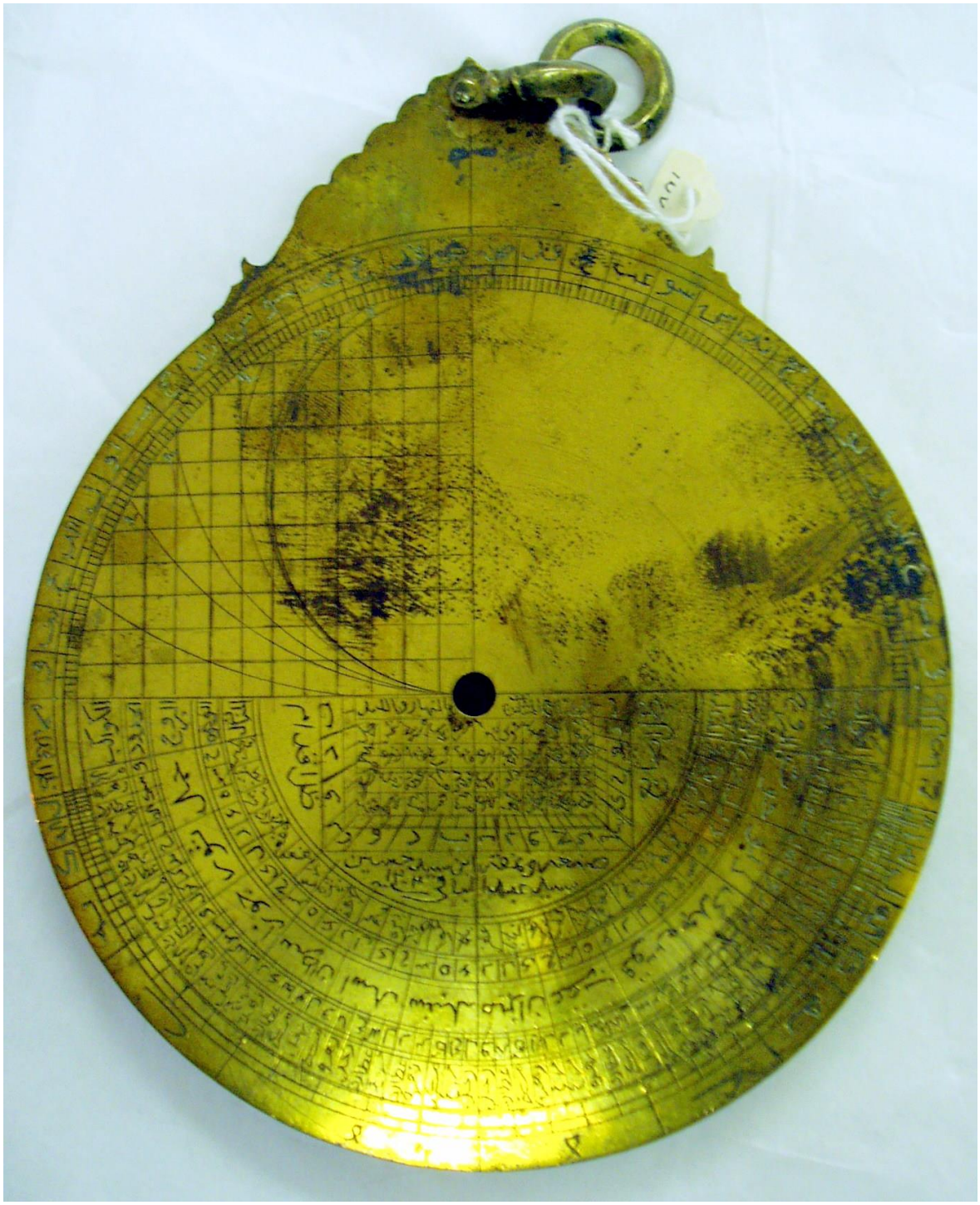


Figure B018.6 – Back of the astrolabe (photo by S. R. Sarma)

BACK

The upper half of the rim is divided in 1° and 6° and numbered in *Abjad* as 6—90; 90—6. In the upper left a universal horary quadrant is engraved. The six lines of unequal hours which are spread out from the horizontal radius to the vertical radius are numbered from 1 to 6 in common Arabic/Persian numerals. The upper right quadrant is empty.

The lower half of the rim bears the cotangent scales and their subdivisions. The scale on the left is in feet; the unequal divisions are numbered clockwise from the vertical diameter as 5, 10, 15, 20, 25, 30, followed by the label *ẓill aqdām* (shadows in feet).

The scale on the right is in digits; the unequal divisions are numbered anticlockwise from the vertical diameter as 5, 10, 15, 20, 25, 30, 35, 40, 45, followed by the label *ẓill aṣābiᶜ* (shadows in digits). Inside the cotangent scales, there are five semi-circular rows.

Row 1 carries the names of the 28 lunar mansions; on both sides of the row is the heading *al-kawākib* (the stars).

Row 3 is filled with the names of the 12 zodiac signs with the heading *al-burūj* (the signs) on both sides.

Row 2 carries the heading *al-ḥudūd* (the limits) on both sides; the space corresponding to each sign is divided into five cells and in these cells are engraved the numerical values of the five limits of each planet, in cumulative manner, that is to say, that in each cell the numerical strength of each limit plus the strengths of the preceding limits are written, so that the value in the fifth cell is always 30; these values are written in *Abjad* notation. The names of the respective planetary regents of these limits are engraved in full in row 5.

Row 4 is filled with *al-wujūh* (the decans or faces); here the space corresponding to each sign is divided into three cells. Since the numerical value of these parts is always the same (10, 20, 30), the cells are filled with the names of the planetary regents, denoted by the symbolic letters.

Inside these astrological tables are the shadow squares, on the left for a base of 7 and on the right for a base 12. Only the vertical scales are given labels: on the left *ẓill aqdām* and on the right *ẓill aṣābiᶜ*.

Within the shadow squares is the rectangular table of triplicities, their diurnal and nocturnal planetary regents.

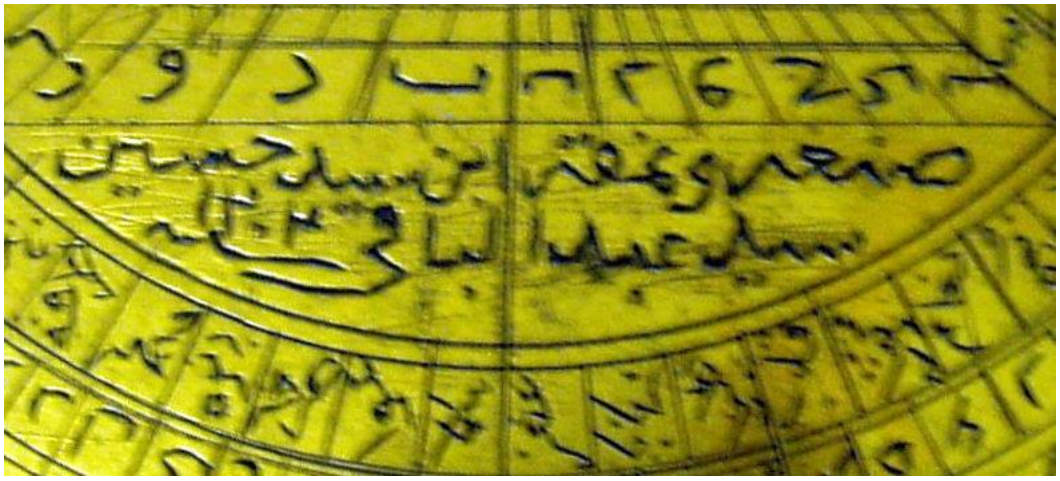


Figure B018.7 – Signature of the astrolabe maker

INSCRIPTION

In the space between the shadow squares and the semi-circular astrological tables is engraved the astrolabe maker's signature as follows:

> *ṣanᶜah wa nummaqah sayyid ᶜabd al-bāqī ibn sayyid ḥussayn sanah 1204*
>
> 'Made and decorated by Sayyid ᶜAbd al-Bāqī ibn Sayyid Ḥussayn [in] the year 1204 [Hijrī = AD 1789-90].'

PROVENANCE

Formerly in the Henri Michel collection, Brussels.

B019⊙ ASTROLATE ATTRIBUTABLE TO SAYYID ᶜABD AL-BĀQĪ IBN SAYYID ḤUSAIN

Not dated, 18th century

Diameter 162 mm

Oxford, Museum of the History of Science (# 47063)



Figure B019.1 – Front of the astrolabe (photo by S. R. Sarma)

There are certain similarities between B018 and this astrolabe in the workmanship, in the design of the rete, in the arrangement of the geographical gazetteer and in the

configuration on the back; therefore, this astrolabe may be attributed to Sayyid cAdb al-Bāqī, the maker of B018.

Even so, there are some inconsistencies in this astrolabe. The limb on the front and the alidade are numbered in 5s, but the rim on the back is labelled in 6s. In the rete, some northern stars are placed outside the ecliptic ring and some southern stars inside the ecliptic ring. While the front side of the solid kursī is blank, the reverse side displays what looks like a European coat of arms with several crosses, surrounded by a floral design.

Components

Body with *kursī* (d. 162, h. 215, t. 10), ring and shackle, rete (d. 143) for 29 stars, 5 plates (d. 143), alidade (length 146), pin, horse and washer.

Front

The ring and shackle are well-crafted; they have diamond cross-sections with sharp edges. The shackle has ornate bases. The *kursī* is solid; it is very wide at the base and the profiles are made up of ogees at the base followed by lobes. The limb is divided in 1° and 5° and numbered in 5s clockwise from 5 to 360.

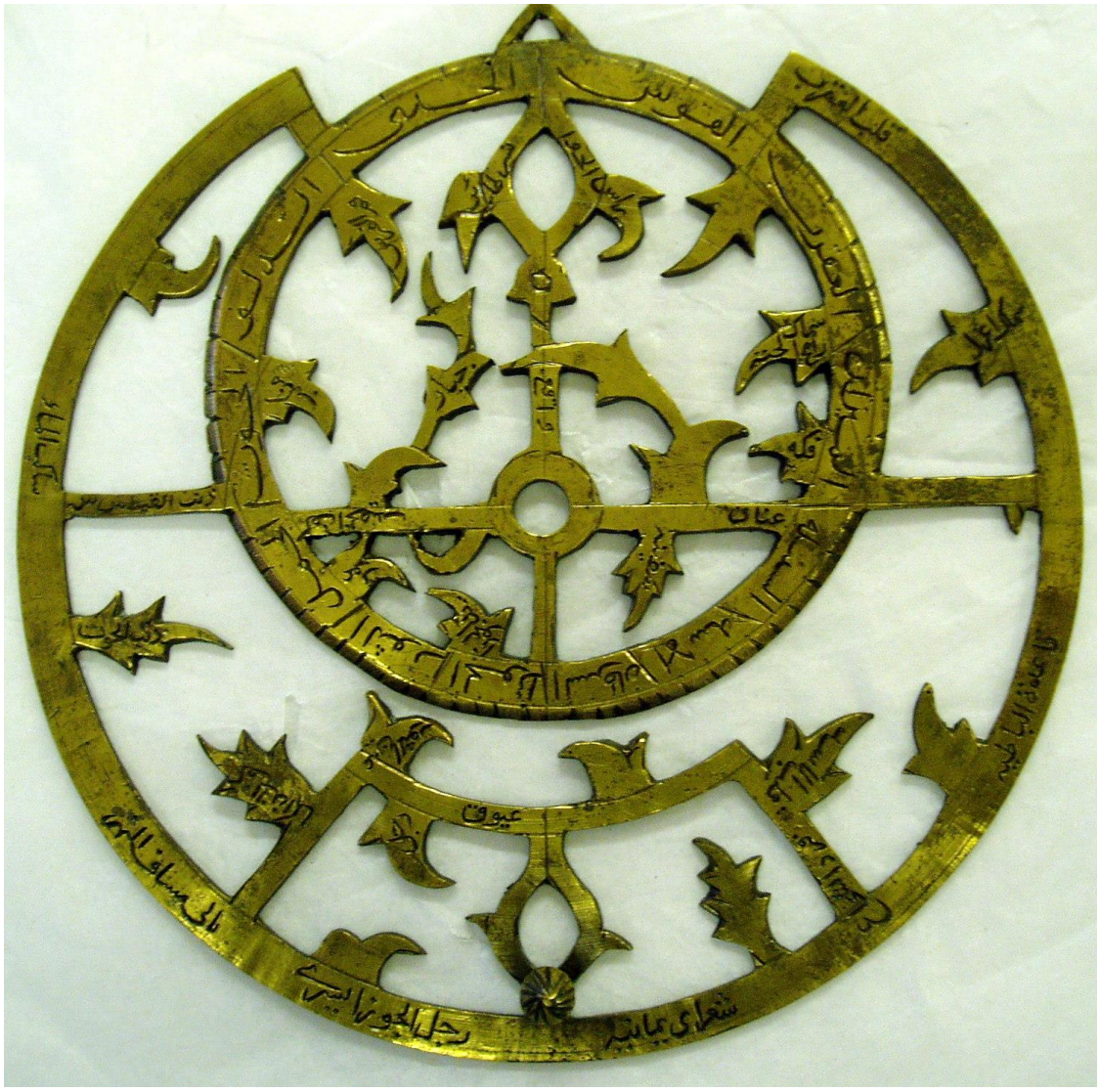


Figure B019.2 – Rete of the astrolabe (photo by S. R. Sarma)

RETE

In the rete, the two rings of Capricorn and ecliptic are held together by the equinoctial bar with counter changes at the equinoxes. A small segment of the equator ring is incorporated below the ecliptic ring in the north. It is joined to the main frame by two transversal bars. The ecliptic ring is divided in 12 signs of the zodiac and is engraved with their names. Each sign is divided in 5 parts on the edge of the ring, but these are not numbered. Just above the north point is an ornate knob to rotate the rete. It is shaped like a serrated cone, exactly in the same manner as the head of the pin. A triangular arch functions as the Capricorn index. There are 28 dagger-shaped star pointers. Some are given wrong names and some are positioned at wrong places; such stars are marked with an asterisk*.

Table B019-1 Stars on the Rete

	Star Name	Identification
1	*Kaff al-Khaḍīb**	β Cassiopeiae
2	*Dhanab al-Ḥūt** should be *Dhanab al-Qayṭus Janūbī*	β Ceti
3	*Kaff al-Jadhmā*	α Persei
4	*Ghūl*	β Persei
5	*Tālī Masāfat al-Nahr*	γ Eridani no pointer
6	*Yad al-Jawzā'**	γ or α Orionis placed inside the ecliptic
7	*ᶜAyn al-Thawr*	α Tauri
8	*Rijl*	κ Orionis
9	*ᶜAyyūq**	α Orionis placed outside the ecliptic
10	*Rijl al-Jawzā' al-Yusrā*	β Orionis
11	*Shiᶜrā Yamānī*	α Canis Majoris
12	*Safīna**	α Carinae placed inside the ecliptic
13	*Fard al-Shujāᶜ*	α Hydrae
14	*Qalb al-Asad*	α Lionis
15	*ᶜAnāq*	ζ Ursae Majoris
16	*Qāᶜidat al-Bāṭiya*	α Crateris
17	*Simāk Aᶜzal*	α Virginis
18	*Fakkā*	α Coronae Borealis
19	*Simāk Rāmiḥ*	α Bootis
20	*[ᶜUnuq] al-Ḥayyah* ?	α Serpentis
21	*Qalb al-ᶜAqrab*	α Scorpii

	Star Name	Identification
22	*Rās al-Ḥawwā*	α Ophiuchi
23	*Wāqiᶜ*	α Lyrae
24	*Nasr Ṭā'ir*	α Aquilae
25	*Fam al-Faras**	ε Pegasi
26	*Jabbār*	??
27	*Mankib [Sākib al-Mā']*	α Aquarii
28	*Sāq [Sākib] al-Mā'*	δ Aquarii
29	*Dhanab al-Qayṭus Sh[amālī]*	ι Ceti

PLATES

There are five plates with the following particulars.

Table B019-2 Plates

	φ	Longest Day
1a	24°	13;38 hours
1b	33°	14;39 hours
2a	23°	13;25 hours
2b	19°+21°	12;53 hours + 13;0 hours
3a	31;30°	14;8 hours
3b	36°+39°	14;30 hours + 15;0 hours
4a	25°	15;32 hours !
4b	26°+28°	13;10 hours + 13;50 hours
5a	35°	14;40 hours
5b	Plate of horizons	

φ	Longest Day

On these plates are drawn altitudes circles are for every 6° and the lines for seasonal hours; both these sets are numbered. There are no azimuth arcs and lines for seasonal hours on any plate. On the three plates which bear combined projections for two latitudes each, there are only altitude circles for every 6°, but no other lines.



Figure B019.3 – Plate for latitudes 19° and 21° (photo by S. R. Sarma)

Plates 2-5 have notches at the north and south points. The plate of horizons should have actually notches at each of the compass points, but here it has only two notches as the others. The limb of the astrolabe has a tooth at the south point which fits into these notches.

Below the oblique horizon are engraved the labels *mashriq* in the east and *maghrib* in the west. At the middle of the plate are mentioned the latitude and the hours of the longest day, both in *Abjad.* On plates with double projections, there values are engraved on the rim.

GEOGRAPHICAL GAZETTEER

The geographical gazetteer is engraved very neatly in two circles with empty spaces outside the outer circle, between the two circles, and inside the inner circle. This gives a very balanced look to the gazetteer. The 50 localities are arranged roughly by the longitude, starting from Egypt and reaching up to India.



Figure B019.4 – Geographical Gazetteer (photo by S. R. Sarma)

Table B019-3 Geographical Gazetteer

	Place Names (*al-bilād*)	**L (*al-ṭūl*)**	**φ (*al-^{a}arḍ*)**
	Outer Circle		
1	Miṣr	63;20	30;20
2	^{c}Adan	76;0	11;0

	Place Names (***al-bilād***)	**L** (***al-ṭūl***)	**φ** (***al-ᵃarḍ***)
3	Madīnat Rasūl ᶜAlayhi al-Salām	75;20	25;0
4	Makka Muᶜaẓẓam	77;10	21;40
5	Tā'if	77;30	21;20
6	Bayt al-Maqdis	66;30	31;50
7	Dimashq	70;0	33;35
8	Ḥalab	72;10	35;50
9	Nakhjawān	81;15	38;40
10	Tabrīz	82;0	38;0
11	Bardᶜah	83;0	40;30
12	Bulghār	90;0	49;30
13	Kūfa	79;30	31;30
14	Madā'īn	72;0	33;10
15	Baghdād	80;0	33;25
16	Baṣra	84;0	30;0
17	Fīrūzābād	84;30	38;10
18	Shīrāz	83;0	29;36
19	Yazd	89;0	22;40 !
20	Hamadān	83;0	35;10
21	Ṣāwa	85;0	35;0
22	Qazwīn	85;0	36;0
23	Iṣfahān	86;40	32;25
24	Kāshān	86;0	34;0
25	Qumm	85;40	34;45

	Place Names (*al-bilād*)	L (*al-ṭūl*)	φ (*al-ᵃarḍ*)
26	Rayy	86;20	35;0
27	Astarābād	89;35	36;50
28	Sabzawār	89;35	36;50
29	Nayshābūr	92;30	36;21
30	Ṭūs	92;30	37;0
31	Harāt	94;20	34;30
	Inner Circle		
32	Balkh	101;0	36;41
33	Badakhshān	104;24	37;10
34	Bukhārā	92;30	35;50
35	Samarqand	99;16	39;37
36	Khujand	100;35	41;55
37	Kāshghar	106;30	44;0
38	Khutan	107;0	42;0
39	Hurmūz	102;0	24;0
40	Kābul	104;40	35;0
41	Kashmīr	108;0	35;0
42	Tibbat	110;0	40;0
43	Qandahār	107;40	43;0
44	Multān	107;35	29;40
45	Lahāwar	109;20	31;50
46	Ḥaḍrat Dihlī	113;35	28;0 !
47	Akra	115;0	24;13 !
48	Aḥmadābād	108;40	23;15

	Place Names (***al-bilād***)	**L** (***al-ṭūl***)	**φ** (***al-ᵃarḍ***)
49	Sarāndīp	130;0	10;0
50	Kanbayāt	109;20	22;20

BACK

On the back, the upper half of the rim is divided in 1° and 6°, but the lower half only in 6°. Both halves are numbered as 6—90; 90—6; 6—90; 90—6.

In the upper left quadrant are drawn 30 vertical lines and 30 horizontal lines; in the upper right quadrant there are 60 declination circles and radial lines from the centre to the arc at every 6°. Very unusually, the lower left quadrant is filled with 24 vertical lines. The arrangement on the back resembles to a certain extent plate 7b in B018 (see Figure B018.5).



Figure B019.5 – Back of the astrolabe (photo by S. R. Sarma)

In the lower right quadrant are drawn two shadow squares, one inside the other; the outer one is for a base of 12 and the inner one for a base of 7. The vertical and horizontal scales in the inner square are divided in 7 parts and numbered from 1 to 7.

The vertical scale is labelled as *aqdām maᶜkūs* and the horizontal scale *aqdām mustawī.* The vertical and horizontal scales in the outer square are divided in 12 parts and numbered from 1 to 12. The vertical scale is labelled as *aṣābiᶜ maᶜkūs* and the horizontal scale *aṣābiᶜ mustawī.*

Within the shadow squares a grid of quarter circles is traced but not filled in.



Figure B019.6 – Back of the *kursī* (detail of Figure B019.5)

While the front of the *kursī* is blank, the reverse is engraved with a cartouche surrounded by floral motifs. Inside the cartouche is a kind of European coat of arms with many crosses. It is difficult to say whether this coat of arms was engraved because the astrolabe was made for a European nobleman or whether the coat of arms was added at a later point of time.

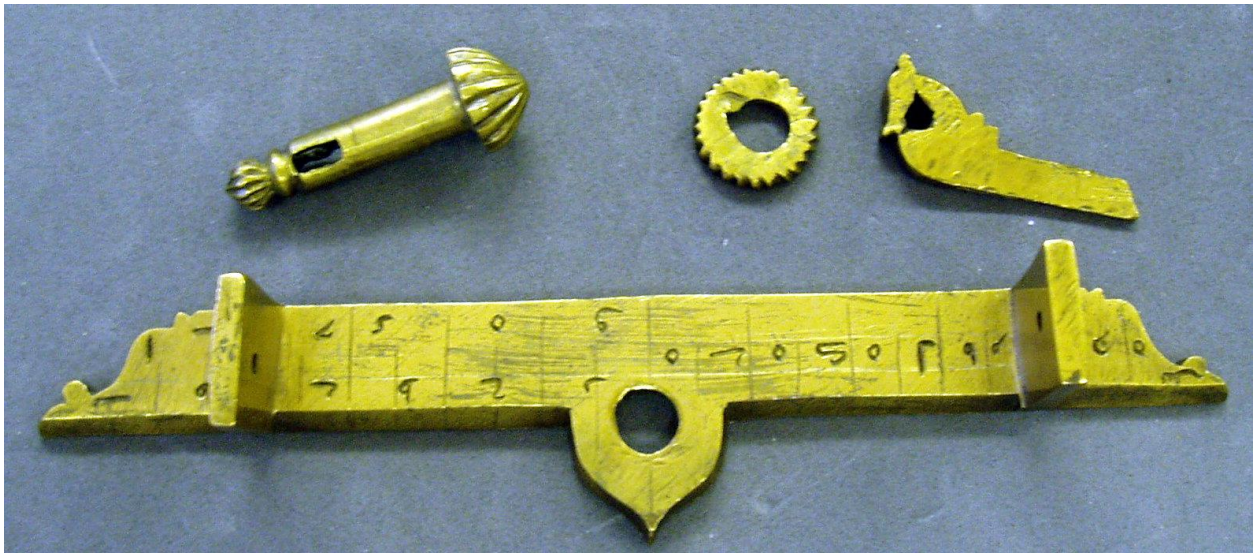


Figure B019.7 – Alidade, pin, washer and horse (photo by S. R. Sarma)

ALIDADE

The alidade has ornate ends and an ornate centre-piece. There is no graduated sloped edge. The left-hand side of the alidade is divided in 12 parts and numbered from the centre onwards as 5, 10, 5, … 50, 5, 60. The left-hand side is marked with the numbers of seasonal hours from 1 to 6 and, in the reverse direction, from 7 to 12. These markings are of use when the alidade is employed as a sundial.

The two ends of the pin are artistically fashioned. The wedge is fashioned as a horse with a bent head.

B020 ASTROLABE BY AḤMAD, 1228 AH (AD 1813)

Diameter 63 mm

PLU, ex-PC of W. S. W. Vaux in 1856

CCA 84

In his *Description of the Persian Astrolabe constructed for Shah Husain Safavi* of 1856, William H. Morley describes the following astrolabe under *E.* This is clearly an Indo-Persian astrolabe, for half of the 22 localities listed in the geographical gazetteer are Indian.

COMPONENTS

Body with *kursī* (d. 60), rete, 7 plates, alidade, pin and horse; shackle and ring are wanting.

FRONT

On the front of the *kursī,* the throne verse from the Qur'ān is engraved. The limb is divided in 1° and 6° and numbered in 6s clockwise from 6 to 90, separately in each quadrant.

RETE

In the rete the ecliptic ring is divided into the 12 signs of the zodiac and each sign into 5 parts. No star names are engraved on the star pointers.

PLATES

There are seven plates.

Table B020-1 Plates

	φ	Longest Day
1a	21°	
1b	24°	
2a	(24°)	
2b	29°	13;12 hours
3a	30°	

	φ	Longest Day
3b	32°	14;4 hours
4a	34°	
4b	36°	14;32 hours
5a	40°	15 hours
5b	(25°)	
6a	(42°)	
6b	0°	
7a	Plate of ecliptic coordinates	
7b	Plate of horizons	

The first four plates are engraved with altitude circles for every 6°, azimuth arcs for every 15° and lines for equal and unequal hours. Azimuth arcs for every 30° are drawn both above and below the horizon; the rest only below the horizon. On some plates the latitude is not mentioned and some others the hours of the longest day are omitted.

GEOGRAPHICAL GAZETTEER

In the gazetteer are engraved the names, longitudes and latitudes of 22 localities in two circles.[624]

Table B020-2 Geographical Gazetteer

	Place Names	L	φ
	Outer Circle		
1	Miṣr	63;20	30;20

624 As in the case of B010, here also Morley seems to read the gazetteer from left to right. We read it from right to left.

	Place Names	L	φ
2	Bayt al-Maqdis	66;30	31;50
3	Madīnat Munawwara	75;20	25;15
4	Makka Muᶜaẓẓam	77;10	21;40
5	Dimashq	70[625]	33;15
6	Kūfa	79;34	31;30
7	Baṣra	87	30
8	Baghdād	80	33;25
9	Shīrāz	88	29;36
10	Iṣfahān	86;40	32;25
11	Ardabīl	82;7	38;3
	Inner Circle		
12	Dihlī	113;35	25;11
13	Tubbat	110	40
14	Kashmīr	108	35
15	Kābul	104;40	34;30
16	Lāhūr	109;20	31;50
17	Banāras	117;20	28;16
18	Qannawj	115;50	26;35
19	Burhānpūr	109	20;34
20	Aḥmadābād	108;40	20;15
21	Bījāpūr	125	20
22	Kawāliyar	114	26;29

625 The gazetteer does not seem to have marked the zeros.

BACK

On the back, there are altitude scales on the upper half of the rim, a trigonometric quadrant in the upper left and a solar quadrant on the upper right. In the lower half, shadow squares are drawn below the horizontal diameter with the usual labels and the cotangent scales on the rim, on the left divided in digits and on the right divided in feet.[626]

INSCRIPTION

Round the outer edge of the main body of the instrument are the following verse, recording the date of the construction of the Astrolabe, and the names of its maker and his patron.

> ‘The sphere of sovereignty Sultan Muhammad,
> When did the world ever behold such a brave lion?
> Since how long has an Aristotle existed in his time,
> That this one should be superior to the mirror of Jamshed?
> When Ahmad its maker asked its year (of construction)
> The Lord of the age said the “The Balance of the Sun”.

‘The last words ميزان خورشيد, *the Balance of the Sun,* form a chronogram, and the numerical values of the letters, according to Abjad, being added together, make up the number 1228, the year of the Hijrah when the Astrolabe was constructed (A.D. 1813). […] ‘I have not been able to ascertain who the Sultan Muhammad alluded to actually was. More than one of the chieftains who alternately rose to almost sovereign power in Afghanistan and Kashmir, about the year 1813, bore that name […].’

PROVENANCE

In 1856, this astrolabe was in the private collection of W. S. W. Vaux; its present location is not known.

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626 Morley 1856 remarks that this is ‘contrary to the usual practice’, but no such convention was observed in Indo-Persian astrolabes.

BIBLIOGRAPHY

Morley 1856, pp. 39-41; plate xx, Fig. 18 (plate for latitude 0°); plate xxi, Fig. 28 (the two upper quadrants on the back); Figs. 45 and 52 (alidade, pin and horse).

Gunther 1932, no. 84, p. 215

LĀLAH BULHOMAL LĀHORĪ

While there had been a hiatus in the production of astronomical instruments at Lahore in the eighteenth century, it was Lālah Bulhomal Lāhorī (*fl.* 1839-1851) who revived it in the nineteenth century. He can be regarded as the true and the last representative of both the Indo-Persian and the Sanskrit traditions of astronomical instrumentation. He produced well-crafted astrolabes and celestial globes with inscriptions and legends either in Arabic-Persian or in Sanskrit. He fashioned *Dhruvabhrama-yantras* and *Turīya-yantras* of Sanskrit tradition. He also created some new Sanskrit instruments of his own. His oeuvre consists of about twenty-eight instruments of excellent workmanship belonging to eleven different varieties. Nine of these instruments bear his signature and were produced between the years 1839 and 1851. Nineteen other instruments do not carry his signature, but because of their close similarity to the signed pieces, they too can be attributed to Bulhomal. In 1839 itself he produced at least four instruments of three different types. At this rate of production, he may have produced many more instruments than the 28 which are extant. No instrument maker in India is known to have produced as many varieties of instruments as Bulhomal did, that too with labels in three different languages.[627]

His name is rather problematic. On the Indo-Persian instruments, he signs his name as *b.l.h.w.m.l* (بلهومل) without any diacritics. Luckily, the vowels can be gleaned from the Sanskrit instruments. In a *Dhruvabhrama-yantra* made in 1839-40, his name appears, in its Sanskritized form, as *bulhomalla* (बुल्होमल्ल) and in an undated horary quadrant as *vulhomalla* (वुल्होमल्ल). In a celestial globe made in 1839, there is a different suffix *vuhlovarmmā* (वुह्लोवर्म्मा). Since in many parts of north India, one writes *va* (व) but pronounces it as *ba* (ब), the first syllable in the name should be definitely *bu* (बु), the second *lho* (ल्हो) and the suffix without Sanskritization *mal* (मल). Thus he must have pronounced his name as 'Bulhomal' (बुल्होमल). I am informed that such names are not prevalent today either in Amritsar or in Lahore. Even so it would be proper to spell his

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627 For a detailed discussion of his entire oeuvre, see Sarma 2015b.

name in a manner that corresponds both to the Persian and Devanagari forms he used on his instruments.

Bulhomal was attached to the court of Nihal Singh Ahluwalia, the Raja of Kapurthala from 1837 to 1852, for whom he fashioned some astrolabes and globes. It is probably at this court that he came in contact with Sir Henry Miers Elliot (1808-1853) for whom he made a very elegant Indo-Persian astrolabe in 1849 (B021). As the Foreign Secretary to the colonial Government, Elliot was negotiating at that time the treaty of annexation of Panjab with the Sikh princes.[628]

Bulhomal was not a mere metal worker specialising in astronomical instruments, but also a scholar well-versed in Persian as well as in Sanskrit. On some Indo-Persian astrolabes and globes he engraved very long florid inscriptions in Persian referring to himself as *Lālah Bulhomal Lāhorī Munajjim wa Muhandis* ('astronomer/astrologer and geometrician/engineer'). On five Sanskrit instruments he signs his name in pretty verses, laying emphasis on his devotion to and Śiva and Pārvatī.[629]

Instead of the conventional *Abjad* notation, he employs the common Arabic/Persian numerals. The degree scale on the limb is invariably divided in 1° and 6° and the groups of 6° are numbered serially from 1 to 60. This is the general practice in Sanskrit astrolabes, because 60 parts of the limb corresponds to the 60 *ghaṭīs,* the time units in which the day-and-night is divided in traditional India. He mentions the years of completion generally in Vikrama Saṃvat and in Christian era, sometimes also in the Hijrī era.

Bulhomal developed his own individual style in the design of astrolabes and other instruments. The stylistic peculiarities of the astrolabes are described here; those of the other instruments will be discussed under the respective instruments.

The *kursī* in Bulhomal's astrolabes is small and low, but is elegantly pierced with three perforations. This design of the *kursī* can be treated as his signature, for it occurs frequently and helps to identify the maker even when there is no actual signature.

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628 He is better known for the *History of India, as Told by its Own Historians,* which he conceived and initiated and which was completed after his death by another servant of the Company, John Dawson, in eight volumes. On his life and a critique of his work, see Wahi 1990.

629 The Sanskrit inscriptions are reproduced and translated in Sarma 2010, pp. 91-92.

In the rete, he incorporates a very small number of star pointers, generally 12, in some astrolabe even less. These are shaped like leaves and the delicate tracery of tendrils which connects these star points is nearly the same in all his astrolabes. Like the *kursī,* the rete can also be treated as his signature.

While the members of the Lahore family tried to decorate every part of the astrolabe, they left the sighting plates mounted on the alidade as mere rectangular blocks. But Bulhomal gives them the shape of tulip flowers (see Figure B022.7 and Figure C028.4).

The other features of his astrolabes are as follows. On the latitude plates, he writes the latitudes, but does not mention the hours or *ghaṭīs* of the longest day. The Lahore astrolabes generally contain a plate with one side engraved as the table of ecliptic coordinates and the other side as the plate of horizons. Bulhomal fills both sides with different sets of half-horizons.

Some of his Indo-Persian and Sanskrit astrolabes are without a geographical gazetteer and the inner surface of the mater is left blank. However, in B022 a gazetteer of 57 localities is engraved with the longitudes and latitudes. The same gazetteer is repeated in B024; Bulhomal's pupil Ghulām Qādir of Kapurthala copies the same gazetteer in his B027 and B028. In this gazetteer, the latitude values are more or less accurate, but the longitudes (counted from the Fortunate Isles) are quite erratic; they differ widely from those in Mughal astrolabes. Particularly intriguing is the longitude of London at 70° which would place London on the same longitude as Damascus. One would expect that, with his contacts with of the colonial government, he would have a more accurate knowledge of London's coordinates.

On the back, Bulhomal generally engraves just the sine quadrant, that too on the upper right (as against the upper left in the Lahore astrolabes) and leaves all the other three quadrants empty. The sine quadrant is also engraved on the back of the *Dhruvabhrama-yantras.* In both instruments, it has an almost identical design; the

vertical and horizontal lines are numbered along the two radii as well as along the 13th vertical line and the 13th horizontal line.[630]

According to the Répertoire, B023, B025 and B026 contain astrological tables on the back. But the exact details of these astrological tables are not available. However, on the back of the two Sanskrit astrolabes C028 and C029, there are several astrological tables. These will be discussed in the entry on C028.

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630 Astrolabe B024 does not share all these peculiarities; the patron who commissioned it must have desired a more conventional specimen with *Abjad* notation, astrological tables and so on. However, Bulhomal's pupil, Ghulām Qādir follows his teacher's style in many respects.

B021 ⊙ ASTROLABE MADE BY LĀLAH BULHOMAL LĀHORĪ FOR SIR HENRY ELLIOT, 1849

Diameter 154 mm

London, Science Museum (# 1982-777)

CCA 60; Répertoire 2



Figure B021.1 – Front of the astrolabe (photo by S. R. Sarma)

This astrolabe was produced, as the inscription engraved around the edge of the astrolabe informs, for Sir Henry Elliot of the East India Company, well known for compiling the multivolume *History of India, as Told by its Own Historians*.

Components

Body with *kursī* (d. 154, h. 184, t. 13), shackle, cord, rete (d. 139) for 12 stars, 7 plates (d. 139), alidade (length 140), pin and washer. Ring and horse are missing. A modern ring from a key chain is inserted wrongly. A nail is used in the place of the missing horse.

Front

The main body of the astrolabe carries a small low *kursī* which is elegantly reticulated with three perforations. The finial of the *kursī* is trifoliate, so also the shackle. To the shackle is attached a tassel made of crimson cord of about 180 mm, bound at both ends by gold thread.

The limb is graduated in 1° and 6°. Groups of 6° are numbered serially from 1 to 60 clockwise in common Arabic/Persian numerals.

Rete

In the rete, the Tropic of Capricorn ring and the much broader ecliptic ring are held together by the equinoctial bar which has no counter change. The equatorial ring is represented only in the lower half. The entire space is filled by a delicate tracery of tendrils and leaves. The tendrils hold the segment of the equatorial ring in position. The ecliptic ring is divided into 12 divisions on which the names of the signs of zodiac are engraved. Each sign is divided into units of 6°which are numbered from 6 to 30. These units are further subdivided into single degrees on the sloped edge of the ecliptic ring. Near the north point is a handle to rotate the rete and at the south point is the Capricorn index.



Figure B021.2 – Rete of the astrolabe (photo by S. R. Sarma)

Twelve star pointers are represented by the pointed tips of the leaves, on which the star names are engraved.

Table B021-1 Stars on the Rete

	Star Name	Identification
1	*Rās al-Ghūl*	β Persei
2	*Mirfaq al-Thurayya*	α Persei
3	*Rijl al-Jawzā' [al-Yusrā]*	β Orionis
4	*ᶜAyyūq*	α Aurigae
5	*Yad al-Jawzā' [al-yumnā]*	α Orionis

	Star Name	Identification
6	*Shiᶜrā Yamānī*	α Canis Majoris
7	*Simāk al-Rāmiḥ*	α Bootis
8	*Nayyir al-Fakkah*	α Coronae Borealis
9	*Rās al-Ḥawwā‘*	α Ophiuchi
10	*Nasr Wāqiᶜ*	α Lyrae
11	*Nasr Ṭā’ir*	α Aquilae
12	*Dhanab al-Dajājah*	α Cygni

PLATES

Beneath the rete are seven plates, six of which are designed for latitudes 17° and 20°; 23° and 26°; 29° and 32°; 35° and 38°; 41° and 44°; 47° and 50°. On these six plates, altitude circles are drawn for every 3° and labelled on both sides. Azimuth circles for every 5° are drawn only above the horizon and labelled. In the lower half are lines for unequal hours and dotted lines for equal hours counted from the eastern and western horizons. Below the oblique horizon are engraved *al-maghrib* in the west and *al-mashriq* in the east. At the central part of the plates, the arguments *sāᶜāt* and *ᶜarḍ* are engraved in large bold letters, but only the latitude values are mentioned in much smaller letters and not the hours of the longest duration. In the seventh plate, both the sides of the seventh plate are designed as the plate of horizons.

GEOGRAPHICAL GAZETTEER

The inner surface of the mater is blank; no gazetteer is engraved there.



Figure B021.3 – Back of the astrolabe (photo by S. R. Sarma)

BACK

On the back, the rim is divided in 1° and 6° as in the front, but labelled separately in each quadrant from 6° to 90°, as 6—90; 90—6; 6—90 90—6. A sine-cosine quadrant is engraved in the upper right quadrant with 30 horizontal and 30 vertical equidistant parallel lines. The seventh and the twelfth vertical and horizontal lines are numbered,

starting from the radii as 1, 2, 3, …27/29. Upon this grid is drawn the quarter circle of obliquity. The other three quadrants are blank.

ALIDADE

The alidade is straight without any counter change. The sloping edge is divided into 30 units in both halves. These are numbered in groups of 6 on both sides of the centre, starting from 6 and reaching up to 30. The upright sights are ornate.



Figure B021.4 – Inscription on the edge of the astrolabe (photo by S. R. Sarma)

INSCRIPTION

Around the wide edge is engraved a long inscription in low relief against a hatched background, which reads thus:

ا این اصطرلاب ثلثی معه ربعه مجیب که در پشت آن حجره
مرتسم است برای پیشکش حضور فیض گنجور سرهنری الیت
(ط) صاحب کی سی بی بهادر سکرتر اعظم نواب معلی القاب لارد
کورنر جنرل صاحب بهادر دام اقباله در کپورتهانه [کذا ؟] باهتمام
بلهومل منجم لاهوری معتمد سرکار اهلوالیه مرتب شد سنة
۱۸٤۹ عیسوی

This tripartite (*thulthī*) astrolabe, with the sine quadrant (*rubaʿ mujayyab*) [on the back] and the limb (*ḥajra*) beneath it, was made with care as a gift (*payshkash*) to the honourable Sir Henry Elliot, K. C. B., Chief Secretary of His Lordship the Governor-General, by Bulhomal, the astronomer

(*munajjim*) of Lahore [who is] attached to the court (*sarkār*) of [Rājā Nihāl Singh] Ahlūwālīya, at Kapūrthala in 1849 of the Christian era. [631]

PROVENANCE

According to Gunther, in 1919, the astrolabe was with the Rev. H. L. Elliot, Gosfield Rectory, Essex; he must be a descendant of Henry Elliot. It was acquired by the Science Museum in 1982.

BIBLIOGRAPHY

Gunther 1932, no. 60, pp. 171-173.

Anderson 1982, no. 129a, p. 35.

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631 The full Persian text is reproduced in the Répertoire along with a French translation.
A translation in English is included in Gunther 1932, p. 171: '*This Sulsi Astrolabe with Mujayyan (Sinus) Quadrant and beneath it the Hajrah, was designed for the Honourable Sir Henry Elliott, K. C. B., Chief Secretary of his Lordship the Governor-General in Kayoorthala (sic!) by Balhoomal, the Astronomer of Lahore in that gentleman's employ, A.D. 1849.*'
This gives the impression that Elliott, as the Chief Secretary of the Governor-General, was stationed in Kapurthala, which was just a minor princely state; the fact is that in 1849 Elliot as 'the Secretary to the Government of India in the Foreign Department' was negotiating with Sikh princes of Panjab the trearty of annexation of Panjab in the British empire. Secondly, Bulhomal was not in 'that gentleman's employ', but was attached to the court of Kapurthala.

B022⊙ ASTROLABE ATTRIBUTABLE TO LĀLAH BULHOMAL LĀHORĪ

Lahore, mid-19th century

Diameter 153 mm

Cologne, PC

Répertoire 4



Figure B022.1 – Front of the astrolabe (photo by Ananda Sarma)

This unsigned astrolabe is identical in all respects — the low openwork *kursī,* the design of the rete and the 12 stars marked on it, the 7 plates and the back— to B021, except that this one has a geographical gazetteer. Interestingly, the same gazetteer occurs in an astrolabe designed by Bulhomal (B024) and in two made by or attributable to Bulhomal's pupil Ghulām Qādir Kapūrthalī B027, B028). Therefore, this astrolabe can be securely attributed to Lālah Bulhomal Lāhorī. Moreover, all the components are extant in this astrolabe, while the ring and wedge are lacking in B021.

Components

Mater (d. 153, h. 184, t. 12), ring, shackle, rete (d. 142) for 12 stars, alidade with a sighting tube, pin, washer, wedge.

Front

The *kursī* is low and small. The profiles and the three large perforations occur uniformly in all astrolabes made by Bulhomal. The *kursī* has a trifoliate finial. The ring is large; the small shackle is plain.

The limb is divided in 1° and 6°; groups of 6° are numbered in common Arabic-Persian numerals clockwise serially from 1 to 60.

Rete

In the rete, the Tropic of Capricorn ring and the much broader ecliptic ring are held together by the equinoctial bar which has no counter change. The equatorial ring is represented only in the lower half. The entire space is filled by a delicate tracery of tendrils and leaves. The tendrils hold the segment of the equatorial ring in position. The Capricorn index is not well defined. At the north point is a handle to rotate the rete, set up on an attractive trifoliate ornament.

The ecliptic ring is divided into 12 divisions on which the names of the signs of zodiac are engraved, starting from the vernal equinox. Each sign is divided into units of 6°which are numbered as 6, 12, 18, 24, 30. These units of 6° are subdivided into single degrees on the sloped edge of the ecliptic ring.



Figure B022.2 – Rete of the astrolabe, with the wedge and washer above (photo by Ananda Sarma)

There are 12 star pointers, represented by the pointed tips of the leaves. The star names are engraved on the leaves.

Table B022-1 Stars on the Rete

	Star Name	Identification
1	*Rās al-Ghūl*	β Persei
2	*Mirfaq al-Thurayya*	α Persei
3	*Rijl al-Jawzā' [al-Yusrā]*	β Orionis
5	*ᶜAyyūq*	α Aurigae
4	*Yad al-Jawzā' Yumnā*	α Orionis

	Star Name	Identification
6	*Shiᶜrā Yamānī*	α Canis Majoris
7	*Simāk al-Rāmiḥ*	α Bootis
8	*Nayyir al-Fakkah*	α Coronae Borealis
9	*Rās al-Ḥawwā*	α Ophiuchi
10	*Nasr Wāqiᶜ*	α Lyrae
11	*Nasr Ṭā'ir*	α Aquilae
12	*Dhanab Dajājah*	α Cygni

PLATES

There are seven plates, the first six of which are designed for latitudes 17° and 20°; 23° and 26°; 29° and 32°; 35° and 38°; 41° and 44°; 47° and 50°. On these the arguments *al-ᶜarḍ* and *al-sāᶜāt* are engraved in large and bold letters, but the actual values of the latitudes are written in small faint numerals. The duration of the longest day is not given at all. Below the horizon is written *al-sharq* in the east and *al-maghrib* in the west, also in large bold letters.

Altitude circles are drawn for every 3° and numbered both to the east and west of the meridian, once making a semi-circle passing through the zenith and another time along the periphery. Azimuth arcs are drawn for every 6°, sometimes above the horizon, sometimes below the horizon and some other times both above and below the horizon. They are numbered along the oblique horizon.

In the lower half, there are lines for seasonal hours and lines for equal hours drawn from the eastern and western horizon; sometimes the latter are dotted. Both sets are numbered from 1 to 12 from the western horizon to the eastern.



Figure B022.3 – Plate for latitude 17° (photo by Ananda Sarma)

There is no plate of ecliptic coordinates. The two sides of the seventh plate carry plates of horizons, where half horizons for each degree of latitude from 14° to 90° are arranged at intervals of 8° in the following manner.

Obverse side:

14	22	30	…	78	86	90
15	23	31	…	79	87	90
16	24	32	…	80	88	90
17	25	33	…	81	89	90

Reverse side:

18	26	34	…	74	82	90
19	27	35	…	75	83	90
20	28	36	…	76	84	90
21	29	37	…	77	85	90

The latitude values are engraved at the beginning of the half horizons near the periphery and at the end along the horizontal or vertical diameters. There are no declination scales.

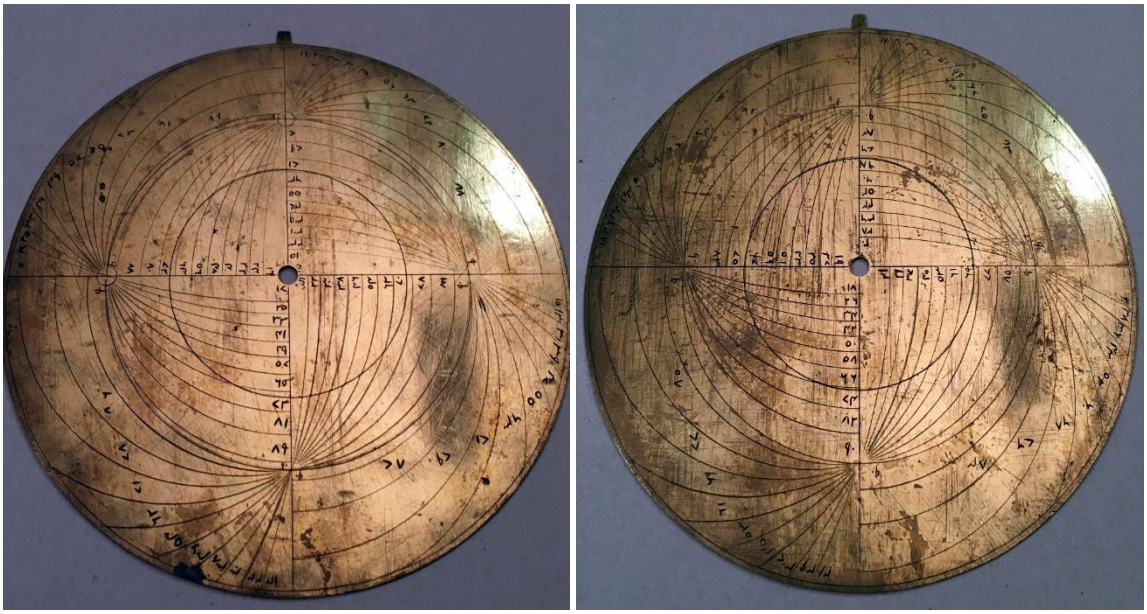


Figure B022.4 – The two sides of the horizon plate (photos by Ananda Sarma)

GEOGRAPHICAL GAZETTEER

On the inner surface of the mater is engraved the geographical gazetteer providing the names, longitudes and latitudes of 57 (19 + 19+ 19) localities in three circles. Each circle contains the same number of entries with the result that the letters become smaller in each successive circle. Zeroes are represented sometimes by small dots and sometimes by an *Abjad* symbol.

Interestingly, the same gazetteer occurs in two other astrolabes which are in the National Museum at New Delhi. One of these is signed by Bulhomal's pupil Ghulām Qādir Kapūrthalī in 1861 (B027); the other is not signed but can be attributed to the same astrolabe maker (B028). In yet another astrolabe which was designed by Bulhomal and fabricated by Pīr Bakhsh in 1841 (B024) and which is with the Lahore Museum, the same gazetteer appears minus three entries. In all these four gazetteers, the latitude values are more or less accurate with the exception of Somnath which receives a very low latitude of 12;0° whereas the actual value is 20;53°. The longitude values (counted from the Fortunate Isles) are quite erratic; they differ widely from those in Mughal astrolabes.



Figure B022.5 – Geographical gazetteer (photo by Ananda Sarma)

Table B022-2 Geographical Gazetteer

	Place Name	L	φ (Modern φ)	Identification[632]
	Outer Circle			
1	Iskandariyya	61;54	30;58 (31;12)	Alexandria, Egypt

632 The following abbreviations are used for the names of the federal states of India: G = Gujarat; HP = Himachal Pradesh; JK = Jammu & Kashmir; M = Maharashtra; P = Panjab; U = Uttarakhand; UP = Uttar Pradesh; WB = West Bengal.

	Place Name	L	φ (Modern φ)	Identification[632]
2	Madinat al-Hikmā	65;40	37;20 (37;58)	Athens, Greece
3	Madinat Rasūl	75;20	25;0 (24;28)	Medina, Saudi Arabia
4	Makka Mubārak	77;10	21;40 (21;25)	Mecca, Saudi Arabia
5	Baṣra	84;0	30;0 (30;30)	Basra, Iraq
6	Balkh	85;20	46;30! (36;45)	Balkh, Afghanistan
7	Iṣfahān	76;4[0]	33;25 (32;38)	Isfahan, Iran
8	Shīrāz	88;0	29;36 (29;37	Shiraz, Iran
9	Hurmuz	92;0	15;0! (27;06)	Hormuz, Iran
10	Tūn	92;30	34;30 (34;01)	Ferdows, Iran
11	Harāt	94;4[0]	34;30 (34;21)	Herat, Afghanistan
12	Bukhārā	97;30	39;50 (39;46)	Bukhara, Uzbekistan
13	Samarqand	99;36	39;37 (39;42)	Samarqand, Uzbekistan
14	Dawlatābād	101;30	20;30 (19;57)	Daulatabad, M, India
15	Ujjayn	102;0	22;30 (23;11)	Ujjain, MP, India
16	Mānsar	102;25	30;10 (25;53)	in Attock district, Pakistan?
17	Badakhshān	104;24	37;10 (37;07)	Faizabad, Afghanistan
18	Kābul	104;40	34;30 (34;320	Kabul, Afghanistan
19	Nurpur	105;15	31;4[0] (32;12)	Nurpur, HP, India[633]
	Middle Circle			
20	Bījāpūr	105;35	20;0 (16;50)	Bijapur, K, India
21	Qannawj	105;55	26;50 (27;03)	Kannauj, UP, India

633 Nurpur, Kangra District, Himachal Pradesh, 32;18 N, 75;54 E.

	Place Name	L	φ (Modern φ)	Identification[632]
22	Sawmnāth	106;10	12;0! (20;53)	Somnath, G, India
23	Kāshghar	106;30	44;0 (39;20)	Kashgar, China
24	Awrangābād	107;27	20;30 (19;53)	Aurangabad, M, India
25	Multān	107;35	29;40 (30;12)	Multan, Pakistan
26	Qandahār	107;40	33;0 (31;37)	Kandahar, Afghanistan
27	Awadh	108;6	22;22 (26;47)	Ayodhya, UP, India
28	Aḥmadābād	108;4[0]	23;55 (23;03)	Ahmedabad, G, India
29	Qashmīr	108;45	35;0 (34;06)	Srinagar, JK, India
30	Kawāliyār	109;0	26;29 (26;14)	Gwalior, MP, India
31	Siyālkūt	109;0	33;0 (32;31)	Sialkot, Pakistan
32	?	109;4[0]	22;20	?
33	Burhānpūr	109;20	2[0];31(21;17)	Burhanpur, MP, India
34	Lāhūr	109;20	31;50 (31;37)	Lahore, Pakistan
35	Tibbat	110;3[0]	40;15 (29;40)	Lhasa, Tibet
36	Shāhjahānābād	113;35	28;39 (28;38)	Delhi, India
37	Mathrā	114;20	27;0 (27;28)	Mathura, UP, India
38	Banāras	117;30	26;55 (25;20)	Varanasi, UP, India
	Inner Circle			
39	Jawnpūr	119;6	26;36 (25;46)	Jaunpur, UP, India
40	Sarandīp	140;0	10;0 (06;56)	Colombo, Srilanka
41	Rayākarh	140;0	27;0	Raigadh[634]
42	Pashāwar	106;35	33;0 (34;02)	Peshawar, Pakistan

634 Raigadh or Raigad may refer to many places with royal forts; the most famous is Raigad in Maharashtra at 18;14 N and 73;26 E.

	Place Name	L	φ (Modern φ)	Identification[632]
43	Pind Dādar Khān	108;5	33;30 (32;35)	Pind Dadar Khan, Pakistan
44	Rāmnakar	108;30	32;30 (32;49)	Ramnagar,[635] JK, India
45	Anbratsar	109;40	31;45 (31;28)	Amritsar, P, India
46	Kapūrthalā	110;20	31;40 (31;23)	Kaputhala, P, India
47	Ludhiyānā	111;11	31;30 (30;91)	Ludhiana, P, India
48	Anbālā	111;50	31;0 (30;23)	Ambala, P, India
49	Hardwār	111;0	31;0 (29;57)	Haridwar, U, India
50	Najībābād	113;15	31;0 (29;38)	Najibabad, UP, India
51	Farkhābād	113;45	31;0 (27;22)	Farrukhabad, UP, India
52	Lakhnaw	114;2[0]	27;0 (26;48)	Lucknow, UP, India
53	Kāyā	14(!);0	24;0 (24;45)	Gaya, Bihar, India
54	Kalkata	124;5	20;20 (22;34)	Kolkata, WB, India
55	Jagannāth	124;0	20;0 (19;49)	Puri, Odissa, India
56	Landan	70;0 !	52;0 (51;30)	London, UK[636]
57	Nakarkūt	110;0	33;3[0] (32;6)	Kangra, HP, India[637]

BACK

The rim is divided in 1° and 6°. Groups of 6° are numbered from 6 to 90, separately in each quadrant, starting from the east and west points and proceeding to the

635 There are more than a dozen places in India named Ramnagar. The most northerly appears to be Ramnagar, Udhampur District, JK, at 32;49 N and 79;19 E.

636 The longitude of 70;0 is absurd!

637 The only place with this name appears to be a small village in Nepal at 27;43 N and 85;31 E. On the other hand, Kangra in Himachal Pradesh is historically known as Nagarkot; it is at 32;6 N and 76;16 E. This is probably meant by the astrolabe makers.

south and north points. In the upper right quadrant is the sine-cosine graph which is typical of Bulhomal. The other three quadrants are blank. The surface of the back is somewhat corroded.



Figure B022.6 – Back of the astrolabe (photo by Ananda Sarma)

ALIDADE

The two ends of the alidade are slanted and plain. The ornate centre-piece has a finial. The sighting plates are shaped like tulips. The alidade is divided in groups of 5

units and numbered 5, 10, 15, 20, 25, 30 on either side of the centre. The pin is plain. The tip of the wedge is shaped like the *fluer de lis* (see Figure B022.2 above).



Figure B022.7 – The ornate centre-piece and the sighting plate of the alidade (photo by Ananda Sarma)

PROVENANCE

Formerly in a private collection in Ireland; cf. Mollan 1995, p. 152.

B023 ASTROLABE ATTRIBUTABLE TO LĀLAH BULHOMAL LĀHORĪ

Lahore, mid-19th century

Diameter 157 mm

PLU, ex-Alain Brieux

Répertoire 5

The Répertoire mentions yet one more astrolabe of about the same size and with 12 star-pointers on the rete. It has, however, 4 plates. The inner surface is blank as in B021. On the back, the rim is numbered in common Arabic/Persian numerals up to 90, separately in each quadrant. The upper right quadrant carries a trigonometric grid. While the other three quadrants are blank in B021 and in B022, here the upper left quadrant is said to carry an astrological table with the names of planets and the names of the 6 signs of the zodiac and the lower left quadrant the names of the 12 sign of the zodiac.

It is not signed, nor dated, but the Répertoire opines that it is attributable to Bulhomal.

It was formerly in the private collection of Alain Brieux. Its present location is unknown.

B024 ASTROLABE DESIGNED BY LĀLAH BULHOMAL LĀHORĪ AND FABRICATED BY PĪR BAKHSH LĀHORĪ[638]

1841 Lahore

Diameter 235 mm

Lahore, Lahore Museum (# MM 1649)



Figure B024.1 – Front of the astrolabe (courtesy Dr Naseem Naqvi)

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638 This description is based on the information and photos kindly provided to me by Mubashir Ul-Haq Abbasi, who will soon publish a comprehensive description of this astrolabe. I am grateful to him for permitting me to use his material in this catalogue. There is a brief description in Dar 1994: 174-176, pls. VII-IX.

This is massive astrolabe was designed by Bulhomal, but the actual production was carried out by the master craftsman (*ustād*) Pīr Bakhsh of Lahore in 1841. According to the inscription engraved on the thick edge of the astrolabe, it was commissioned by Mawlwī Ghulām Muḥammad Khān Ghulāmī for the use of the young Mubārak ʿAlī Khān. Unlike the other astrolabes produced by Bulhomal, *Abjad* notation is employed on this astrolabe.

Components

Mater with *kursī* (d. 235, h. 305, t. 20), shackle, chain, rete, 7 plates, alidade, pin and wedge.

Front

The *kursī* is solid. The profiles consist of ogees at the base and at the top with a lobe in between. The finial is trifoliate. There is small shackle to which is attached a long chain for suspension. The *kursī* is decorated in the front by intertwining vines with leaves and flowers; on the back there is a cartouche inside which the maker's signature is incorporated. The limb is graduated in single degrees of arc and groups of 6° are numbered in *Abjad* notation from 6 to 360.



Figure B024.2 – Rete of the astrolabe (photo by Mubashir Ul-Haq Abbasi)

RETE

In the rete, the slender Capricorn ring and the much broader ecliptic ring are held together by the equinoctial bar which has no counter change. The equator is represented in the lower half. At the centre is a perforated disc through which the equinoctial bar passes. A flower with eight petals is engraved on the central disc. The Capricorn ring and the equatorial ring are decorated with an identical engraved design. There is round knob just above the north point. The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names. Each sign is divided in groups of 6° and numbered from 6 to 30. The sloped edge of the ecliptic ring is divided in 1°.

The star pointers are joined by a pleasing tracery. While the leaf shape of the star pointers is similar to that on the astrolabes made by Bulhomal (B021, B022), the tracery

here is much more elaborate. It was emulated twenty years later by Bulhomal's pupil Ghulām Qādir Kapūrthalī in his astrolabe (B027).

There are 26 leaf-shaped star pointers, with the names of the stars engraved on them. At the tip of each leaf, there is dot enclosed in a circle, indicating the exact position of the star; the metal inside the circle looks like inlaid silver.



Figure B024.3 – Detail of the rete (photo by Mubashir Ul-Haq Abbasi)



Figure B024.4 – Back of the rete, detail (photo by Mubashir Ul-Haq Abbasi)

On the reverse side of the rete is some engraving in Sanskrit; it looks like the ecliptic ring in a rete with the names of the zodiac signs in the upper row and their divisions of 6° in the lower row. It was apparently discarded because some errors occurred in the engraving.[639]

Most of the star names are followed by a serial number. These numbers follow more or less the sequence when the stars are arranged by their right ascensions, with some gaps. Probably the star names and the serial numbers are copied from a list in some *zīj*.

Table B024-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus Janūbī*	β Ceti
2	*Baṭn al-Ḥūt 3*	β Andromedae
3	*Sharaṭayn*[640]	β Arietis
4	*Rās al-Ghūl 6*	β Persei

639 On the left is the name *atha siṃhaḥ* (now Leo); on the right can be seen *tulā* (Libra). The arc of the ecliptic circle indicates that, if completed, the Sanskrit rete would have been of about the same dimension as the present Indo-Persian rete and that therefore Bulhomal was planning a large Sanskrit astrolabe.

640 Engraved on the ecliptic ring; there is no pointer.

	Star Name	Identification
5	*Barshāwish*[641]	α Persei
6	*ᶜAyn al-Thawr 8*	α Tauri
7	*Rijl al-Jawzā' [al-Yusrā] 9*	β Orionis
8	*Rijl [al-Jawzā'] al-Yumnā 10*	κ Orionis
9	*ᶜAyyūq 11*	α Aurigae
10	*Yad al-Jawzā' al-Yumnā 12*	α Orionis
11	*Shiᶜrā Yamānī 14*	α Canis Majoris
12	*Muqaddam al-tawamān*[642]	α Geminorum
13	*Qalb al-Asad 17*	α Leonis
14	*Janāḥ al-Ghurāb 16*	γ Corvi
15	*Simāk al-Aᶜzal 20*	α Virginis
16	*Simāk Rāmiḥ*	α Bootis
17	*Nayyir al-Fakkah 22*	α Coronae Borealis
18	*Rās al-Ḥawwā 24*	α Ophiuchi
19	*Nasr Wāqiᶜ 27*	α Lyrae
20	*Nasr Ṭā'ir 28*	α Aquilae
21	*Minqār al-Dajājah*	β Cygni
22	*Dhanab al-Dajājah 30*	α Cygni
23	*Fam al-Ḥūt 39*	α Piscis Austrini
24	*Mankib al-Faras*	β Pegasi
25	*Surrat al-Faras 31*	δ Pegasi = α Andromedae
26	*Kaff al-Khaḍīb 5*	β Cassiopeiae

641 Perseus with slight phonetic change, cf. Kunitzsch 1959, p. 114.

642 *Rās al-Muqaddam al-Taw'am*? Engraved on the ecliptic ring; there is no pointer.

Star Name	Identification

PLATES

There are seven plates. The first six serve the latitudes 14° and (blank); 20° and [27°]; 25° and 32°; 33° and [38°]; [48°] and 50°; 56° and 60°. The reverse of the first side is blank, except for the two circles of equator and Cancer. The seventh plate carries multiple half-horizons on both sides. The plate of ecliptic coordinates is not represented in this astrolabe.

On plates 1 to 6, altitude circles are drawn for every 3° and numbered on both sides of the meridian. Azimuth arcs are drawn for every 6° above and below the horizon and numbered along the oblique horizon. On the plates for 25° and 32°, however, these are drawn only above the horizon. This plate carries lines for seasonal hours, but not the other plates. Lines for equal hours are drawn on all plates from the western horizon.



Figure B024.5 – Plate for latitude 32° (photo by Mubashir Ul-Haq Abbasi)

GEOGRAPHICAL GAZETTEER

The geographical gazetteer is engraved on the inner side of the mater in four circles, providing the names, longitudes and latitudes of 54 localities, roughly in the order of increasing longitude. The circles do not commence at the vertical diameter as is normally the case, but at 45° before the vertical diameter. In the argument, the place names are called *iqlīm,* which very is intriguing.



Figure B024.6 – Geographical gazetteer, detail showing the argument, engraved off centre (photo by Mubashir Ul-Haq Abbasi)

Table B024-2 Geographical Gazetteer

	Place Name	L	φ
	First Circle		
1	Iskandariyya	61;54	30;58
2	Madīnat al-Hukumā’	65;40	37;20
3	Madīnat al-Rasūl	75;20	25;0
4	Makka Muᶜẓẓam	77;10	21;40
5	Baṣra	84;0	30;0

	Place Name	L	φ
6	Balkh	85;20	46;30
7	Iṣfahān	86;4	32;25
8	Shīrāz	88;0	29;36
9	Hurmūz	91;0	25;0
10	Tūn	94;30	34;40
11	Herāt	94;4	34;30
12	Bukhārā	97;30	39;50
13	Samarqand	99;36	39;37
14	Dawlatābād	101;30	20;30
15	Ujjayn	102;0	22;30
	Second Circle		
16	Mānsar	102;25	30;10
17	Badakhshān	104;24	37;10
18	Kābul	104;40	34;30
19	Nūrpūr	105;15	31;4
20	Pijāpūr	105;35	20;0
21	Qannawj	105;55	26;50
22	Sawmnāth	106;10	12;0
23	Kāshghar	106;30	44;0
24	Awrangābād	107;27	20;30
25	Multān	107;35	29;40
26	Qandahār	107;40	33;0
27	Awadh	108;6	22;22
28	Aḥmadābād	108;40	23;55

	Place Name	L	φ
29	Kashmīr	108;45	35;0
30	Gawāliyār	109;0	26;29
	Third Circle		
31	Siālkūt	109;0	33;30
32	Burhānpūr	109;20	20;31
33	Lāhūr	109;20	31;50
34	Tibbat	110;3	40;15
35	Dihlī	113;35	28;29
36	Mathrā	114;20	27;0
38	Banāras	117;20	26;55
39	Jawnpūr	119;6	26;36
40	Sarandīp	149;0	10;0
41	Nakarkūt	110;0	33;30
42	Pashāwar	106;?	35;?
43	Pind Dādan Khān	108;5	33;30
44	Rāmnakar	108;30	32;30
	Fourth Circle		
45	Anbratsar	109;40	31;45
46	Lūdyānā	111;0	31;30
47	Anbālā	111;50	31;0
48	Hardwār KankācheyX Hardwar Gangājī	115;5	31;0
49	Najībābād	113;15	31;0
50	Farrukhābād	113;45	31;0

	Place Name	L	φ
51	Lakhnaū	114;10	27;0
52	Gayā	14(!);0	24;0
53	Kalkata	124;5	20;20
54	Jagannāth	124;0	20;0

BACK

The rim of the back is divided in 1° and 6°. Groups of 6° are numbered from 6° to 90°, separately for each quadrant. In the upper half, the numbering commences at the east and west points and reaches up to the south point. In the lower half, the numbering proceeds in clockwise direction.



Figure B024.7 – Back of the astrolabe (photo by Mubashir Ul-Haq Abbasi)

In the upper right quadrant is a sine-cosine graph with 15 vertical and 15 horizontal equidistant parallels. The lines are numbered along the radii in *Abjad* notation in both directions, i.e. from the centre to the periphery and from the periphery to the centre as 2, 4, … 30. In the scale carrying the numbers from the periphery to the centre, common Arabic numerals are also written above the *Abjad* numerals. Again these lines are numbered in the seventh vertical column and in the seventh horizontal row from 2 to 28, starting at the radius and proceeding up to the arc, also in *Abjad* notation.

In the lower half there are shadow squares, on the left for a base of 12 and on the right for a base of 7. The vertical and horizontal scales on the left are divided in 12 parts each and numbered from 1 to 12 in common Arabic/Persian numerals. Again each part

is divided into 6 divisions. The vertical and horizontal scales on the right are divided in 7 parts each and numbered from 1 to 7 in common Arabic/Persian numerals. Again each part is divided into 6 divisions. These subdivisions are unusual. There are no labels accompanying these four scales.

Inside the squares, a semi-circle is drawn with the centre of the astrolabe as the centre. Then from the centre three sets of lines are drawn up to the semi-circle; one in the middle and the other two on the left and right. The lines are numbered at regular intervals in common Arabic/Persian numerals. Such numbered lines are not found on any other astrolabe and require further research about their function and significance.

In the lower left quadrant, four quarter circles are drawn inside the degree scale, in which the names of the 12 zodiac signs are written in four lines; in the second and fourth lines the names are written upside down.

al-Jawzā'	*al-Thawr*	*al-Ḥamal*
al-Saraṭān	*al-Asad*	*al-Sunbulah*
al-Qaws	*al-ᶜAqrab*	*al-Mīzān*
al-Jadī	*al-Dalw*	*al-Ḥūt*

This arrangement is according to the rising times of the signs at the equator in the tropical zodiac. Aries, Virgo, Libra and Pisces in the first column from the right rise in 1;51,36 hours. Taurus, Leo, Scorpio and Aquarius in the middle column rise in 1;59,40 hours. Gemini, Cancer, Sagittarius and Aquarius rise in 1;59,40 hours.[643]

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643 I am grateful to Dr. Martin Gansten for explaining the significance of this table in his mail of 26 June 2016.



Figure B024.8 – Astrological table in the upper left quadrant on the back
(photo by Mubashir Ul-Haq Abbasi)

In the upper left quadrant is a large astrological table, engraved in two parts, one below the other. In both parts, row 2 carries the names of the zodiac signs and row 1 the names of the planets which govern the signs. In the both rows the names are written in full. Rows 2, 3, 4 constitute the table of limits of signs (*al-ḥudūd*). Under the name of each sign, in row 3 the names of the five planets which govern the limits are written by symbolic letters and in row 4 the strength of each planet is mentioned in common Arabic numerals. Row 5 carries the names (in full) of the planetary regents of the three decan or faces of the signs.

We reproduce the sectors of the table below with the following abbreviations:

1 = Planets, 2 = Signs, 3 = Planets, 4 = Limits, 5 = Regents of Decans

M = Mars, Me= Mercury, J = Jupiter, V = Venus, S = Saturn

Table B024-3 Transcript of table shown in Figure B024.8

1	*Mirrīkh* (Mars)					*Zuhra* (Venus)					ᶜ*Uṭārid* (Mercury)				
2	*al-Ḥamal* (Aries)					*al-Thawr* (Taurus)					*al-Jawzā'* (Gemini)				
3	J	V	Me	M	S	V	Me	J	S	M	Me	V	J	M	S
4	6	6	8	5	5	8	6	8	5	3	6	6	5	7	6
5	Mars		Sun		Venus	Mercury		Moon		Saturn	Jupiter		Mars		Sun

1	*Qamar* (Moon)					*Shams* (Sun)					ᶜ*Uṭārid* (Mercury)				
2	*al-Saraṭān*(Cancer)					*al-Asad* (Leo)					*al-Sunbulah* (Virgo)				
3	M	V	Me	J	S	J	V	S	Me	M	Me	V	J	M	S
4	7	6	6	7	4	6	5	7	6	6	7	10	4	7	6[644]
5	Venus		Mercury		Moon	Saturn		Jupiter		Mars	Sun		Venus		Mercury

1	*Zuhra* (Venus)					*Mirrīkh* (Mars)					*al-Mushtawī* (Jupiter)				
2	*al-Mīzān* (Libra)					*al-ᶜAqrab* (Scorpio)					*al-Qaws* (Sagittarius)				
3	S	Me	J	V	M	M	V	Me	J	S	J	V	Me	M	S
4	6	8	7	7	2	7	4	8	5	6	12	5	4	5	4
5	Moon		Saturn		Jupiter	Mars		Sun		Venus	Mercury		Moon		Saturn

1	*Zuḥal* (Saturn)					*Zuḥal* (Saturn)					*Mushtawī* (Jupiter)				
2	*al-Jadī* (Capricorn)					*al-Dalw* (Aquarius)					*al-Ḥūt* (Pisces)				
3	Me	J	V	S	M	Me	V	J	M	S	V	J	Me	M	S
4	7	7	8	4	4	7	6	7	5	5	12	4	3	9	2
5	Jupiter		Mars		Sun	Moon		Mercury		Venus	Saturn		Jupiter		Mars

644 This should correctly read as 2.

Alidade

The alidade has slanted ends and an ornate centre piece. The two sighting plates are nicely shaped like flowers. The sloping edge is divided into 30 units in both halves. The length of the alidade is divided in 12 equal parts and numbered in 6s from the centre up to each end as 6, 12, 18, 24, 30 in *Abjad* notation, thus corresponding to the divisions in the sine quadrant in the upper right of the back. The pin has a broad round head and as also the wedge.

Inscriptions

There are several inscriptions in low relief against a hatched background, on both sides of the *kursī,* on the equinoctial bar in the rete and on the thick edge of the astrolabe. According to Abbasi, these include a quotation from the Quran, a prayer recited by Shias and a Persian quatrain in praise of the astrolabe.

On the back of the *kursī* is the signature of the astrolabe maker inside a cartouche:

ʿamal ustād pīr bakhsh lāhūrī

The work of the master-craftsman Pīr Bakhsh of Lahore.'



Figure B024.9 – Inscription on the edge of the astrolabe (photo by Mubashir Ul-Haq Abbasi)

On thick edge of the astrolabe is a long inscription in two lines engraved in relief against a hatched background. The first part of the inscription mentions the components

of the astrolabe and its various functions. The second part describes Mawlwī Ghulām Muḥammad Khān Ghulāmī who suggested the production of this astrolabe as 'a scholar of global repute, an icon of knowledge of visible and invisible worlds, inventor, innovator, unique administrator, exceptional person, a soldier and a literary figure'.

The third part describes Bulhomal; since he is himself the author of this inscription, it is interesting to see his self-assessment: 'a trailblazer of astrologers, chief of engineers, leader of technicians, head of the community of astronomers, encyclopedia of diverse knowledge, one who has a profound knowledge of the nature of the stars, solver of difficult and tedious problems, a person with practical demeanor, a perfectionist, Lālah Bulhomal Lāhūrī.'

The inscription concludes with the blessing that the young Mubārak ᶜAlī Khān for whom the astrolabe was made may have a long life and may seek beneficial knowledge.[645]

The inscription is dated in three eras: Vikrama Saṃvat 1897, Hijrī 1257 and Christian 1841. The Saṃvat year 1897 commences on 11 April 1840 and concludes on10 April 1841; the Hijrī year 1257 starts on 22 February 1841 and ends on 10 February 1842. Therefore, the astrolabe was completed between 22 February and 10 April 1841.

PROVENANCE

Acquired by the Lahore Museum in 1986 for 'a high price'.

BIBLIOGRAPHY

Dar 1994, pp. 174-176, pls. VII-IX.
Abbasi forthcoming.

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645 According to Abbasi forthcoming, this Mubārak ᶜAlī Khān may be a member of the elite Shia family of ᶜAlī Razā Khān (d.1865) and his son Nawāb Nawaizh ᶜAlī Khān, who contributed to the development of Lahore and patronized scholars and artisans.

B025 NORTH-SOUTH ASTROLABE BY LĀLAH BULHOMAL LĀHORĪ, 1 JANUARY 1851

Diameter 406.4 mm

PLU

Répertoire 3



Figure B025.1 – North-South Astrolabe (courtesy Museum of the History of Science, Oxford)

The Répertoire lists an astrolabe with a double ecliptic made by Bulhomal on 1 January 1851. In the archives of the Museum of the History of Science, Oxford, there is a photograph with a note by Francis Maddison which reads thus:

> 'Indo-Persian astrolabe with double rete. Overall ht 4, 10 inches [= 1m 47.32 cm], astrolabe diameter 16" [=406.4 mm]. submitted by Sotheby 1976 for examination, said to be in a palace of a maharaja. Negative no. 76-27.35.s.'

Possibly the photo shows the same astrolabe listed as 3 in the Répertoire.

FRONT

The astrolabe can be easily identified as the creation of Bulhomal from the signature *kursī* with three perforations. The photo shows a bird with a longish tail perched on the *kursī*. It could not have been a real bird sitting on the astrolabe coincidentally when the photograph was taken, but rather a decorative addition made by the astrolabe maker himself.

The rete contains the peripheral Capricorn ring, the ring of the equator and the ecliptic ring both in its northern and southern projection, all held together by the equinoctial bar. No star pointers can be discerned in the photo.

An unusual feature of this large astrolabe is that it is mounted on a high stand. From the way it is attached to the stand, it does not seem possible that the astrolabe could be lifted from the stand, held in the upraised hand and tilted appropriately for observation. It could at the most be used for demonstration.

BACK

According to the Répertoire, the rim on the back is numbered in 6s separately in each quadrant in 'Indian numerals'; the upper left quadrant carries the long inscription, the upper right quadrant a sine-cosine graph and the lower half astrological tables containing the names of the zodiac signs, of the sun, moon and the planets.

No information is available on the number of plates and on the content of the inner surface of the mater.

INSCRIPTION

The long inscription, cited and translated into French in the Répertoire, begins with a long encomium of Queen Victoria, goes on to eulogise Rāja-Ṣāḥib Nihāl Singh Bahādur Ahlūwāliya of Kapūrthala, and concludes with the statement that Lālah

Bulhomal, geometrician, astrologer and astronomer, resident of Lahore, attached to the entourage of the Rājā-Ṣāḥib, has fabricated the astrolabe at Kapūrthala on the first January 1851 AD which corresponds to Saṃvat 1908 of the Vikrama era.

PROVENANCE

Formerly in the private collection of the Maharaja of Kapurthala; Sotheby's 1976; Hew Kennedy, Shropshire, UK; now Saudi Arabia (?).

B026 NORTH-SOUTH ASTROLABE BY LĀLAH BULHOMAL LĀHORĪ

Not dated, mid-19th century

Diameter ?

PLU

Répertoire 7

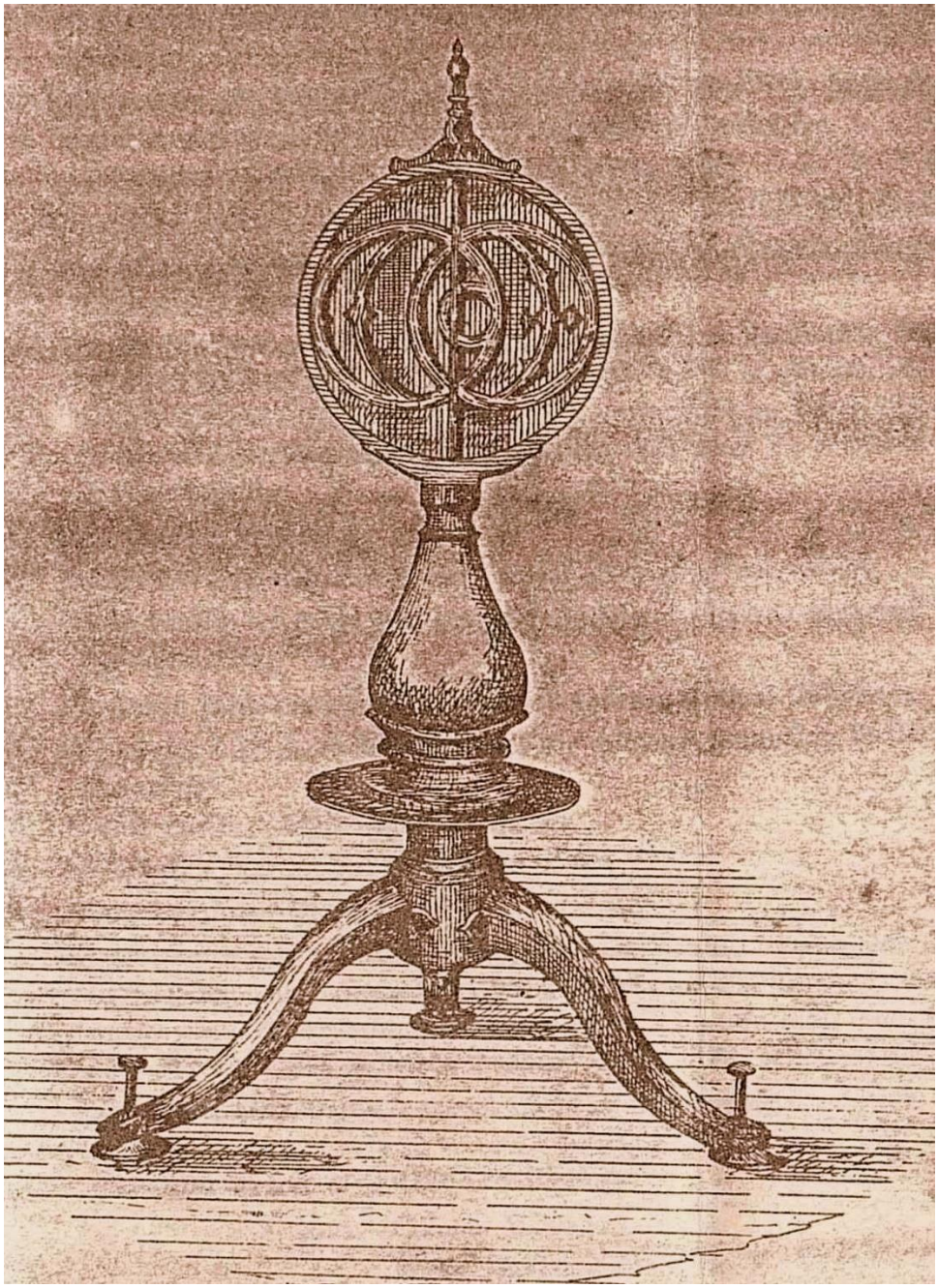


Figure B026.1 – North-South astrolabe (from Powell 1872)

The Répertoire lists one more astrolabe by Bulhomal with a north-south projection of the ecliptic. It may be the same as the one exhibited by the Maharaja of Kapurthala

at the Lahore Exhibition of 1864 and illustrated with a wood-cut image by B. H. Baden Powell in his *Handbook of the Manufactures and Arts of the Panjab.*

The wood-cut image looks exactly like the astrolabe B025 minus the bird perched on the *kursī* and probably of the same dimensions.

The Répertoire states that there are no star pointers on the rete. On the back, in the upper left quadrant is an astrological table containing the names of the planets and those of 6 signs; the upper right quadrant is occupied by sine-cosine graph, the lower left has the names of the 12 signs of the zodiac, but the lower right is blank. There are said to be 6 plates in this astrolabe.

PROVENANCE

Formerly in the private collection of the Maharaja of Kapurthala; Hew Kennedy, Shropshire, UK; now Saudi Arabia (?).

BIBLIOGRAPHY

Powell 1872, pp. 260-261.

GHULĀM QĀDIR KAPŪRTHALĪ

In the lone astrolabe of 1861 (B027) which carries his signature, Ghulām Qādir Kapūrthalī calls himself the pupil (*shāgird*) of Bulhomal, the astronomer (*munajjim*) of Lahore. Like his master, he avoids the *Abjad* notation and employs the common Arabic/Persian numerals. The rete is similar to the rete in the astrolabe B024 designed by Bulhomal.

Besides the astrolabe B027, there are two others (B028and B029) which can be attributed to Ghulām Qādir on stylistic reasons. While a strong influence of his master's work can be seen in these three astrolabes, the workmanship is uneven; B027 and B029 are well crafted, but B028 lacks proper finishing and the *kursī* is joined to the mater in a strange manner.

The Répertoire lists him under Qādir Kapūrthalī and treats the first name Ghulām as an attribute denoting 'aprenti'!

B027⊙ ASTROLABE BY GHULĀM QĀDIR KAPŪRTHALĪ, 1278 AH, 1918 VS (AD 1861-62)

Diameter 337 mm

New Delhi, National Museum (# 56.155/2 (c))

Répertoire: ‘Qādir Kapūrthalī’



Figure B027.1 – Front of the astrolabe (photo by S. R. Sarma)

The construction of this astrolabe is very unusual. It does not have a limb as such, but a very wide rim. The portion inside the rim is depressed to accommodate two plates, which have a two-pronged bit projecting outside at the south point. There is a small notch at the corresponding point in the depressed portion on the main plate to receive the projecting bits on the plates. On the wide rim is engraved the degree scale and beyond it the geographical gazetteer.

Components

Body with *kursī* (d. 337, h. 363, t. 2), shackle and tassel, rete (d. 277) for 26 stars, 2 plates, alidade (length 290, width 19, t. 2.5) pin and washer. Original horse is lacking.

Front

The *kursī* is small and low. Its finial has the shape of a stylized trefoil and the same shape is given to the sighting plates on the alidade. The large trifoliate shackle is not riveted to the finial, but to the main plate at the bottom of the *kursī.* An extravagant tassel in red silk is attached to the shackle.

The degree scale on the rim is divided 0;30°, 1° and 6° and numbered clockwise in 6s from 6 to 360.

Rete

In the rete the ring of the Tropic of Capricorn which forms the outer circumference is very narrow. The celestial equator is shown only in the lower half, its ring is slightly wider, and the ring of the ecliptic circle is much wider to accommodate the names and sub-divisions of the signs of the zodiac. The three rings are arranged in the same manner as in the astrolabes made by Bulhomal. The elaborate tracery closely resembles the same in the astrolabe made by Pīr Bakhsh in 1841 (Figure B024.2) and contains the same named star pointers. But the Capricorn ring and the equator ring are not decorated with ornate engravings, nor are the star pointers endowed with silver inlay as is done in B024 (see Figure B024.3).

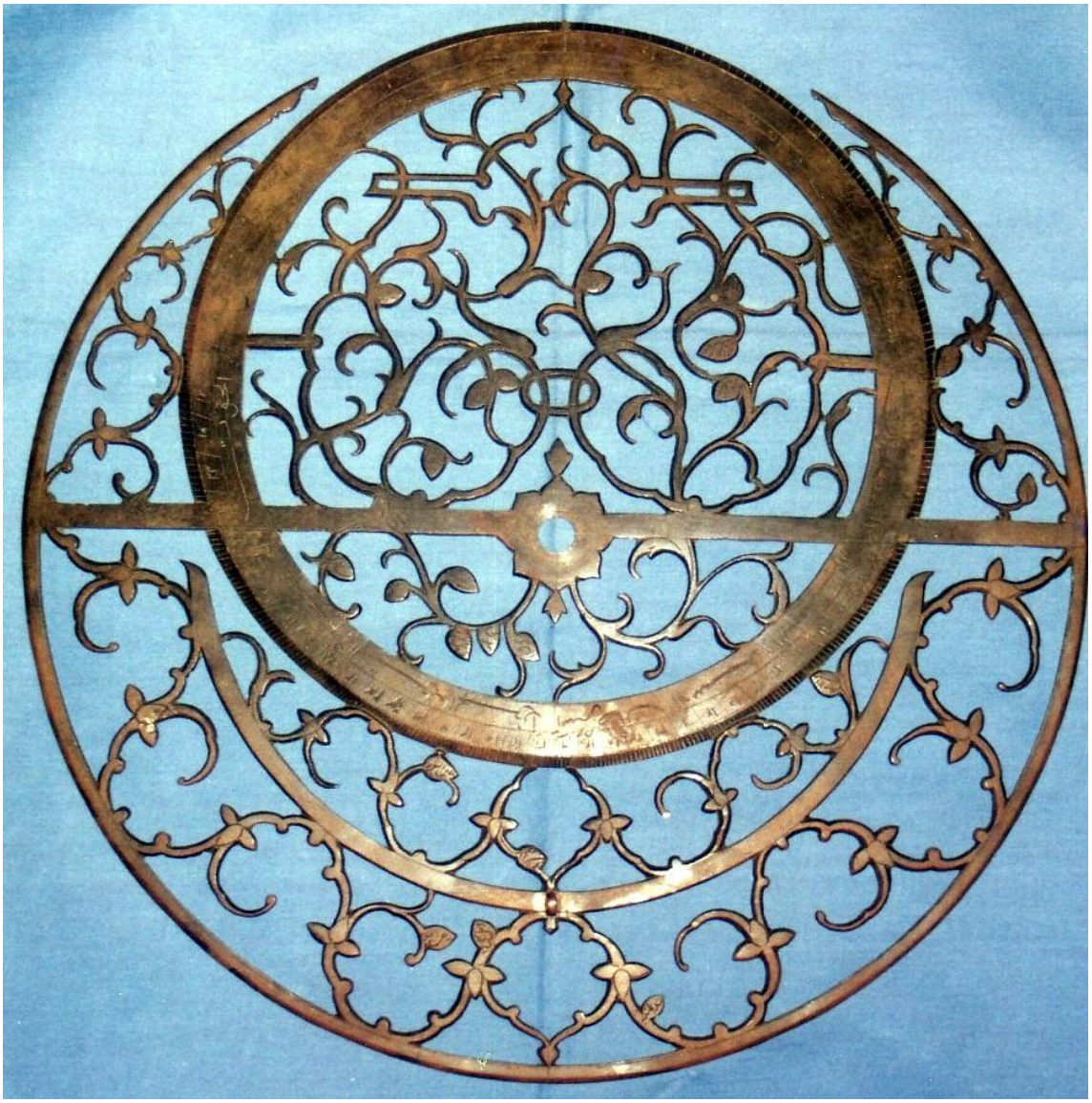


Figure B027.2 – Rete of the astrolabe (photo by S. R. Sarma)

PLATES

Inside the circular degree scale, the main body is slightly depressed to accommodate two latitude plates. The depressed portion is engraved as a *ṣafīḥa* for the latitude of Lahore at 32°. One of the two plates is calibrated for 36° on one side; the reverse is blank. The second plate carries multiple horizons on both sides as in Bulhomal's astrolabes.

On the plates for 32° and 36°, altitude circles are drawn for every 3°, azimuth circles for every 3° above and below the horizon. In the lower half are drawn the lines for unequal hours and dotted lines for equal hours counted from sunset as well as sunrise.



Figure B027.3 – Geographical gazetteer on the rim of the astrolabe, detail showing the localities from Harāt (11) to Nūrpūr (19) (courtesy Anthony J. Turner)

GEOGRAPHICAL GAZETTEER

As stated above, the geographical gazetteer is engraved around the degree scale on the rim of the main plate in three concentric circles. In the outer circle are engraved the place names, in the second the longitudes and in the third the latitude. Each entry in the gazetteer occupies 6° of the circumference and thus coincides with the 6° divisions of the degree scale. Of the sixty divisions, one carries the argument and two are blank. The remaining 57 divisions are engraved with the same 57 localities in the same sequence as in Bulhomal's astrolabes B022 and B024; the minor variations in the values of the coordinates can be scribal errors.

Table B027-1 Geographical Gazetteer

	Place Name	L	φ
1	Iskandariyya	61;40	30;58
2	Madinat al-Hikmā	60;40	37;20
3	Madinat Rasūl	75;20	25;00
4	Makka Mubārak	77;10	21;40
5	Baṣra	84;0	30;0
6	Balkh	85;20	42;30
7	Iṣfahān	86;40	34;20
8	Shīrāz	88;0	29;32
9	Hurmūz	88;0	29;34

	Place Name	L	φ
10	Tūn	92;30	34;30
11	Harāt	94;40	34;30
12	Bukhārā	98;30	39;55
13	Samarqand	99;32	39;37
14	Dawlatābād	101;30	20;30
15	Ujjayn	102;0	22;30
16	Mānsar	102;20	30;10
17	Badakhshān	104;24	37;10
18	Kābul	104;40	34;30
19	Nūrpūr	105;15	31;40
20	Bījāpūr	105;30	20;0
21	Kannawj	105;55	26;55
22	Sawmnāt	106;10	12;0!
23	Kāshghar	106;30	44;0
24	Awrangabād	107;27	20;30
25	Multān	107;35	29;40
26	Qandahār	107;40	33;0
27	Awadh	108;20	22;22
28	Aḥmadābād	108;40	23;55
	---- two blank cells ---		
29	Kashmīr	108;45	35;0
30	Kawaliyar	109;0	26;29
31	Siyālkūt	109;0	33;0
32	?	109;0	22;20

	Place Name	L	φ
33	Burhānpūr	109;30	20;30
34	Lāhūr	109;20	31;50
35	Tibbat	110;27	40;15
36	Shāhjahānābād	113;35	28;29
37	Mathrā	114;20	27;20
38	Banāras	117;2[0]	26;55
39	Jawnāpūr	119;5	26;21
40	Sarandīp	104;0	10;0
41	Rayākarh	106;20	37;0
42	Pashāwar	106;20	34;0
43	Pind Dādar Khān	108;5	33;30
44	Rāmnakar	108;30	32;30
45	Anbratsar	109;40	31;45
46	Kapūrthala	110;20	31;40
47	Ludhiyāna	111;0	31;30
48	Anbālā	111;5	31;50
49	Hardwār	113;5	31;0
50	Najībābād	113;15	31;0
51	Farkhābād	113;45	31;0
52	Lakhnaw	114;20	27;0
53	Gayā	12[0];0	24;0
54	Kalkata	124;5	22;30
55	Jagannāth	124;0	25;0
56	Landan	70;0!	52;0

	Place Name	L	φ
57	Nakarkūt	110;0	33;30

BACK

On the back, there is a degree scale all around, divided in 0;30°, 1° and 6°, as in the front, but numbered separately in each quadrant, as 6—90; 90—6; 6—90; 90—6.

In the upper left quadrant are drawn 60 horizontal parallels and 90 radial lines which join the centre to the 90 divisions of the arc. In the upper right quadrant, there is a sine-cosine graph with 30 horizontal and 30 vertical parallels, numbered in the same fashion as in the instruments by Bulhomal.



Figure B027.4 – Back of the astrolabe (courtesy Anthony J. Turner)

In the lower half is a double shadow square, on the left for a base of 12/60 and on the right for a base of 7. The vertical and horizontal scales are divided first in 12

divisions and numbered from 1 to 12, then each division is subdivided in 5. The vertical scale carries the incomplete label *ẓill [aṣābiᶜ] maᶜkūs sullam* and the horizontal scale *ẓill aṣābiᶜ mustawī.* The horizontal and vertical scales on the right are divided in 7 divisions and are numbered from 1 to 7; they carry the labels *ẓill aqdām mustawī* and *ẓill aqdām maᶜkūs.*

Alidade

The alidade is straight without counter change; in both halves, the sloping edge is divided in 30 units; on the surface groups of 6 units are numbered from 6 to 30 on either side. The sighting plates are ornate like Bulhomal's astrolabes (see, eg., Figure B022.7). The pin has a high hemispherical head.

Inscription

Inside the shadow square is the maker's signature, engraved above the horizontal scales:

> *ᶜamal ghulām qādir kapūrthalī shāgird bulhūmal munajjim lāhūr*
> *ḥasb al-irshād rāizādah shankar dās harbanspūrī*
> *1278 hijrī sambat 1918*
>
> The work of Ghulām Qādir Kapūrthalī, the pupil (*shāgird*) of Bulhomal, the astronomer (*munajjim*) of Lahore, [made] at the behest of Raizādā Shankar Dās Harbanspūrī, Hijrī 1278, Saṃvat 1918.

The Hijrī year 1278 runs from 8 July 1861 to 27 June 1862 and the Vikrama Saṃvat 1918 from 11 April 1861 to 30 March 1862; therefore, the astrolabe was completed sometime between 8 July 1861 and 30 March 1862.

Bibliography

Behari & Govind 1980, p. 97.

B028⊙ ASTROLABE ATTRIBUTABLE TO GHULĀM QĀDIR KAPŪRTHALĪ

Diameter 153 mm

New Delhi, National Museum (# 56;155/2 (a))



Figure B028.1 – Front of the astrolabe (photo by S. R. Sarma)

This astrolabe is not signed, but the design of the rete clearly indicates that it was produced by Ghulām Qādir Kapūrthalī. Its construction is unusual: the *kursī* and a part of the limb are made separately and joined crudely to the main body with brass pins. The surface of the rete, that of the back, and those of the plates are rough, they are not properly smoothened. The rete has just 7 star pointers.

Components

Body with *kursī* (d. 153, h. 181, t. 12) and shackle, rete (d. 134, t. 3) for 7 stars, 3 plates, alidade, pin and washer; the horse is missing; a nail holds the ensemble together.

Front

The shackle is trifoliate; the *kursī* is crudely shaped and solid. The rim is divided in 1° and 6° and groups of 6° are numbered serially from 6 to 60.



Figure B028.2 – Rete of the astrolabe (photo by S. R. Sarma)

Rete

In the rete, the three rings of the Tropic of Capricorn, equator and the ecliptic are arranged as in astrolabe B027. The ecliptic ring is very wide; it is divided into the 12 signs of the zodiac and engraved with their names in large letters. Each sign is divided

into groups of 6° and numbered from 6 to 30. The space between the rings is filled with a pleasing tracery which contains six leaf-shaped star-pointers. The exact position of the star is marked by a thick dot at the tip of the leaf. The pointer of the seventh star β Ceti is not leaf-shaped, but looks like a human foot.

Table B028-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus [Janūbī]*	β Ceti
2	*ᶜAyn al-Thawr*	α Tauri
3	*Shiᶜrā Yamānī*	α Canis Majoris
4	*Qalb al-Asad*	α Leonis
5	*Nayyir al-Fakkā*	α Coronae Borealis
6	*Rās al-Ḥawwā*	α Ophiuchi
7	*Nasr Ṭā'ir*	α Aquilae

PLATES

There are three plates for 20° and 26°, 27° and 32°, and 36° and 44°. Altitude circles are drawn for every 6° and azimuth arcs for every 6° above the horizon. In the lower half are traced lines for seasonal hours and lines for equal hours drawn from both the eastern and western horizons. Under the horizon are engraved *al-mashriq* in the east and *al-maghrib* in the west. At the middle of the plate are the arguments *al-ᶜarḍ* and *al-sāᶜāt,* but —as in the astrolabes by Bulhomal—the values of only latitudes are mentioned and not the hours of the longest day.

GEOGRAPHICAL GAZETTEER

The geographical gazetteer of 57 localities is exactly the same as in B022, B024 and B027, with minor differences in the values of the coordinates.

Table B028-2 Geographical Gazetteer

	Place Name	L	φ
	Outer Circle		
01	Iskandariyya	61;54	30;57
02	Madinat al-Hikmā	60;4[0]	37;2[0]
03	Madinat Rasūl	75;20	25;00
04	Makka Mubārak	77;10	21;40
05	Baṣra	84;0	30;0
06	Balkh	75;20	46;30
07	Iṣfahān	86;40	32;25
08	Shīrāz	88;0	29;36
09	Hurmūz	92;0	15;0
10	Tūn	92;30	34;30
11	Harāt	94;40	34;30
12	Bukhārā	97;30	39;50
13	Samarqand	99;36	39;37
14	Dawlatābād	101;30	20;30
15	Ujjayn	102;0	22;30
16	Mānsar	102;20	30;10
17	Badakhshān	104;24	37;10
18	Kābul	104;40	34;30
19	Nūrpūr	105;15	31;8
	Middle Circle		
20	Bījāpūr	105;35	20;0
21	Kannawj	105;55	26;50
22	Sawmnāt	106;10	12;0

	Place Name	L	φ
23	Kāshghar	106;30	44;0
24	Awrangabād	107;27	20;30
25	Multān	107;35	29;4[0]
26	Qandahār	107;40	33;0
27	Awadh	108;20	22;22
28	Ahmadābād	108;40	23;55
29	Kashmīr	108;45	35;0
30	Kawaliyar	109;0	26;29
31	Siyālkūt	109;0	33;0
32	?	109;0	22;20
33	Burhānpūr	109;20	20;30
34	Lāhūr	109;20	31;50
35	Tibbat	110;3	40;15
36	Shāhjahānābād	112;30	28;29
37	Mathrā	114;20	27;20
38	Banāras	117;2[0]	26;55
	Inner Circle		
39	Jawnāpūr	119;5	26;36
40	Sarandīp	120;0	10;0
41	Rayākarh	140;0	27;0
42	Pashāwar	106;35	34;0
43	Pind Dadar Khān	108;5	33;35
44	Rāmnakar	108;30	32;30
45	Anbratsar	109;40	30;45

	Place Name	L	φ
46	Kapūrthala	110;20	21;40
47	Ludhiyāna	111;0	31;0
48	Anbālā	111;50	31;0
49	Hardwār	113;5	31;0
50	Najībābād	113;5	31;0
51	Farkhābād	113;45	31;0
52	Lakhnaw	114;2[0]	27;0
53	Gayā	112;0	24;0
54	Kalkata	124;5	24;2[0]
55	Jagannāth	124;0	30;0
56	Landan	70;0!	52;0
57	Nakarkūt	110;0	33;30



Figure B028.3 – Back of the astrolabe (photo by S. R. Sarma)

BACK

The surface of the back is not properly treated and engravings are very faint. The rim is divided in 1° and 6° and numbered in 6s as 6—90; 90—6; 6—90; 90—6. The quadrant on the upper left is blank, on the upper right is a trigonometric quadrant with 30 horizontal and 30 vertical lines which are numbered along the two radii and along the 13th vertical line and the 13th horizontal line.

In the lower half are shadow squares; on the left for a base of 12 and on the right for a base of 7. The vertical and horizontal scales on both sides are divided and numbered accordingly, but there are no labels.

ALIDADE

The two ends of the alidade are plain, but the centre-piece and the two sighting plates are ornate. There is no bevelled edge; the surface is merely divided on either side into six parts and numbered from 6 to 30.

B029⊙ ASTROLABE ATTRIBUTABLE TO GHULĀM QĀDIR KAPŪRTHALĪ WITH A SINGLE PLATE FOR LATITUDE 32°

Diameter 139 mm

New Delhi, National Museum (# 56;155/2 (b))



Figure B029.1 – Front of the astrolabe (photo by S. R. Sarma)

This single-plate astrolabe is not signed, but it can be safely attributed to Ghulām Qādir. It displays good workmanship; all the engraved parts are filled with some white substance.

COMPONENTS

Body with *kursī* (d. 139, h. 167) and shackle, rete (d. 122) for 12 stars, 1 plate for latitude 32°, alidade and pin; the ring and horse are missing.

FRONT

There is no ring; the shackle is trifoliate; the *kursī* is rather high; the profiles are made up of two ogees at the base and at the top with a lobe in between; the finial is

circular. A design is carved in low relief on the front of the *kursī*. The rim is graduated in 1° and 6° and the groups of 6° are numbered as 1, 2, 3 … 60 clockwise.

RETE

As in the astrolabes of Bulhomal and Ghulām Qādir, the rete here displays the three rings of Capricorn, ecliptic and the equator, the last one only in the lower half. The rings of Capricorn and the ecliptic are held together by the equinoctial bar without a counter change. The ring of the ecliptic is very wide; it is divided into the 12 signs of the zodiac; the names of the signs engraved in very large and bold letters; each sign is divided in units of 6° and numbered from 6 to 30; the edge is bevelled, but not sub-divided. The tracery contains 11 leaf-shaped star pointers; the name of the twelfth star is engraved on the eastern segment of the equinoctial bar; the star pointer is seen faintly below the bar.



Figure B029.2 – Rete of the astrolabe (photo by S. R. Sarma)

Table B029-1 Stars on the Rete

	Star Name	Identification
1	*Dhanab al-Qayṭus [Janūbī]*	β Ceti
2	*Rās al-Ghūl*	β Persei
3	*Mirfaq al-Thurayya*	α Persei
4	*Yad al-Jawzā' al-Yusrā*	γ Orionis
5	*Shiʿrā Yamānī*	α Canis Majoris
6	*Qalb al-Asad*	α Leonis
7	*Simāk Aʿzal*	α Virginis
8	*Nayyir al-Fakkah*	α Coronae Borealis
9	*Rās al-Ḥawwā*	α Ophiuchi
10	*Nasr Wāqiʿ*	α Lyrae
11	*Nasr Ṭā'ir*	α Aquilae
12	*Dhanab al-Dajājah*	α Cygni

PLATE

The front side of the main plate is designed as the plate for the latitude of 32°. There are altitude circles for every 6°, azimuth circles also for every 6° above and below the horizon, and lines for unequal hour lines and dotted lines for equal hours counted from the western and eastern horizons. All the lines are numbered. In the middle of the plate are engraved the arguments *al-ʿarḍ* and *sāʿāt,* but only the value of latitude is mentioned as 32°.



Figure B029.3 – Plate for latitude 32° (photo by S. R. Sarma)

BACK

On the back, the upper half of the rim carries the altitude scales, divided in 1° and 6° and numbered as 6—90; 90—6. As in the other astrolabes belonging to this group, the upper right quadrant is occupied by a sine-cosine graph, with 30 horizontal and 30 vertical lines. These lines are numbered along the two radii and along the 13th vertical line and the 13th horizontal line. At 12th division, a quarter circle is drawn to represent the obliquity of the ecliptic.



Figure B029.4 – Back of the astrolabe (courtesy National Museum, New Delhi)

Shadow squares are drawn in the lower half, on the left for a base of 12 and on the right for a base of 7. The vertical and horizontal scales on both sides are divided and numbered accordingly, but no labels are inscribed next to these scales. The rim of the lower half is divided in 6°, but not numbered.

ALIDADE

The alidade has an ornate centre-piece and two very thick and ornate sighting plates which are placed at the very end of the alidade on each side. The sloping edge of the alidade is divided in 30 parts and numbered in 6s from 6 to 30 on both sides of the centre.

B030 BILINGUAL ZARQĀLĪ UNIVERSAL ASTROLABE, ENGRAVED IN ARABIC/PERSIAN AND GURMUKHI[646]

Not dated, 19th century

Diameter 921 mm

PLU, ex-Milan



Figure B030.1 – Front of the astrolabe (courtesy Jeremy Collins, Christie's)

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646 Cf. Christie's, London, auction catalogue, 24 September 1992, lot 119; Sotheby's, London, auction catalogue, 21 September 2001, lot 148.

This *Zarqālī* universal astrolabe, with its diameter of 921 mm, is almost twice as large as Ḍiyā' al-Dīn Muḥammad's *Zarqālī* astrolabe (A091) which measures 555 mm in diameter.[647] It is also the second largest astrolabe produced in India, the first being the Sanskrit astrolabe produced for Sawai Jai Singh in the first quarter of the eighteenth century with a diameter of 2115 mm (D001).

It is engraved in Arabic/ Persian and also Gurmukhi, the script in which Panjabi language is written. However, the Gurmukhi script used here is not of the standard type, but some local variant. The scales are numbered in common Arabic/Persian numerals as well as in Gurmukhi numerals, which are almost the same as the Devanagari numerals. The names of the zodiac signs are written in full in Arabic/Persian script; but in Gurmukhi are inscribed only the first syllables of the Panjabi names, which are derived from Sanskrit.

The astrolabe is not signed, nor dated, but the fact that it is engraved in Arabic/Persian and Gurmukhi scripts helps in determining its time and the place of its production. Two other instruments with Gurmukhi engravings are known. The first is an astrolabe made for Maharaja Narinder Singh of Patiala (r. 1845-1862) by Rahīm Bakhsh under the supervision of the astronomer Rishīkesh in 1850 (C031).[648] The second is an unsigned and undated double quadrant which belongs to the same period and milieu.

The present *Zarqālī* astrolabe too should be attributed to this period and provenance, namely the middle or the second half of the nineteenth century Panjab. The absence of *abjad* notation and in its stead the use of the standard Arabic numerals, as in the astrolabes by Bulhomal and his pupil Ghulām Qādir, support this identification. It must have been produced in some princely state in Panjab.

COMPONENTS

Main plate (d. 921, h. ?), ring and shackle. The diametral rule and the transversal rule are missing.

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647 Sarma 1996b.

648 Sarma 2012b.

FRONT

The astrolabe is made up of two brass plates riveted together. The low and small *kursī* is elegantly decorated with 'dagger-handles'; there are a small suspension shackle and a ring.

The degree scale on the rim on both sides is divided for each 5°, subdivided for each 1° and then for each 1/6°. Groups of 5° are labelled in Gurmukhi as well as in the common Arabic/Persian numerals, separately for each quadrant, both in clockwise and in anti-clockwise directions. Of three numbered rows, the upper and lower rows contain Arabic/Persian numerals, while the middle row is inscribed with Gurmukhi numerals.

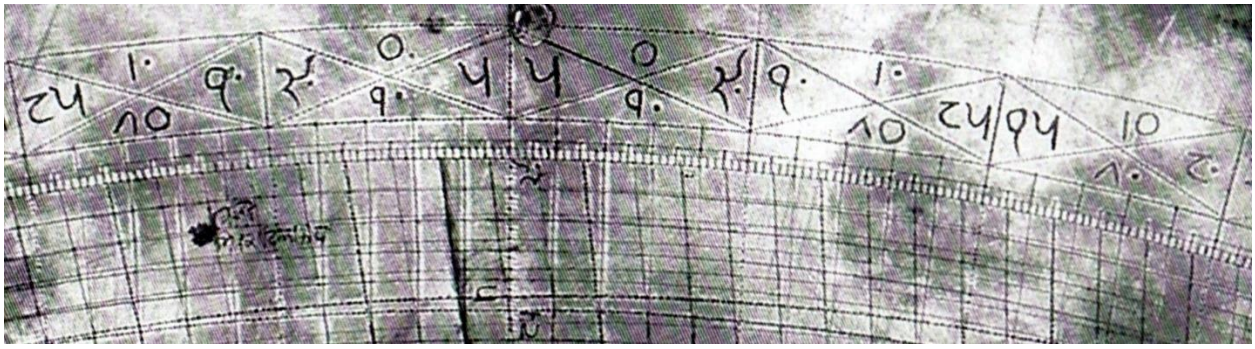


Figure B030.2 – Degree scale on the rim in the front (courtesy Professor G. L'E. Turner)

The *Zarqālī* projection engraved inside the degree scale is almost the same as that on Ḍiyā' al-Dīn's astrolabe.[649] Here also the celestial equator is represented by the vertical diameter. Circles of declination parallel to the equator and circles of right ascension perpendicular to the equator are drawn for every 1°.

The ecliptic is drawn as a straight line which passes through the centre of the plate and is inclined to the equator at an angle equal to the obliquity of 23;30°. In Ḍiyā' al-Dīn's astrolabe, the upper end of the line of ecliptic is to the right of the equator at 23;30° SE; here it is to the left at 23;30° NE. It is marked with the zodiac signs from Capricorn to Gemini in the north and from Cancer to Sagittarius in the south. While the Arabic names of the signs are written in full, only the first syllables of the Panjabi names are inscribed in Gurmukhi. Circles of latitude parallel to the ecliptic and circles of

649 The Christie's catalogue calls this a *Shakkaziyya* grid, but here two *Shakkaziyya* grids are superimposed one upon the other at an angle equal to the obliquity of the ecliptic, thus creating the *Zarqālī* grid.

longitude perpendicular to the ecliptic are drawn for each 1°. From the available photos, it is difficult to say how these four families of circles are numbered.

The Christie's catalogue states that about 40 stars are marked on the plate. Again from the available photos, it is not possible to see how they are named. Some stars like *ᶜAyyūq* seem to carry just the Arabic names; in some cases what is engraved in Gurmukhi is not the star name in Panjabi language, but a mere transliteration of the Arabic name in Gurmukhi script. For example, the star α Bootis is given the labels *Simāk Rāmiḥ* in Arabic/Persian script and *simāk rāma-* in Gurmukhi script.

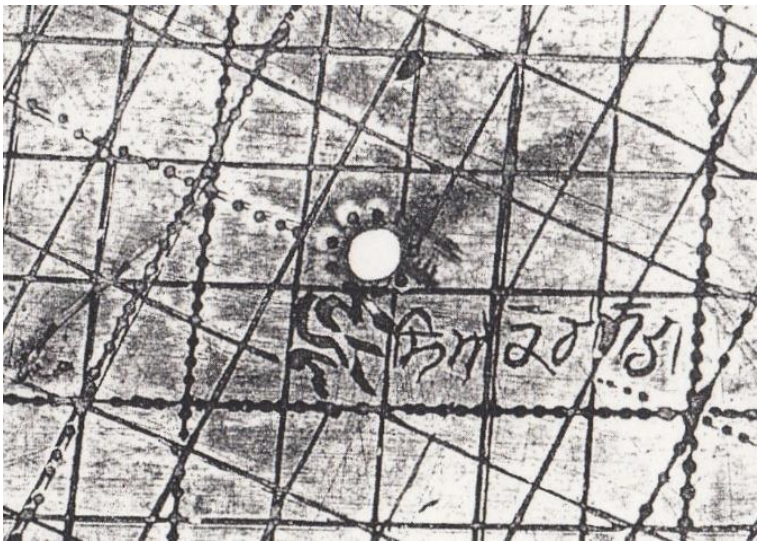


Figure B030.3 – The star pointer *Simāk Rāmiḥ* (from the Christie's catalogue)

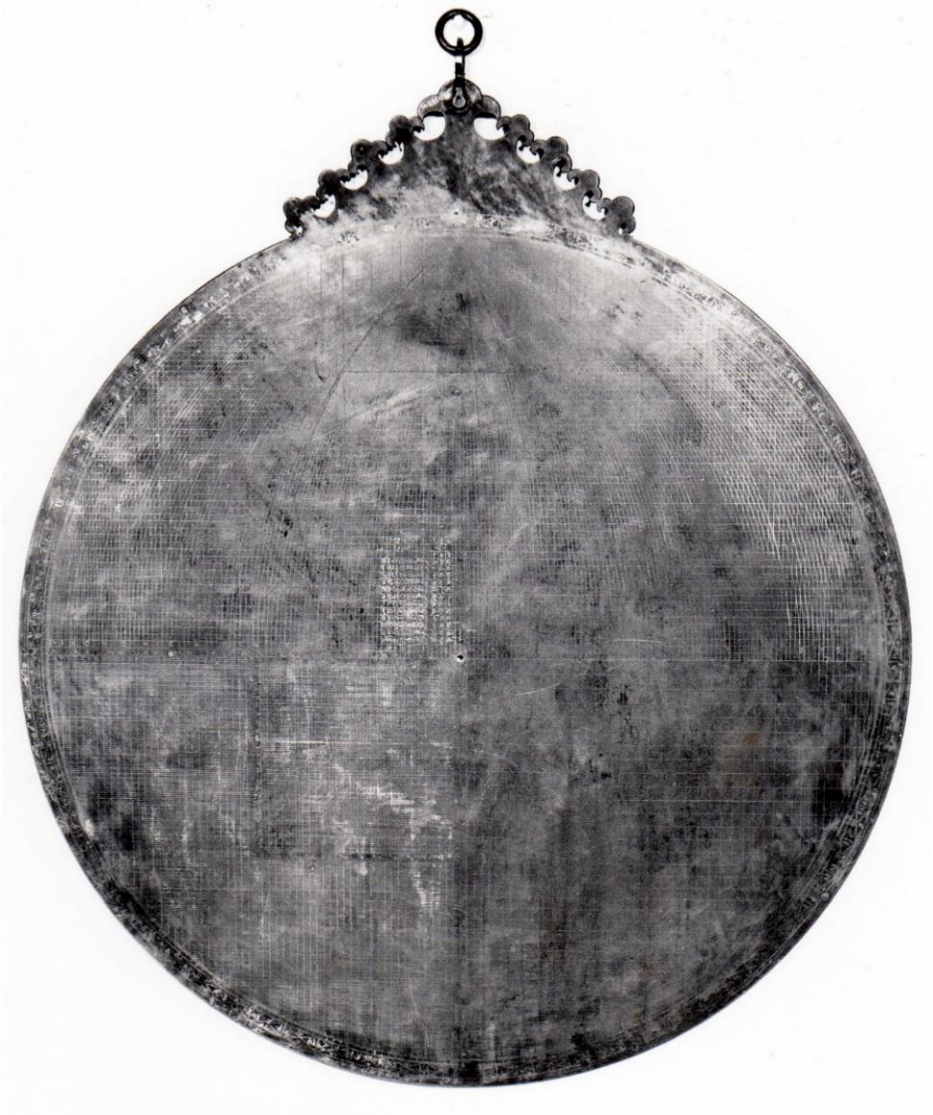


Figure B030.4 – Back of the astrolabe (courtesy Jeremy Collins)

BACK

The arrangement on the back is slightly different from that in Ḍiyā's astrolabe. In the two upper quadrants are drawn vertical and horizontal lines for every 1° and arcs are traced from the top of the vertical diameter to each division of 1° on the horizontal diameter.

The lower right quadrant appears to carry vertical and horizontal lines for every 2° while the lower left quadrant has vertical lines for every 1° and horizontal lines for every 1/6°. It must have been a stupendous task to draw these lines on such a large astrolabe.

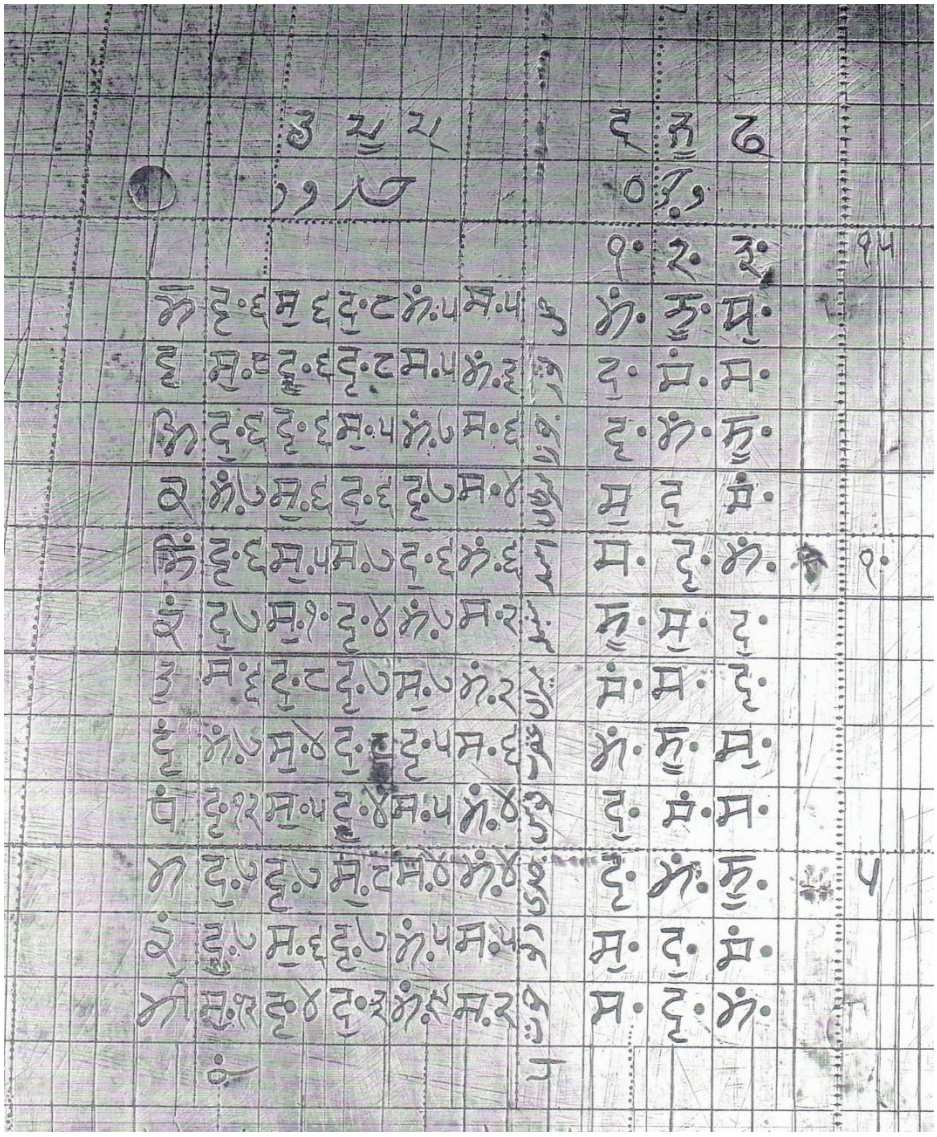


Figure B030.5 – Astrological tables on the back (from the Christie's catalogue)

At the apex of the upper left quadrant are engraved two tables displaying the astrological limits and faces. The first table has the heading *ḥudūd* in Arabic/Persian; above it is written the transliteration in Gurmukhi. The table consists of 7 columns; in the first column are the first syllable of the Panjabi names of the signs in Gurmukhi script; in the last column the full Arabic names of the signs in Arabic/Persian script. The five columns between these two columns are engraved in Gurmukhi script with the first syllables of the Panjabi names of the planetary regents and the numerical value of the limits in each cell.

The second table has the heading *wujuh* in Arabic/Persian and its transliteration in Gurmukhi above it. Here also the cells are filled with the first syllables of the Panjabi names of the planetary regents.

Finally, on the rim of the lower left quadrant, the names of some zodiac signs are inscribed in an irregular sequence; here also the Arabic names are inscribed in full and the Panjabi name only with only the first syllables. The names, starting from the horizontal diameter and going downwards, are as follows: *Saraṭān, Jadī, Mīzān, Ḥūt, Sunbula, Qaws, Jawjā',* (after a gap) *ᶜAqrab, Thawr, Sunbula, Ḥūt, Qaws, Jawzā', Jadī.*

PROVENANCE

Before 1992, the astrolabe was in a private collection, bearing the number M-289-7? which is painted on the throne. It came up for auction at Christie's, London, on 24 September 1992, lot 119; again at Sotheby's, London, on 21 September 2001, lot. 148; it was in a private collection in Milan in 2003 when Professor G. L'E. Turner sent me some photos. I understand that subsequently the collection was acquired by the Ahuan Gallery of Islamic Art, London; it is not known if the astrolabe is still with this Gallery.

C. SANSKRIT ASTROLABES WITH MULTIPLE PLATES

INTRODUCTION

1. SANSKRIT TEXTS ON THE ASTROLABE

Abū Rayḥān al-Bīrūnī states that he composed a book on the astrolabe in Sanskrit verses during his sojourn in India in the first quarter of the eleventh century:

> 'Most of their books are composed in *Śloka* [a particular verse meter in Sanskrit], in which I am now exercising myself, being occupied in composing for the Hindus a translation of the books of Euclid and of the Almagest, and dictating to them a treatise on the construction of the astrolabe, being simply guided herein by the desire of spreading science.'[650]

However, not a single manuscript of any of these three works mentioned above came to light. Moreover, scholars are of the view that Al-Bīrūnī's command of Sanskrit was not adequate enough for translating either the books of Euclid or the *Almagest* of Ptolemy into Sanskrit, not to speak of composing an independent work on the astrolabe in Sanskrit verse.[651] But it cannot be denied that he discussed the astrolabe and its variants in several of his works; therefore it is entirely probable that he may have brought an astrolabe with him and taught its working principles to his Hindu interlocutors. However, the response of his Hindu interlocutors, if any, is not recorded.

The first extant Sanskrit manual on the astrolabe was composed in 1370 at the court of Sulṭān Firūz Shāh Tughluq (r. 1351-1388) in Delhi by the Jaina monk Mahendra Sūri of Bharuch (Bhṛgupura). Impressed by the versatile functions of the astrolabe, Mahendra Sūri called it *Yantra-rāja,* 'the king of instruments,' and since then the astrolabe was known by this name in Sanskrit.[652]

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650 Bīrūnī 1910, I, p. 137.

651 Pingree 1975.

652 In 1428, Rāmacandra Vājapeyin, 1.11, attempted to give it another name *Sulabha* (the easy one), but this name did not gain currency.
sulabhākhya-yantrarājaṃ pūrvam eva pravadāmi |
yasmin karāmalakavad vidite viditaṃ bhaved viśvam ||
'I teach, at the outset, the king of instruments named *Sulabha.* When it is understood well, like the [small] myrobalan fruit on [one's own] palm, the entire universe becomes known.'

Mahendra Sūri's manual on the astrolabe, entitled *Yantrarāja*[653] consists of five chapters. The first chapter *Gaṇitādhyāya* provides various trigonometric and other tables necessary for the construction of the astrolabe. The second chapter (*Yantra-ghaṭanādhyāya*) discusses the components of the astrolabe. The construction of the common northern astrolabe (*saumya-yantra*) and the two other variants, viz. the southern astrolabe (*yāmya-yantra*) and the combination of the two (*miśra-yantra*) is described in the third chapter (*Yantra-racanādhyāya*), while the next one (*Yantra-śodhanādhyāya*) deals with the method of verifying whether an astrolabe is properly balanced or not. The final chapter (*Yantra-vicāraṇādhyāya*) discusses the use of the astrolabe as an observational and computational device and dwells on several problems in astronomy and spherical trigonometry which can be solved by it. Mahendra Sūri's pupil Malayendu Sūri wrote a detailed commentary on the *Yantrarāja* in about 1378. There survive today at least one hundred manuscript copies of the *Yantrarāja*, attesting to its great popularity.

Mahendra Sūri's manual was followed by a succession of other Sanskrit manuals. Thus between 1370 and the middle of the nineteenth century at least sixteen manuals were composed in Sanskrit on the astrolabe.[654] In 1423, Padmanābha, who is otherwise known as the inventor of the *Dhruvabhrama-yantra,*[655] composed a manual on the southern astrolabe which is a theoretical curiosity rather than of practical utility.[656] Five years later, in 1428, the polymath Rāmacandra Vājapeyin devoted the major part of his *Yantraprakāśa* to the astrolabe.[657]

The study of the astrolabe received a great impetus from Sawai Jai Singh in the early eighteenth century. Although he preferred huge masonry instruments for astronomical observations, he had great esteem for the astrolabe on which he composed a manual in Sanskrit prose under the title *Yantrarāja-racanā.* In particular, he seems to

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653 On Mahendra Sūri, see CESS, s.v., Pingree 1978b, Sarma 1999a, Sarma 2000, Plofker 2000. Some extracts from this work are reproduced with English translation in Apx.D1.

654 These texts are discussed in Sarma 1999a.

655 Sarma 2012a; see section L.

656 Cf. Ôhashi 1997, for the text, translation and commentary.

657 Cf. Sarma 2008b.

have popularized Sanskrit astrolabes with just one plate calibrated for the latitude of Jaipur at 27°.

Even after Jai Singh's time, the astrolabe continued to be discussed in some Sanskrit works, notably in the *Yantrarāja-kalpa* or °*ghaṭanā* of 1782 by Mathurānātha Śukla, who knew also Persian well, and was the librarian of the Sarasvati Bhavan Library of the Sanskrit College at Varanasi from 1813 up to his death in 1818. At the outset, he declares that his work is composed in a novel manner in prose and is accompanied by diagrams (*vicitra-racanā-citrācita*). Indeed his work is unique in that it is the only Sanskrit text of this genre instruments which contains detailed diagrams. His autograph copy, therefore, would have been very valuable, but it is not available, even in the Sarasvati Bhavan Library where he was the librarian. The only manuscript extant of this remarkable work was copied after his death in on Friday, 30 June 1820 (Manuscript 35245 of the Sarasvati Bhavan Library, Varanasi Sanskrit University). Unfortunately, some of the diagrams and tables in this manuscript are incomplete.

2. Sanskrit Astrolabes

These Sanskrit manuals on the astrolabe must naturally have been accompanied by the production of Sanskrit astrolabes. But the earliest surviving Sanskrit astrolabe was the one which was produced in 1605 at Ahmadabad in Gujarat (C001). This large and elaborate astrolabe suggests that it is not the first or earliest attempt at the production of Sanskrit astrolabes. There must have been a long line of Sanskrit astrolabes before this. There survive today some 130 Sanskrit astrolabes which were made in the seventeenth, eighteenth and nineteenth centuries in Gujarat and Rajasthan. Chronologically the last traditional astrolabe (as distinct from modern copies or fakes) bears a date corresponding to 1903.

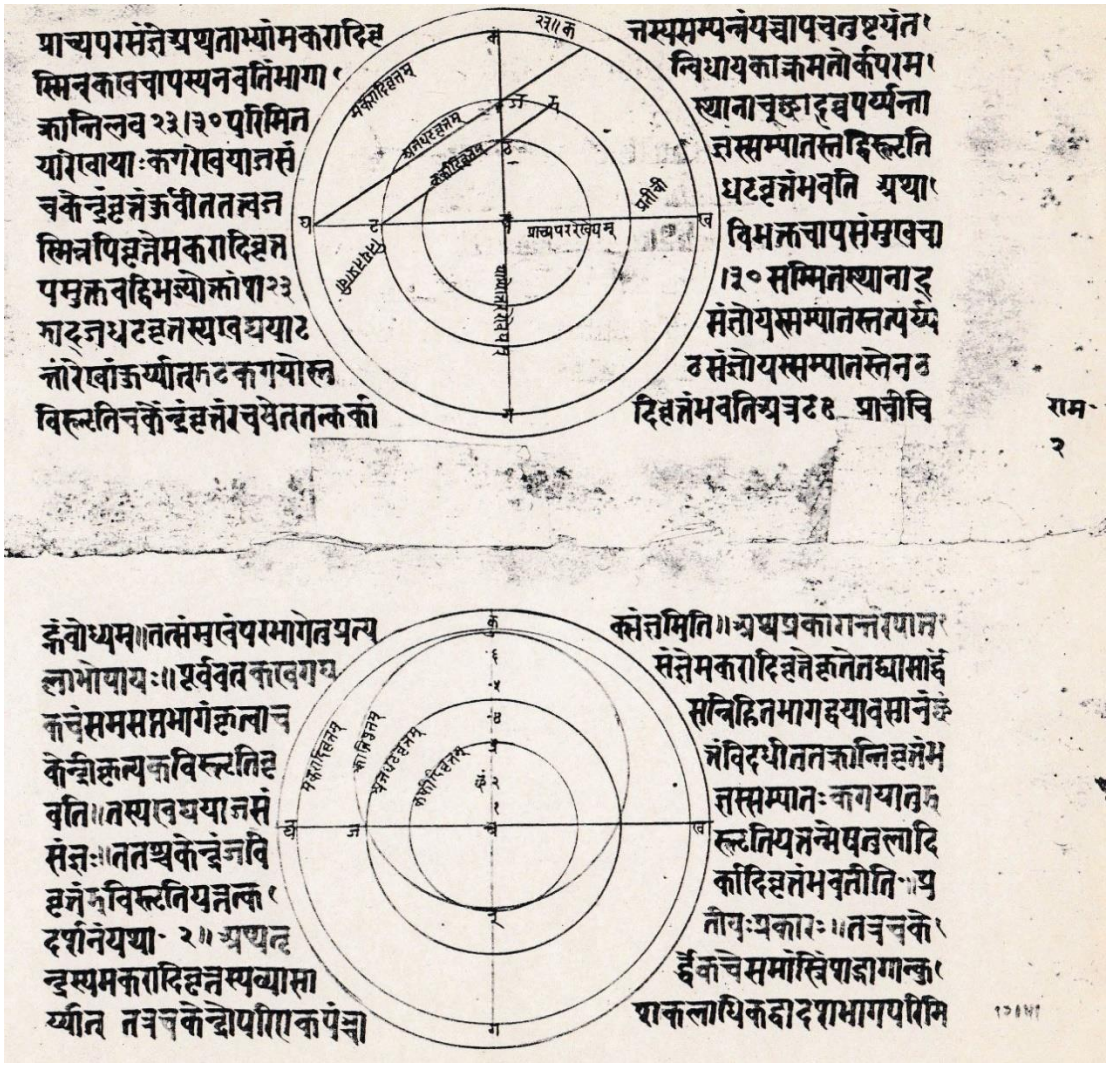


Figure C1 – Two diagrams from *Yantrarāja-kalpa* showing how to draw the circle of the ecliptic (*f*2*v* and *f*3*r* from MS 35245 of Varanasi Sanskrit University)

Until now scholars did not have the opportunity to examine sufficiently large number of Sanskrit astrolabes together. They saw just a few specimens and noticed that these Sanskrit astrolabes did not display any influence of the Lahore astrolabes and therefore concluded that these were produced on the basis of illustrations in Arabic/Persian manuscripts. Thus, writing in 1957, Francis Maddison observes:[658]

> ‘Although there are Hindu treatises on astrolabes (derived from Islamic sources) from as early as the fourteenth century, there do not appear to be any surviving instruments engraved in Sanskrit earlier than the astronomical activity under Jai Singh (see Kaye pp. 3, 69 et passim). Many Indian

658 Maddison 1957, p. 30.

> astrolabes resemble in design the Indo-Persian instruments, inscribed in Arabic and Persian, of the Mogul period. This astrolabe [D019 MHS], like that formerly in Plimpton Collection (Gunther, op. cit., no. 98, fig. 115) [D007] which it closely resembles in many respects, probably dates from the eighteenth century (cf. also the astrolabe, belonging to the Royal Asiatic Society, described by Morley …) [C012]. Nevertheless it differs from the Mogul-inspired instruments and its maker may have been guided by an early Islamic treatise on the astrolabe, a tradition deriving from such source, or have copied partially an early Islamic instrument. The design of the *rete* and its star-pointers, the drawing of the azimuth lines *below* the horizon, and the simplicity of the engraving on the back, are all features variously associated with early Syro-Egyptian astrolabes and the somewhat later early Persian instruments.'

Anthony Turner elaborates on this hypothesis and goes on to declare:

> 'Among the [Indian] instruments that survive, we may discern two traditions. The first of these stemmed from the manufactory established at Lahore already described. The second is quite different, being exemplified by a group of instruments inscribed in the *devanagari* script of northern India and characterized by a marked resemblance in their design, both on the *rete* and on the back, to the earliest astrolabes known from Syro-Egypt and Persia … This circumstance suggests that their design was influenced by illustrations in the copies of the early treatises on the astrolabe such as those by as-Sijzī, al-Bīrūnī … or aṣ-Ṣūfī.'

He even reproduces an illustration from a manuscript of the Bodleian Library, Oxford, as an example of manuscript illustration which must have been the basis of the design of the Sanskrit astrolabes.[659]

These two eminent experts on the astrolabe admit the possibility of illustrated manuscripts of Arabic or Persian texts on the astrolabe being available in India, but do not consider the possibility that some specimens of Syrian-Egyptian astrolabes

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[659] Turner 1984, p. 28.

themselves could have been available in India. After all it is easier to copy an actual astrolabe rather than to make an astrolabe on the basis of illustrations in Arabic manuscripts unless one knew Arabic very well. In fact, scores of Arabic and Persian manuscripts on the astrolabe exist even today in India and Pakistan, but also several Syrian and Persian astrolabes are extant in Indian collections.[660] After the establishment of the Delhi Sultanate, Muslim scholars began to migrate in large numbers from Central Asia to the court of Delhi and some of them brought with them manuscripts as well as astrolabes. Some of these early Kufic astrolabes are still extant in India, e.g. two astrolabes made by al-Sirāj of Damascus in the years 623 AH (AD 1226) and 626 AH (AD 1228-29) are at Hyderabad[661] and Rampur[662] respectively. Such early astrolabes must have served as models for Sanskrit astrolabes and not Arabic manuscripts. Outside the limited circle of Muslim scholars, Arabic or Persian manuscripts would not be easily accessible (both physically and linguistically) to Hindu astronomers and certainly not to Hindu metal workers.

2.1. Social Milieu of Sanskrit Astrolabe Production

Moreover, there is a basic difference between the Sanskrit astrolabes and the Islamic astrolabes. In Islamic culture, astrolabe making was not just a craft but a learned profession; the astrolabists were not mere metal workers, but also scholars well read in the literature on the instruments, well versed in astronomy, spherical trigonometry and other sciences. Here the same person prepared the technical design and then executed it from brass sheets. In the Hindu context, the technical design was drawn by the upper caste astronomer, who was usually a Brahmin, and the actual manufacture was done by the lowly brass worker who may not even be literate. He managed to draw the lines and curves reasonably well, but often made mistakes in orthography.

In many cases, these must have been one-time exercises, that is to say, a brass worker prepares an astrolabe because the local astronomers had requested, but does not cultivate the art or science of the astrolabe any further. On the other hand, when an

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660 Cf. Y001 and Y002.

661 Sarma 1996a, pp. 23-24, pl. 12.

662 Sarma 2003, pp. 25-33.

artisan specializes in a particular trade, he passes on his skills to his descendants and thus families begin to specialize in a particular product and give it their characteristic imprint, just as the members of the Lahore family did. But instrument making did not develop into a specialized profession among the Hindus.

Consequently, the Sanskrit astrolabes produced by these artisans did not turn out to be precision instruments of observation and measurement or objects of beauty like the Indo-Persian astrolabes; they served the limited didactic purpose of demonstration. Therefore, it is not appropriate to compare Sanskrit astrolabes with the astrolabes of the Lahore family.

2.2. Centres of Production

The earliest Sanskrit astrolabes were produced in Gujarat on the west coast of India. Because of the maritime contacts with Arab countries, it was in Gujarat that the first exchanges took place between the Islamic and Sanskrit intellectual traditions; thus the earliest Sanskrit manuals for learning the Persian language and first Sanskrit texts on Islamic astrology were composed in Gujarat.[663] Moreover, Mahendra Sūri who composed the *Yantrarāja,* the earliest Sanskrit manual on the astrolabe in 1370, hailed from Bharuch (Bhṛgupura) in Gujarat.

As mentioned above, the earliest extant Sanskrit astrolabe (C001) was made at Ahmedabad in 1605, i.e. much before the time when the Lahore astrolabes became fully developed in the work of Qā'im Muḥamad (*fl.* 1624-1635), Muḥammad Muqīm (*fl.* 1621-1659) and Ḍiyā' al-Dīn Muḥammad (*fl.* 1637-1680). Two other specimens C008 and C009 were made at Surat, also in Gujarat. Indeed, all the Sanskrit astrolabes of the seventeenth century appear to have been produced in Gujarat, although we do not know the exact locations in each case.

In the eighteenth century astrolabe production gradually shifted to the neighbouring Rajasthan; it is partly due to the interest Sawai Jai Singh of Jaipur took in the astrolabe, but other princely courts also patronized astrolabe production. While Jaipur and Kuchaman were the major centres of production, astrolabes were produced also at other places like Jodhpur, Bundi and Tonk, all in Rajasthan.

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663 Sarma 2002; Sarma 2009c.

Very few extant Sanskrit astrolabes emanate from places outside Gujarat and Rajasthan. An interesting case is C004. It was made in 1638 at Varanasi, but the name of the man who made it, Ṭhākura Murārajī Kuarajī, looks like a Gujarati name.

Sakhārāma Jośī is said to have made 1790 astrolabes for the latitude of Kadoli at 17;21° (D056) and for the latitude of Kaḍegaḍḍi at 17;42° (D057), both in Maharashtra, and several other types of instruments, but none of these are extant now.

Four astrolabes with single plates (D052 to D055) are designed for latitude 30°. There is no major town on this latitude in Rajasthan. Possibly these astrolabes were made either in Kurukshetra or in Thanesar, both situated roughly at 29;58° N, 76;50° E.

In the middle of the nineteenth century Lālah Bulhomal Lāhorī produced several kinds of instruments, some with Arabic/Persian and others with Sanskrit legends.[664] Three astrolabes with multiple plates (C028, C029, C030) and two with single plates (D069 and D070) can be attributed to him on stylistic grounds. Finally, a unique astrolabe with Gurmukhi script was made at Patiala in Panjab (C031).

Thus the production of Sanskrit astrolabes was mainly concentrated in Gujarat and Rajasthan. Even so, compared to the Indo-Persian astrolabes, Sanskrit astrolabes were produced at more centres and more people were associated with their design, manufacture and patronage.[665] Consequently, they also display great variety of styles.

2.3. Varieties of Sanskrit Astrolabes

Sanskrit astrolabes can be classified into two broad categories: those with plates designed for several different latitudes and those with a single plate calibrated for a single latitude. The second category will be discussed in section D. There is a small group of astrolabes, which can be treated as a third category, viz., Islamic astrolabes to which Sanskrit labels were added so that these could be used by people who cannot read Arabic or Persian. These will be taken up in section E.

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664 Cf. Sarma 2015b.

665 For an alphabetical directory of the makers, designers and patrons of Sanskrit astronomical instruments, see Sarma 2010.

3. Main Features of Sanskrit Astrolabes with Multiple Plates

Since the production of the Sanskrit astrolabes did not become a specialized profession, there did not develop distinct styles in design and ornamentation and the Sanskrit astrolabes remianed by and large utilitarian devices with plain suspension brackets and retes. Alidades are usually equipped with sighting tubes. On the plates, not only the latitude and the duration of the longest day are mentioned, but also other functions of the latitude like the length of the equinoctial shadow. However, plates of ecliptic coordinates occur very rarely and plates of multiple horizons occurs occasionally. More striking and very intriguing is the fact that in nearly half of the Sanskrit astrolabes with multiple plates, there are empty or unfinished areas; on some, a circular grid is drawn but not filled with the geographical gazetteer or rectangular grids are made and then left empty and so on. If it is so in one or two cases, one can say that the engraver left the job midway; but this does not explain the large number of cases in astrolabes produced in three centuries and at several different centres of production.

3.1. Suspension Bracket

In some early Islamic astrolabes, the Throne Verse from the Qur'ān was engraved on the suspension bracket and therefore the suspension bracket came to be called kursī (throne) in Islamic parlance. The Sanskrit writers merely called it the 'crown' (kirīṭa).[666] In Sanskrit astrolabes, the crown is generally high and often solid with lobed profiles, occasionally with the two decorative holes as in the early mid-eastern astrolabes. In some cases, the front side of the solid crown is decorated by floral design in bas relief (C008, C010, C011, C012, C013). Towards the end of the nineteenth century, Lakṣmīnārāyaṇa of Kuchaman introduced a pleasing inverted lotus motif into the crown (C034, C035, D034, D035, D036 etc.) and this motif became the distinguishing feature of the astrolabes produced at Kuchaman. A few astrolabes have simple fretwork, but the most outstanding fretwork can be seen on the crown of the Gurmukhi astrolabe made by Rahīm Bakhsh for the Maharaja of Patiala in 1850 (C031) and in the single plate astrolabe commissioned by Mannālāla at Jaipur (D005).

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666 Since the astrolabe was called *Yantra-rāja,* 'king of instruments,' it is but appropriate to call the upper part the 'crown'.

3.2. Degree Scales on the Limb and Back

Mahendra Sūri lays down that the limb of the astrolabe (*pālī, pāli-vṛtta*) should be numbered in 6s, from 1 to 60, to measure the 60 *ghaṭīs* in the day-and-night.[667] Several astrolabes follow this system of having the *ghaṭī* scale on the limb. But other methods of numbering are also followed in Sanskrit astrolabes, such as counting by 6s from 6 to 360, or from 6 to 90 in each quadrant, or from 1 to 15 in each quadrant. In some astrolabes, the limb is numbered in 5s as well.

On the back, the altitude scales on the upper half of the rim are generally marked in 6s from 6 to 90, but other patterns are also employed.

3.3. Rete

Unlike in the Lahore astrolabes, in the retes (*bha-patra*) in most of Sanskrit astrolabes, the equator ring is generally represented, either in full or just as the lower segment, for the simple reason that it can be made to support a number of star pointers as in C001, C007, C015 etc. The influence of the Lahore astrolabe can be perceived in a small number of astrolabes; here the equator ring is not represented at all, but the solstitial bar is fully represented. In the lower half, i.e., between the rings of Cancer and Capricorn, the star pointers are joined by an arabesque tracery (C008 - C013). Two of these astrolabes (C008 and C009) carry also the graph of the solar meridian altitude on the back.

3.3.1. The 'bird in the cage' pattern

While the retes in the Sanskrit astrolabes are generally very austere, some astrolabe retes display an agreeable pattern that can be called the 'bird in the cage' pattern. Here the position of the star *Abhijit* (α Lyrae) is indicated by the tip of the beak of a bird perched on the small ring around the central hole. The figure of the bird is framed by two creepers that arise from the central ring, encircle the bird, and then entwine together for a short while along the south-north solsticial bar, then branch off and, after touching the inner periphery of the ecliptic ring, bend downwards and

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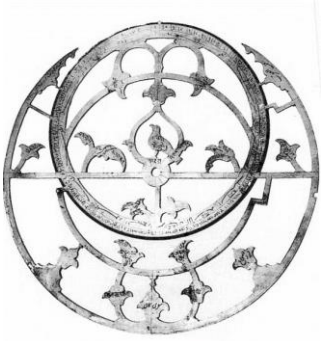
667 Mahendra Sūri, 3.4: 'Having drawn three [concentric] circles on the limb (*pālī*), in the first circle mark the *ghaṭīs,* starting from the middle of the crown. [In the middle circle] mark 360 degrees at desired intervals. Below that, draw the lines of their subdivision.'

terminate in three-petalled flowers just as they reach the upper part of the equator ring. The bird then looks as if it is sitting inside a cage formed by the two creepers.

Besides the 'bird in a cage' pattern in the upper part of the rete, the configuration of the stars directly below has also a distinct pattern. On the left, just above the equator ring is a flower the three petals of which indicate the stars *Pretaśira* (β Persei), *Brahmahṛdaya* (α Aurigae) and *Manuṣya-pārśva* (α Persei). This flower is counterbalanced on the right hand side by a similar flower, but with no stars marked on it. Below the ring of the equator, the three groups of (1) *Rohiṇī* (α Tauri), *Mithuna-vāma-hasta* (γ Orionis) and *Mithuna-dakṣiṇa-pāda* (κ Orionis), (2) *Lubdhaka* (α Canis Majoris), (3) *Lubdhaka-bandhu* (α Canis Minoris) and *Agasti* (α Carinae) are arranged in three creepers rising from the ring of Capricorn symmetrically on both sides of the meridian. Likewise the flower containing the pointer for *Mahāpuruṣa* (α Hydrae) on the right is counter-balanced by a flower on the left which however does not contain any star pointer.

This pattern is significant because it occurs at least in nine Sanskrit astrolabes, albeit with slight variations, produced in western India between 1618 and 1884, namely C002, C006, C014, C017, C024, D009, D058, D071 and E002.

Interestingly, this pattern occurs for the first time in India in the bilingual astrolabe made by Pandit in 1616 (B002). Both Pandit as well as the makers of these Sanskrit astrolabes derive inspiration from a common source which is yet to be identified.[668]



B002



C002



C006

668 Cf. Sarma 2011a.



C014 C020 C024

Figure C2 – Retes with the ‘bird in the cage’ pattern

3.3.2. Stars on the Rete

In his *Yantrarāja,* Mahendra Sūri gives a list of 32 astrolabe stars with their celestial longitudes (*dhruvaka*) and latitudes (*vikṣepa*) for the year 1370.[669] Many of the names are literal translations of the Arabic names (e.g. *Matsyodara* from *Baṭn al-Ḥūt,* ‘the belly of the fish’, β Andromedae), some are Sanskrit names of the lunar mansions (e.g. *Rohiṇī,* α Tauri) and a few others are star names occurring in earlier Sanskrit texts (e.g. *Brahma-hṛdaya,* α Aurigae).

Most problematic, however, is Mahendra Sūri’s designation of α Canis Majoris by the double name *Ārdrā-Lubdhaka.*[670] *Ārdrā* and *Lubdhaka* are generally treated as two distinctly separate stars in Sanskrit astronomy, the former denoting α Orionis (Betelgeuse) and the latter for α Canis Majoris (Sirius). A large majority of Sanskrit astrolabes follow this nomenclature.

However, a small number follow Mahendra’s nomenclature. On the rete of astrolabe made for Maṇirāma in 1644 (C006), the star names are engraved in an abbreviated form, but always followed by the serial number from Mahendra’s list. Here the star pointer for Sirius carries the label *ā 14* for *Ārdrā-Lubdhaka.* The name is shortened as *Ārdrālu* in C001, as *Ālu* in C002, C008 and C010; and as *Ārdrā* in C012, C014, C015 and D071. The full name *Ārdrā-Lubdhaka* occurs in C017 and C020.

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669 Mahendra Sūri, pp. 1.22-43; cf. Pingree 1978b, p. 628. See also Apx.D1.

670 The 14th star in the list (p. 26, verse 28) is *ārdrā*. In the tables appended to the commentary, this star is mentioned as *ārdrā-lubdhaka* (pp. 37, 41) and the corresponding Arabic name is given as *sorāmānī* or *serāimānī.* This is clearly an incorrect transcription of *shiʿrā yamānī*, i.e. α Canis Majoris (Sirius).

While Mahendra Sūri changes the traditional name given to Sirius from *Lubdhaka* to *Ārdrā-Lubdhaka,* he retains the original name *Lubdhaka* in the designation he gives to Procyon which he calls *Lubdhaka-bandhu,* 'friend', 'kinsman' or 'companion of *Lubdhaka*', i.e., Sirius. Strictly speaking, Mahendra should have called the star *Ārdrā-Lubdhaka-bandhu.* Be that as it may, in the hands of the incompetent engravers this star name assumes bizarre forms, sometimes as *Lubdhaka-vadhu* (Lubdhaka's bride) and other times as *Lubdhaka-vadha* (murder of Lubdhaka). Even the conjunct consonant in *Lubdhaka* gives difficulties to the engravers who often transcribe it as *ludhvaka.*

Occasionally star names are engraved on wrong pointers, but two anomalies deserve attention. The star name *Siṃha-hṛdaya* means the 'heart of the lion', being a literal rendering of the Arabic *Qalb al-Asad* (α Leonis). Generally, *Siṃha-hṛdaya* and *Maghā* are treated as alternative designations of α Leonis. However, on some astrolabes (C032, D008, D011, D014, D015 and D020), both names occur; while *Maghā* is engraved on the pointer of α Leonis, *Siṃha-hṛdaya* is engraved on a star pointer to the right of ζ Ursae Majoris (Arabic *ʿAnāq,* Sanskrit *Vaśiṣṭha*); it is not clear which star is denoted by *Siṃha-hṛdaya* in these cases.

Second, the name *Śatabhiṣā* (λ Aquarii) is wrongly inscribed on the pointer for the star *Kukkuṭa-puccha* (Arabic *Dhanab al-Dajājah,* α Cygni) on eight astrolabes (A064, C002, C004, C024, D051, D062, D063 and D071).

3.4. Plates

On the plates (*akṣa-patra, akṣāṃśa-patra*) altitude circles (*unnatāṃśa-valaya*) are drawn at intervals which vary according to the size of the astrolabe; but azimuth arcs (*digaṃśa-vṛtta*) are often omitted. The situation of the hour lines (*horā-vṛtta*) is more complex.

Unlike in the Islamic world and Europe where time was measured in Middle Ages in unequal hours which vary according to seasons, in India time is always measured in *ghaṭīs* of 24 minutes' duration. Mahendra Sūri teaches the method for measuring time in equal *ghaṭīs* as follows. First measure the sun's altitude with the alidade on the back of the astrolabe. Note the sun's longitude (*ravy-aṃśaka*) for the day from some almanac and locate that point (S) on the ecliptic in the rete. Rotate the rete so that the point S touches the eastern horizon. Note where the index at the first point of Capricorn (*mṛgāsya*) touches the degree scale on the limb. Then rotate the rete once again so that

S rests on the altitude circle corresponding to the sun's altitude just measured. Note again where the Capricorn index touches the degree scale on the limb. The interval between the two positions is the altitude in degrees of arc. Divide it by 6. The result in *ghaṭīs* is the time elapsed since sunrise.[671] In order to simplify this procedure, Mahendra Sūri recommends that that degree scale on the limb should be divided into groups of 6° and numbered from 1 to 60.

Therefore, for the purpose of measuring time, it is not necessary to have the lines of unequal hours and those of equal hours on the lower half of the plates. Even so, Mahendra Sūri mentions that curves for unequal hours (*viṣama-horās*) as counted from the western horizon should be drawn on plates.[672] More than half of the Sanskrit astrolabes carry just lines for unequal hours (*viṣama-horā*); less than half of such astrolabes have also lines for equal hours (*sama-horā*) drawn from the western horizon. A few astrolabes have lines for equal hours drawn from both western and eastern horizons. Lines for equal *ghaṭīs* could easily be drawn; in fact, about a dozen Indo-Persian astrolabes have such lines,[673] but no Sanskrit astrolabe does so.

Then why did the makers of Sanskrit astrolabe draw hour lines at all? The simple answer is because such lines are engraved on Islamic astrolabes. Of course, one can measure time in equal hours of 60 minutes and convert them easily into *ghaṭīs* of 24 minutes by multiplying the hours by 2.5.[674] As for the lines of unequal hours on the Sanskrit astrolabes, in theory these can be used for measuring unequal time units of *prahara* or *yāma.* In popular time keeping in India, the variable duration of the day time is divided into four parts called *prahara-s* and the variable duration of the night into

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671 Mahendra Sūri, 5.3-4ab.

672 Mahendra Sūri, 3.9.

673 See A. Introduction, 2.4.1; Figure A3.

674 Although conversion of hours into *ghaṭīs* and vice versa is very easy, it is highly intriguing that many astrolabe makers could not convert correctly. As pointed out in A. Introduction 2.4.1, on some Indo-Persian astrolabes the duration of the longest day is given in both these units, often incorrectly. These astrolabes are A014, A015, A051, A064, A067, A072, A096, A104 and A112. In some Sanskrit astrolabes, the duration of the longest day is given in *horā-s* (hours) and not in *ghaṭī-s.* In C007, the values are given in both the units, but they do not match; cf. Figure C007.2.

four parts called *yāma-s* or also *prahara-s.*[675] Thus with the astrolabe, time can be first measured in unequal hours and then by dividing the hours by 3, *prahara-s* or *yāma-s* can be obtained. But these units are not mentioned in any Sanskrit text on astronomy or mathematics and there is no record of an astrolabe being used to measure these units.

3.4.1. Geographical Data engraved on the Plates

On the plates of the Indo-Persian astrolabes, the latitude (*al-ᶜarḍ*) and the hours of the longest day (*al-sāᶜāt*) are engraved in the middle, to the left and right of the meridian line. On Sanskrit astrolabes are engraved, besides the latitude (*akṣāṃśa*) and the length of the longest day in *ghaṭīs* (*parama-dina*), also the length of the midday equinoctial shadow (*chāyā*) and the name of the locality. Indeed, Mahendra Sūri recommends that these four items be inscribed on the astrolabe plates.[676] The length of the midday equinoctial shadow and the duration of the longest day are dependent on the latitude and are its functions. Sanskrit astronomical texts provide formulas for converting any one of the three values into another parameter.[677] Several astrolabes follow this recommendation.

In addition to these four parameters, the rising times of the signs at these latitudes (*svodaya-s*) are given on the plates of C016 and the length of the hypotenuse (*karṇa*) of the right-angled triangle formed by the gnomon and its shadow at the equinox is mentioned on the plates of C024. The only surviving plate of C019 carries still more information, namely the accessional differences (*cara-khaṇḍa*) and the names of localities whose latitudes are close to the latitude of the plate. In C031, the latitude, the longitude, the names of the localities with proximate latitudes, the climate and the planetary regent of the climate are mentioned. On the other hand, in some astrolabes,

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675 Kauṭilya, *Arthaśāstra,* 1.19.6-8, lays down that at the royal court the variable day time should be divided into 8 parts and the night into another 8 parts, by means of a water clock or a gnomon; see also Bīrūnī 1910, pp. 337-338.

676 Mahendra Sūri, 3. 8: 'On both sides, i.e., in the eastern and the western sides of the meridian or midday line (*madhyāhna-rekhā*) situated inside the tropic of Cancer, one should write successively the equinoctial shadow (*bhā*), maximum daylight (*paramadina*), the name of the locality (*deśābhidhāna*) and the degrees of latitude (*akṣa-bhāga*).'

677 Mahendra Sūri, 3.25-27, gives formulas for converting local latitude into the duration of the longest day and the longest day into the equinoctial shadow.

only the latitude is mentioned, but not the longest day or the length of the shadow are given.

3.4.2. Plates of Ecliptic Coordinates and of Horizons

The Islamic astrolabes generally contain, besides the plates calibrated to specific latitudes, one more plate, one face of which is designated as *ṣafīḥa mīzān al-ᶜankabūt* (plate for the measures on the rete) and the other as *ṣafīḥa al-afāqiyah* (plate of horizons). The former is a projection for the latitude which is the complement of the obliquity of the ecliptic, i.e. 90-23;30 = 66;30˚ or roughly 66˚. This plate enables us to measure the longitudes and latitudes of all the stars marked on the rete. Mahendra does not mention it or the plate of horizons. A few astrolabes contain this plate (e.g. D008, D009, D010 etc.), but no special designation was coined for this plate.

The plate of horizons contains the projections of families of horizons at several latitudes and is used for determining the times of sunrise and sunset at latitudes other than one's own, or to determine the latitude from the time of sunrise or sunset. This plate is included in some Sanskrit astrolabes, where it is called *sarvadeśī* or *sarvadeśī-patra*.

3.5. Geographical Gazetteer

About half of the astrolabes carry geographical gazetteers on the inner side of the mater, but of these just eight have longitudes (*deśāntara* or *tūlāṃśa,* from the Arabic *al-ṭūl*) marked on them (C008 - C013 and C015). Other gazetteers carry only the latitudes (*akṣāṃśa*). In some like C006, C023, C024 and C029) a grid is drawn but not filled in.

These gazetteers are mainly derived from Indo-Persian and other Islamic astrolabes and copied most carelessly with the result that non-Indian names are barely recognizable. In Sanskrit there are extensive geographical tables generally providing the latitudes (*akṣāṃśa*) and the length of the noon equinoctial shadow at these latitudes (*akṣabhā* or *palabhā*).[678] These have not been used in compiling the gazetteers on Sanskrit astrolabes.

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678 Pingree 1996.

Moreover, Malayendu Sūri's commentary (ca. 1378) on the *Yantrarāja* of Mahendra Sūri contains a list of 77 places with their latitudes.[679] Kamalākara's *Siddhānta-tattva-viveka* (1658) has a list of 20 localities with their latitudes and longitudes.[680] The *Yantraprakāra,* which was compiled at the court of Sawai Jai Singh of Jaipur, has a list of 65 towns with their latitudes and longitudes.[681]

3.6. Back

Mahendra Sūri enjoins that the four quadrants (*pakṣa*) on the back of the astrolabe should be filled with the sine graph (*jyā*), the declination arcs (*apakramajā- vibhāgāḥ*) and shadow squares (*śaṅku-prabhā*).[682]

Accordingly, on most of the astrolabes, the upper left quadrant is engraved with a sexagesimal sine graph and the upper right quadrant with declination arcs with the names of the corresponding signs inscribed along the two radii. In two astrolabes (C007 and C014) the declination arcs are without labels and in two others (C017 and C029) radial lines are drawn for each 5° of arc. In four astrolabes (C001, C010, C023 and C024) there are universal horary quadrants. On six astrolabes there are graphs of the meridian altitude of the sun for different latitudes, a feature borrowed from the Lahore astrolabes: C008 (for lat. 22°), C009 (22°), C015 (32°), C020 (27° and 32° ?), C021 (27°, 29°, 32°), C023 (27°, 29°, 32°) and C024 (two graphs without labels).

Double shadow squares are engraved on most of the astrolabes; just single squares on C010, C011 and C012. There are no shadow squares on C028 and C029 which are attributable to Bulhomal of Lahore. There are no shadow squares either on the Indo-Persian astrolabes made by him (B021) or attributable to him (B022 and B023).

3.6.1. Trigonometric Tables

Unlike the Indo-Persian astrolabes, some of the early Sanskrit astrolabes carry on the back sine tables (C004), tables of gnomon shadows (C003 and C006) and tables of declinations (C004, C006, C010 - C012).

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679 Malayendu Sūri, pp. 18-19; see also Pingree 1978b, pp. 626-627.

680 Kamalākara, *Siddhānta-tattva-viveka,* p. 57; see also Pingree 1978b, p. 616.

681 Sarma 1986-87b, pp. 115-116.

682 Mahendra Sūri, 3.3.

3.6.2. Astrological Tables

On the other hand, astrological tables occur rarely on Sanskrit astrolabes. In a few astrolabes, the names of zodiac signs (*rāśi*) and those of the lunar mansions (*nakṣatra*) are engraved in two concentric semi-circles as in the Indo-Persian astrolabes.

Interestingly, in C031 only 27 names of the lunar mansions are engraved, omitting *Abhijit.* In this astrolabe, there are also other astrological tables based on Sanskrit astrology: regents of the 7 planets, regents of the 12 zodiac signs, regents of the various kinds of subdivisions of the zodiac signs, such as when zodiac signs are divided in two parts of 15° (*horā*), three parts of 10° (*dreṣkāṇa*), 5 parts of 6° (*pañcāṃśa*), 7 parts of 4 2/7° (*saptāṃśa*), 9 parts of 3 1/3° (*navāṃśa*) and 12 parts of 2 ½° (*dvādaśāṃśa*).

Astrological tables derived from the Islamic tradition like the limits of the signs (*hudūd,* Sanskitized as *haddā*) and regents of the decans (*wujūh*) are engraved on the astrolabes attributable to Lālah Buhlomal of Lahore (D028, D029, probably also D030).

Moreover, there is one more table in these astrolabes, where zodiac signs are arranged in a zigzag fashion in groups of three as shown below:

Aries	Taurus	Gemini
Virgo	Leo	Cancer
Libra	Scorpio	Sagittarius
Pisces	Aquarius	Capricorn
278 *palas*	299 *palas*	323 *palas*

When arranged in this manner, each column represents zodiac signs having the same right ascension, i.e. the same rising time at the equator (*laṅkodaya*). Thus the four signs Aries, Virgo, Libra and Pisces rise at the equator in 278 *palas* or *vināḍis* (= 1;51,36 hours); the four signs Taurus, Leo, Scorpio and Aquarius rise in 299 *palas* (= 1;59,40 hours) and the four signs in the third column Gemini, Cancer, Sagittarius and Capricorn rise in 323 *palas* (= 2;08,44 hours).[683]

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683 Cf. Varāhamihira, 4.30:
vasu-muni-pakṣā vyekaṃ śatatrayaṃ tridvikāgnayāś cāṅkāḥ |
paratas ta eva vāmāḥ ṣaḍ utkramāt te tulādy-ardhe ‖
'The *vināḍīs* of right ascensional difference for the three signs from Meṣa are 278, 299 and 323. In the next quadrant they are the same in the reversed order, *viz.* 232, 299, 278. In the half of ecliptic

This table occurs also on sine quadrants; sometimes the names of the signs are written in full, sometimes they are indicated by the serial number as on C001. Sometimes, the second and the fourth rows are written upside-down to indicate the reverse order of the first and third lines.

3.6.3. Shadow Squares

Although Sanskrit texts on mathematics treat the geometry of shadows, shadow squares do not receive proper attention in Sanskrit astrolabes. Double shadow squares are drawn often on the back, but the four scales are rarely labelled **or** labelled correctly.

In Islamic astrolabes, two types of shadows are clearly distinguished: **the** shadows cast by a gnomon of 12 digits (*ẓill aṣābi*^{c}) and **the** shadows cast by a gnomon of 7 feet (*ẓill aqdām*). This distinction is not maintained in Sanskrit astrolabes: both units are treated as *aṅgula-s* and the two types of shadows are named as *dvādaśāṅgula-chāyā* and *saptāṅgula-chāyā.* Just two astrolabes C031 and E004 maintain this distinction. In the former, the shadow of the 12-digit gnomon is called *narabhā* and the shadow of 7-feet gnomon *pada-chāyā* or *pāda-chāyā*; in the latter, the shadow of the 12-digit gnomon is called *dvādaśāṅgula-chāyā* and that of the 7-foot gnomon *pāda-chāyā.*

Moreover, the astronomers who design the Sanskrit astrolabes have difficulty in rendering umbra recta or direct shadow (*ẓill mustawī*) into Sanskrit. While umbra versa is correctly translated as *viloma-chāyā,* umbra versa is often translated as *loma-chāyā* or *solama-chāyā,* which is absolutely incorrect. The correct expression *sama-chāyā* occurs rarely.

3.7. Alidade

Islamic astrolabes, whether in India or outside, do not have sighting tubes attached to their alidades. The same is the case with European astrolabes. In the Sanskrit astrolabes, however, the alidade (*bhujā, vedha-paṭṭī*) is fitted with a sighting tube in most of the cases. In India, the sighting tube was used as an independent device to view

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beginning from Libra, the differences are those of the first half, taken in the reverse order.' See also Malayendu Sūri, p. 46.

celestial bodies.[684] It was called *Nalaka-* or *Nālikā-yantra* and was described in several Sanskrit texts.[685] Apparently Hindu astronomers decided, at quite an early period, to combine the already known sighting tube with the newly imported astrolabe. This, no doubt, facilitates the sighting, but prevents the calibration of the upper surface of the alidade and thus robs off the trigonometric functions envisaged for the alidade in Islamic tradition. No Sanskrit text appears to mention this innovation.

3.8. Inscriptions

Most of the Sanskrit astrolabes do not contain inscriptions mentioning the name of the astrolabe maker and the date of production. In the few cases where such inscriptions occur, prominence is given to the astronomer who commissioned the astrolabe (by providing the technical drawings) and the name of the artisan who made the astrolabe takes a secondary place. The astronomer who designed the astrolabe bears the title *jyotirvid*[686] (knower of the [science of the] luminaries) or *daivajña*[687] (knower of the fate) or *jośī*[688]*/ joṣī* (derived from Sanskrit *jyotiṣin,* one who possesses the astral science); the astrolabe maker is given the title *śilpin*[689] (artisan) or *sūtradhāra*[690] (lit. one who holds the [measuring] rope, denoting primarily the architect, but applied *honoris causa* to the artisan), or *ustād*[691] (from Persian *ustād,* 'master craftsman). The language of the inscriptions is Sanskrit mixed with Old Gujarati, which is a common practice in the seventeenth century Gujarat.

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684 It was also known to the Greeks and Arabs; cf. Schmalzl 1929, pp. 218-219.

685 Cf. Rai 1985, pp. 333-336.

686 C006.

687 C008.

688 C010.

689 D090.

690 C026; C027; D062 – D065.

691 D035 – D038.

C001 ⊙ SANSKRIT ASTROLABE MADE FOR DĀMODARA

1605, Ahmedabad, Gujarat

Diameter 276 mm

Brussels, PC



Figure C001.1 – Astrolabe made for Dāmodara (photo by S. R. Sarma)

The inscription on the inner surface of the mater states that this astrolabe was commissioned by the astrologer Caṇḍīdāsa for his son Dāmodara on Sunday, 25 December 1605 at Ahmedabad. This is the earliest extant Sanskrit astrolabe known to us. It is also worth noting that the original design of this astrolabe closely follows the prescriptions given in the earliest Sanskrit manual on the astrolabe, viz. the *Yantrarāja* by Mahendra Sūri which was composed in 1370. The name of the artisan who produced it is not recorded. The workmanship and the calligraphy are excellent; however, this is not reflected in the rete which is crudely made and has poor calligraphy. It is clearly a late replacement. Otherwise, the instrument is well preserved.

Components

Mater with crown, shackle and ring (d. 276, h. 380, t. 10.3), rete (d. 250) for 24 stars (replacement), 6 plates (d. 252); alidade with a sighting tube; the pin and horse are replacements.

Front

It is a large massive piece surmounted by an elaborately pierced suspension bracket or crown (*kirīṭa*) with a very wide base that stretches to about 106 degrees of arc. The crown is worked *à jour* to produce an ornate pattern with a human figure entwined in vines and leaves. The surface of the crown is plain and undecorated and no attempt was made to smoothen and polish the sharp edges. There is a hole at the top of the crown through which passes a shackle (*kaṇṭaka*) with ornate terminals. The ring (*mudrikā*) which passes through the shackle is too small for this large astrolabe. Both the shackle and the ring have diamond-shaped cross-sections as in the contemporary Indo-Persian astrolabes. At the top of the crown, immediately below the hole is engraved *śrī-divyacakṣuṣe namaḥ,* 'salutation to the divine eye,' i.e. the sun.

The limb carries a degree scale divided in 1° and 3° and numbered in 3s from 3 to 360 in very elegant Devanagari numerals of western Indian style.

Rete

The rete (*bhacakra-patra* or *bha-patra*) is somewhat thicker and slightly smaller than the latitude plates. The circle of equator is fully represented. The three rings of Capricorn, equator and ecliptic are held together by the equinoctial bar without counter change and by the short segments of solstitial bar which join the equatorial ring with the

ecliptic at the top and the same with the Capricorn ring below. A turning knob is affixed to the lower segment of the solstitial bar.

The ecliptic circle is divided into the 12 signs of the zodiac, in unequal divisions in proportion to the right ascensions or the rising times of the signs at the equator (*nirakṣodaya* or *laṅkodaya*). On each sign its Sanskrit name is engraved rather carelessly as *maṣa* (sic! read *meṣa*), *vaṣa* (*vṛṣa*), *mithana* (*mithuna*), *karka, siṃha, kanyā, tulā, vṛścika, dhana* (*dhanuḥ*), *makara, kubha* (*kumbha*), *mīna*. Each sign is further subdivided into 10 units of 3 degrees and numbered as 3, 6, 9…24, 27, 30 in an anti-clockwise direction. The divisions under Gemini (*mithuna*), however, are not numbered.



Figure C001.2 – Rete of the astrolabe (courtesy the owner)

On this grid are marked the positions of 24 prominent stars and these points are connected to the nearest circles or bars in the form of star pointers (*nakṣatra-cañcu*), curved like tiger's claws, with the names of the respective stars engraved on them. Leaving aside the circular and horizontal bands and the star pointers, the rest of the plate

is cut off in a very crude manner. Moreover, the tips of five pointers (nos. 1, 3, 11, 13, 20) are not clearly cut out. While the workmanship of the latitude plates is inferior to that of the mater, the workmanship of the rete is much worse. The calligraphy of the letters and numerals is also different from that on the latitude plates and on the mater.

The names on the star pointers are generally correct, but with occasional errors. Sometimes the names are abbreviated. The stars are listed below, starting from the vernal equinox and proceeding in the order of increasing right ascension. In the list are given first the star names as they are engraved, then their full or correct forms, followed by modern identification.

Table C001-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*	β Ceti	
2	*Maghodara*	*Matsyodara*	β Andromedae
3	illegible		
4	*Pre*	*Pretaśira*	β Persei
5	*Rohiṇī*	γ Tauri	
6	*Ṣaṇmuṣa*	*Ṣaṇmukha*	α Aurigae
7	*Vāmaskada*	*Mithuna-vāma-skandha*	γ Orionis
8	*Mithunaha*	*Mithuna-hasta*	α Orionis
9	*Mithunapāda*	*Mithuna-pāda-dakṣiṇa*	κ Orionis
10	*Ārdrālu*	*Ārdrā-lubdhaka*	α Canis Majoris
11	*Pravā*	*Prathama-bāla-śīrṣa*	α Geminorum
12	*Lubdhakavadha*	*Lubdhaka-bandhu*	α Canis Minoris
13	*Maghā*	α Leonis	
14	*Uttarāphā*	*Uttara-phālghunī*	β Leonis

	Star Name as engraved	Full/Correct Form	Identification
15	*Kākaskanda*	*Kāka-skandha-pakṣa*	γ Corvi
16	*Citrā*	α Virginis	
17	*Svāti*	α Bootis	
18	*Viśāṣā*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
19	*Dhanukoṭi*	*Dhanuṣ-koṭi*	α Ophiuchi
20	*Dhanuśirā*	*Dhanuḥ-śarāgra*	$\mu^{1,2}$ Sagittariii
21	*Abhijit*	α Lyrae	
22	*Śravaṇa*	α Aquilae	
23	*Kubha*	*Kukkuṭa-puccha*	α Cygni
24	*Pūbhā*	*Pūrva-bhādrapadā*	β Pegasi

PLATES

The mater accommodates six plates (*akṣāṃśa-patra* or *akṣa-patra*). There is a hole at the centre through which passes the pin that holds together all the components of the astrolabe. There is another smaller hole on the lower half of the meridian. When the plates are stacked together inside the recess, the short pin projecting from the lower half of the mater passes through this second hole in the plates and holds them firmly in position and prevents them from turning around the central pin.

On both faces of all the six plates, altitude circles (*unnata-vṛtta*) are drawn for each 3° and numbered from 3 to 90, but no azimuth lines (*digaṃśa-vṛttas*) are drawn. In the lower half of the plate, there are lines for unequal hours (*viṣama-horā*), which are numbered from 1 to 12, starting at the western horizon and going up to the eastern horizon. Finally, in the space between the oblique horizon and the Tropic of Cancer are engraved four items of data regarding the projections drawn on this particular face, viz. the name of a town, its latitude (*akṣāḥ,* φ) in degrees and minutes, the length of the

midday equinoctial shadow (*chāyā,* tan φ), in *aṅgulas* and *vyaṅgulas,* thrown by a gnomon of 12 *aṅgulas,* and the length of the longest day at this latitude (*parama-dina*)[692] in *ghaṭīs* and *palas*.[693]

The relevant inscriptions are reproduced below.

Table C001-2 Geographical Data engraved on the Plates

1a	*akṣāḥ*	*18*	*vījāpura*	*chāyā*	*3/45*	*paramadinaṃ*	*32/52*
1b	*akṣāḥ*	*22/30*	*ujjani*	*chāyā*	*4/9*	*paramadinaṃ*	*33/34*
2a	*akṣāḥ*	*20/30*	*bahrānapura*	*chāyā*	*4/30*	*paramadinaṃ*	*33/16*
2b	*akṣāḥ*	*23*	*amadāvāda*	*chāyā*	*5/5*	*paramadina*	*33/38*
3a	*akṣāḥ*	*25/52*	*kāśī*	*chāyā*	*5/45*	*dinamānaṃ*	*34/5*
3b	*akṣāḥ*	*27/40*	*ḍhākā*	*chāyā*	*6/20*	*paramadina*	*34/24*
4a	*akṣāḥ*	*25/56*	*yodhapura*	*chāyā*	*5/51*	*paramadinaṃ*	*34/8*
4b	*akṣāḥ*	*31/50*	*lāhora*	*chāyā*	*7/30*	*paramadina*	*35/20*
5a	*akṣāḥ*	*26/24*	*āgarā*	*chāyā*	*6/*	*paramadinaṃ*	*34/12*
5b	*akṣāḥ*	*28/39*	*dillī*	*chāyā*	*6/23*	*paramadinaṃ*	*34/34*
6a	*akṣāḥ*	*29/40*[694]	*mulatāṇa*	*chāyā*	*6/47*	*paramadi°*	*34/44*
6b	*akṣāḥ*	*35/20*	*kaśmīra*	*chāyā*	*8/6*	*paramadi*	(not filled)

This material is arranged and interpreted in the table below, where the localities are re-arranged according to increasing latitude. Interestingly these plates are locality-

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692 Turner 1985, p. 122, and following him, Christie's 1988, pp. 98-99, mention erroneously that the plates carry the length of half the longest day, but it is actually the length of the full day.

693 In fact Mahendra Sūri recommends that these four items be engraved on the astrolabe plates; cf. Mahendra Sūri 3. 8.

694 It looks as if the latitude value of Multan was first engraved as 39/40 and then corrected to 29/40. The values given for the midday equinoctial shadow and the longest day match the latitude value of 29/40.

specific and not latitude-specific. The latitude values are reasonably close to modern values, except in the case of Dhaka.



Figure C001.3 – Plate for Ahmedabad on latitude 23° (courtesy the owner)



Figure C001.4 – Plate for Delhi on latitude 28;39° (courtesy the owner)

On all the six plates, the almucantar circles are drawn well. However, the calligraphy of the legends and numerals is not the same as that on the mater and is considerably inferior. The workmanship of these plates is also rather inferior to that of the mater.

Table C001-3 Geographical Data arranged according to increasing Latitudes

	Place Name	φ	tan φ	Longest day	Modern Name
1a	Bijāpura	18	3;45	32;52	Bijapur
2a	Bahrānapura	20;30	4;30	33;16	Burhanpur
1b	Ujjani	22;30	4;09!	33;34	Ujjain
2b	Amadāvāda	23	5;05	33;38	Ahmedabad

	Place Name	φ	tan φ	Longest day	Modern Name
3a	Kāśī	25;52	5;45	34;05	Varanasi
4a	Yodhapura	25;56	5;51	34;08	Jodhpur
5a	Āgarā	26;24	6;00	34;12	Agra
3b	Ḍhākā	27;40	6;20	34;24	Dhaka
5b	Dillī	28;39	6;23	34;34	Delhi
6b	Mulatāna	29;40	6;47	34;44	Multan
4b	Lahora	31;50	7;30	35;20	Lahore
6b	Kaśmīra	35;20	8;06	—	Srinagar

BACK

The rim of the entire surface is divided in 1° and 3° and numbered in 3s, separately for each quadrant from 3 to 90, starting from the east or west points and proceeding towards the south or west points (3—90; 90—3; 3—90; 90—3). The upper left quadrant contains a sexagesimal sine graph, with sixty horizontal parallel lines drawn at equal intervals. These are numbered serially, three at a time, on the right along the vertical radius, starting from the centre and proceeding upwards as 9, 12, 15, … 54, 57, 60. An arc is drawn at 24˚ inside the quadrant to mark the obliquity of the ecliptic. The quadrant is divided by three radii into three sectors of 30˚ each. In these sectors are engraved the numbers 1 to 12 in the following manner. In the first row immediately next to the arc of the obliquity are the numerals 1, 2, 3, written in each sector. The tops of these numerals are towards the degree scale in the circular edge. In the next row are the numerals 6, 5, 4 (as read from left to right). These are upside down (i.e., the tops are towards the centre). In the third row are 7, 8, 9 with orientation as in the first row. The fourth row has numbers 12, 11, 10, with orientation as in the second row.

These numbers refer to the zodiac signs which are arranged here in three columns so that each column contains zodiac signs having the same right ascension, i.e., the same rising time at the equator. Thus the four numbers in the first column 1, 6, 7, 12 denote

respectively Aries, Virgo, Libra and Pisces which rise at the equator in 278 *palas* (= 1;51,36 hours); the four numbers in the second column 2, 5, 8, 11 stand respectively for Taurus, Leo, Scorpio and Aquarius which rise in 299 *palas* (= 1;59,40 hours) and the four numbers in the third column denote respectively Gemini, Cancer, Sagittarius and Capricorn which rise in 323 *palas* (= 2;08,44 hours).[695]

The upper right quadrant contains lines for unequal hours, which are numbered from 1 to 12. This feature occurs also in the Sanskrit astrolabe of 1673 (C010).

In the lower half are engraved shadow squares, on the left for a gnomon of 12 digits, and on the right for a gnomon of 7 digits. The scales are numbered, but there are no labels.

On the inner side of the mater, on the meridian line below the centre and somewhat close to the rim, is a pin affixed at right angles to the surface of the mater. This pin holds the latitude plates firmly in position and prevents them from rotating around the centre.

In the upper half of the inner side is an inscription, mentioning the name of the patron who caused this astrolabe to be made and the date of manufacture. The inscription will be discussed below.

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695 Cf. B024.



Figure C001.5 – Back of the astrolabe (courtesy the owner)

ALIDADE

The alidade, pivoted at the centre on the Back of the astrolabe is a straight metal bar without any counter change; it is 265 mm long and has pointed ends. A sighting tube is attached to it by means of two upright supports. The tube measures 290 mm and is slightly longer than the diameter of the astrolabe.

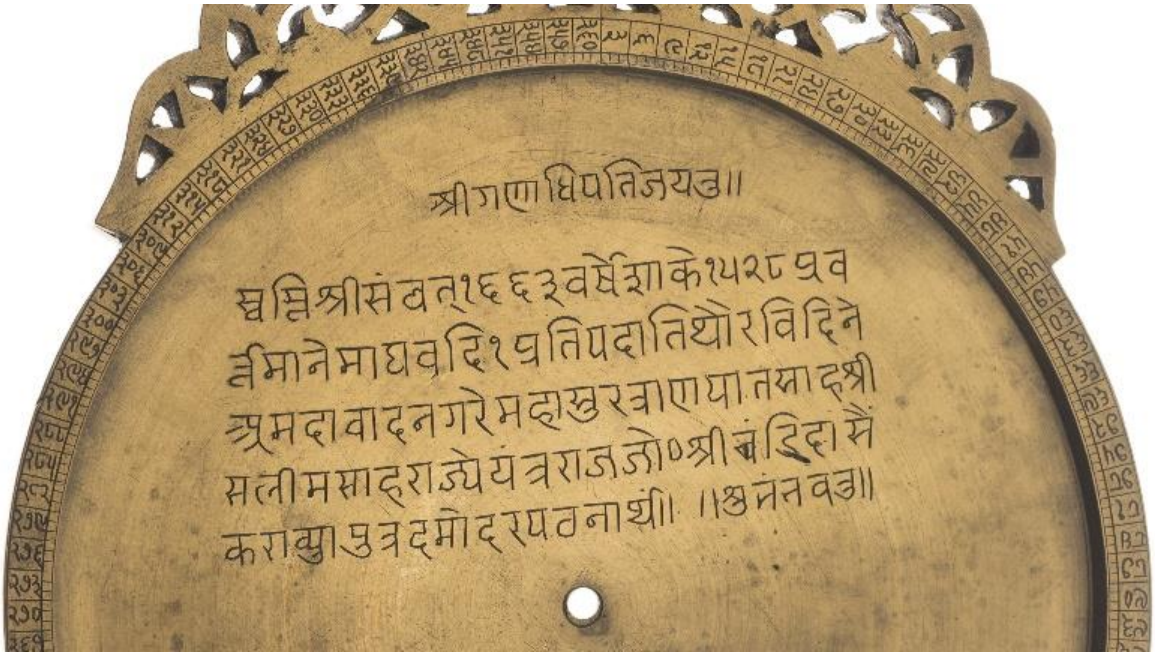


Figure C001.6 – Inscription on the mater (courtesy the owner)

INSCRIPTION ON THE THE MATER

On the inner side of the mater is an inscription in six lines in elegant Devanagari letters of western Indian style, which reads as follows:

śrīgaṇādhipati[r] jayatu ‖
svasti śrī saṃvat 1663 varṣe śāke 1528 prava
rttamāne māghavadi 1 pratipadātithau ravidine
amadāvādanagare mahāsuratrāṇa pātasāha śrī
salīmasāharājye yaṃtrarāja jo° caṃḍidāsaiṃ
karāvyu | purtra damodara paṭhanārthaṃ ‖ śubhaṃ bhavatu ‖

‘May the lord of gaṇas (= Gaṇeśa) be victorious. May it be well. In Saṃvat 1663, Śaka 1528 current, on the first, i.e. *pratipadā* tithi, of the Kṛṣṇapakṣa (*vadi*) of Māgha, on Sunday, at the city of Ahmedabad, during the reign of the Great Sultān, the Badshāh, the illustrious Salīm Shāh (i.e., Mughal Emperor Jahangir), [this] astrolabe (*yantrarāja,* lit. king of instruments) was caused to be made (*karāvyu*) by the astrologer Caṇḍidāsa for the sake of reading [by his] son Damodara. Let it be auspicious.’

The sentence begins in Sanskrit, but the ending *caṃḍidāsaiṃ karāvyu* (Sanskrit *caṇḍīdāsena kāritam*) is medieval Gujarati. The engraver spelt the name Dāmodara wrongly as Damodara. The name of his father who commissioned the astrolabe should

properly be Caṃḍīdāsa, but Caṃḍidāsa is not incorrect either. He has the title *jo*˚, which is an abbreviation of Joṣī, 'astrologer'.

The date given in the inscription translates to Sunday, 25 December 1605. Just two months previous to this date, i.e. on 24 October 1605 Salīm Shāh ascended the Mughal throne at Agra and assumed the name Nūr al-Dīn Jahāngīr. As the title is still new, he is still referred to here with the old name Salīm Shāh. There was some controversy about the authenticity of this inscription and the date. I have discussed this question elsewhere and showed that both are authentic.[696]

PROVENANCE

This astrolabe was said to be in the private collection of a certain Roberto Riva several years ago and to have been exhibited at the Museum of Natural History, Houston, Texas.[697] The Time Museum at Rockford, Illinois, acquired it soon afterwards, probably from Sotheby's in 1976. An excellent catalogue of the astrolabes in this museum was prepared by Anthony Turner in 1985. In 1988, the Time Museum decided to part with this astrolabe and several other instruments. Christie's held a special auction of these instruments on 14 April 1988 in London. In this auction, it was acquired by Saul Moskowitz, a dealer in scientific instruments of Marblehead, Massachusetts, USA. After his death, his collections were disposed of[698] and the present owner acquired the astrolabe in question.

BIBLIOGRAPHY

Turner 1985, no. 15, pp. 120-123.

Sarma 2012c.

Christie's, London, auction catalogue of 14 April 1988, lot 157, pp. 98-99.

Christie's, London, auction catalogue of 1992, lot118, pp. 46-47.

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696 Sarma 2012c, pp. 107-114.

697 Turner 1985, p. 122. CCA lists under 3921 a Sanskrit astrolabe whose location is mentioned as SAP (=South America, Private Collection (Riva Collection). It must be the same Sanskrit astrolabe.

698 Christie's 1992, pp. 46-47.

C002⊙ SANSKRIT ASTROLABE, NOT SIGNED

1618, Gujarat

Diameter 148.5 mm

Pune, Raja Dinkar Kelkar Museum (# 106 PMC)



Figure C002.1 – Sanskrit Astrolabe of 1618, Crown (photo by S. R. Sarma)

The year of manufacture is engraved on the front side of the crown in three different eras and in two scripts: in Devanagari script *saṃvata* 1675 *śake* 1540, in Arabic/Persian script 1028. Saṃvat 1675 / Śaka 1540 began on 26 March 1618, while AH 1028 began on 28 Dec 1617 and ended on 17 Dec 1618. Therefore, the astrolabe was manufactured sometime between 26 March and 17 Dec 1618.

COMPONENTS

Only the mater (d. 148.5, h. 194, t. 10) and the rete (d. 123) for 15 stars of this astrolabe survive; the plates, alidade, pin and wedge are lost. Many parts are left incomplete on the back of the mater and on its inner side.

FRONT

The high and solid crown is nicely crafted with elegant profiles. There is a heavy shackle and ring. The limb is divided in 1° and in groups of 6°; the latter are numbered

serially from 1 to 60. At the north point there is a small peg in the rim to hold the plates in position.

RETE

The rete exhibits the characteristic 'bird in the cage' pattern. Here the star pointer for *Abhijit* (α Lyrae) is shaped like the head of a bird, and the bird itself looks as if it is inside a cage formed by two creepers that rise from the ring at the centre, encircle the bird and then bend outwards to terminate in the star pointers for *Śravaṇa* (α Aquilae) and *Dhanuṣkoṭi* (α Ophiuchi) respectively. This pattern occurs in several Indo-Persian and Sanskrit astrolabes.[699] The ecliptic circle is divided into 12 signs and labelled with the first syllables of the Sanskrit names of the zodiac signs. Each sign is further subdivided into groups of 6° and labelled. On the bevelled edge, each of these divisions is halved to produce divisions of 3° each. There is a handle on the lower segment of the equator circle close to the pointer for α Canis Minoris. There are 15 named star pointers, 7 outside the ecliptic and 8 within. These are labelled with abbreviated names, sometimes with incorrect spellings. These are listed below according to increasing right ascensions.

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699 For a discussion of this pattern, cf. Sarma 2011a, esp. pp. 107-110 and figure 8.

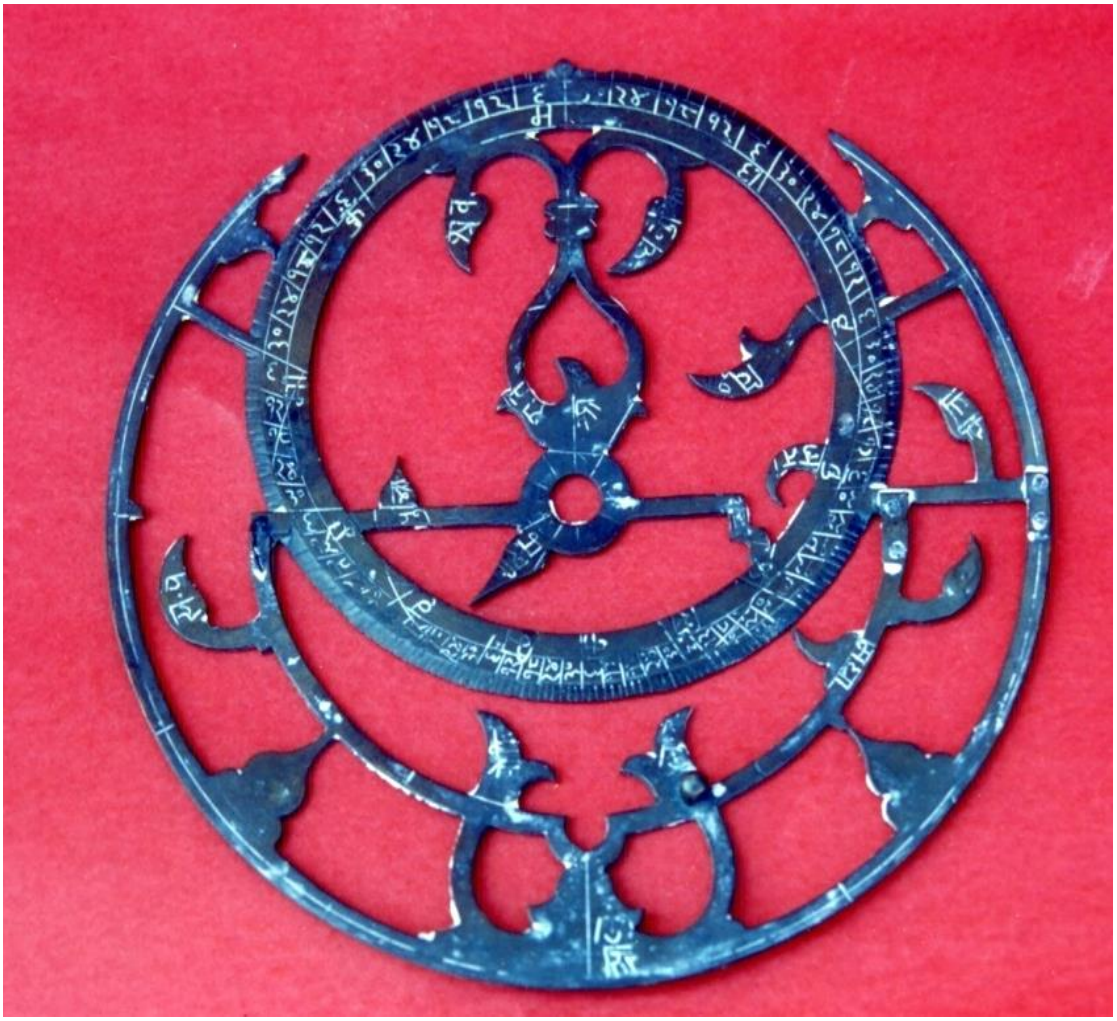


Figure C002.2 – Rete of the Astrolabe (photo by S. R. Sarma)

Table C002-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Sa.pa*	*Samudra-pakṣī*	β Ceti
2	*Maśī*	*Manuṣya-śīrṣa*	β Persei
3	*Rohi*	*Rohiṇī*	α Tauri
4	*Ālu*	*Ārdrā-lubdhaka*	α Canis Majoris
5	*Luva*	*Lubdhaka-bandhu*	α Canis Minoris
6	*Maghā*		α Leonis
7	*Pūphā*	*Pūrva-phālgunī*	δ Leonis
8	*Uta*	*Uttara-phālgunī*	β Leonis

	Star Name as engraved	Full/Correct Form	Identification
9	*Cītrā*	*Citrā*	α Virginis
10	*Viśākhā-mātṛ-maṇḍala*		α Coronae Borealis
11	*Dhanuko*	*Dhanuṣkoṭi*	α Ophiuchi
12	*Abhī*	*Abhijit*	α Lyrae
13	*Śrava*	*Śravaṇa*	α Aquilae
14	*Śata*[700]	*Kukkuṭa-puccha*	α Cygni
15	*Pubhā*	*Pūrva-bhādrapadā*	β Pegasi

The rete was broken at three places (where the equator ring joins the ecliptic ring on the left and on the right, and where the Capricorn ring joins the east-west bar on the right). Small strips of metal were nailed at these places to join the broken areas. At the back of the rete, the lines of tropics and equator can be seen. Also on the front of the rete, construction lines can be seen on the ecliptic circle.

[700] Wrongly labelled as *śata[bhiṣa]* λ Aqr. The same wrong label occurs also in the astrolabes of 1638 (C004) and of 1805 (C024).



Figure C002.3 – The Geographical Gazetteer (photo by S. R. Sarma)

GEOGRAPHICAL GAZETTEER

On the inner surface of the mater, an elaborate gazetteer had been planned. Six concentric circles are drawn, each of which is divided into 16 cells by radial lines. But only 34 cells, i.e. less than half, are filled with the names of localities and their latitudes.

The first two annuli contain 16 names each and the third just two. The names of the towns are not carefully engraved. Sometimes the names are abbreviated by dropping the last syllable. These are listed in the table below, starting from the top and proceeding clockwise.

Table C002-2 Geographical Gazetteer

	Place name	φ	Modern Name
1	Laṃkā	10	Sri Lanka
2	Kāti	12	Kanchi, Tamilnadu
3	Vidyānaga	15	Hampi Vijayanagara, Karnataka
4	Vijāpura	16	Bijapur, Karnataka
5	Amadānaga	19	Ahmednagar, Maharashtra
6	Devagairi	20	Daulatabad, Maharashtra
7	Āśerara	32!	Asirgarh, Madhya Pradesh
8	Makkā	21;40	Mecca, Saudi Arabia
9	Elācapura	21	Elichpur, Maharashtra
10	Māḍava	22	Mandu, Madhya Pradesh
11	Junāgaḍha	22	Junagadh, Gujarat
12	Amedāvā	23	Ahmedabad, Gujarat
13	Ujayinī	23	Ujjain, Madhya Pradesh
14	Ghārakāra	23	?
15	Īḍara	24	Idar, Gujajarat
16	Siroṃja	24	Sironj, Madhya Pradesh
17	Gvālera	25	Gwalior, Madhya Pradesh
18	Ajamera	26	Ajmer, Rajasthan
19	Vārāṇasī	26;15	Varanasi, Uttar Pradesh
20	Āgarā	27	Agra, Uttar Pradesh

	Place name	φ	Modern Name
21	Gayā	27	Gaya, Bihar
22	Dillī	29	Delhi
23	Kurukṣetra	32	Kurukshetra, Haryana
24	Lahora	32	Lahore, Pakistan
25	Nagarakoṭa	32	Nagarkot = Kangra, Himachal Pradesh
26	Kedāra	33	Kedarnath, Uttarakhand
27	Gandhāra	33	Qandahar, Afghanistan
28	Vadarī	34	Badrinath, Uttarakhand ?
29	Vagadāda	34	Baghdad, Iraq
30	Kaśmīra	35	Srinagar, Jammu & Kashmir
31	Halaba	35	Aleppo, Syria
32	Kāvīla	36	Kabul, Afghanistan
33	Samarakada	40	Samarqand, Uzbekistan
34	Tavaraja	38;31	Tabriz, Iran

BACK

In the two upper quadrants, the rim carries two bands of degree scales as in the front. The inner band is neatly graduated in single degrees, while the outer scale is divided in groups of 6°, and labelled as 6—90, 90—6. Interestingly enough, *Abjad* numbers are added above 6, 12 and 30 on the left as well as on the right.

The upper left quadrant contains the sine graph with 60 equi-distant horizontal parallels. An attempt was made to highlight each fifth line by making it deeper, but not consistently throughout. The upper right quadrant is blank.

On the rim of the two lower quadrants, seven concentric semi circles are drawn, producing thereby six annular rings. In the outermost one, there is an unlabelled scale of cotangents. The rest are blank.

Within these semicircles are inscribed two shadow squares; on the left for a gnomon of 12 digits; on the right for a gnomon of seven digits. The cells are not numbered. The shadow tables are labelled only below. Below the left table is written *dvā. chā.* (for *dvādaśāṅgula-chāyā,* shadow of [the gnomon of] twelve digits) and below the right table *sa. chā*. (for *saptāṅgula-chāyā,* shadow of [the gnomon of] seven digits). The area inside the squares is engraved as a grid of 8 x 4 cells, but these are also left blank.



Figure C002.4 – Back of the astrolabe (photo by S. R. Sarma)

C003 SANSKRIT ASTROLABE [DESIGNED] BY CAKRAPĀṆI[701]

1625, Jodhpur, Rajasthan

Diameter 110 mm

Hastings-on-Hudson, NY, Tesseract



Figure C003.1 – Mater of the astrolabe (courtesy Professor David Pingree)

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701 Cf. Skinner 2002, no. 244, pp. 38-39.

According to the inscription, this astrolabe was made, or more probably designed, by Cakrapāṇi, son of Viśvanātha, in 1625 at Jodhpur during the reign of Gajasiṃha (r. 1619-1638). Only the mater (d. 110) of this astrolabe survives.

FRONT

The crown is elegantly lobed with two decorative holes; there is a shackle with lance-head-shaped terminals and diamond cross-section; the ring is plain. The limb carries two degree scales, the inner one of 1° and the outer one divided into groups of 6° and labelled separately for each quadrant from 6 to 90, starting from the east and west points and reaching up to the south and north points (6—90; 90—6; 6—90; 90—6). A small peg is added to the lower rim where the meridian crosses it, to hold the plates in position. Four concentric circles are drawn on the inner surface of the mater for engraving the geographical gazetteer, but this was not filled in.



Figure C003.2 – Back of the astrolabe (courtesy Professor David Pingree)

BACK

The upper rim carries the altitude scale, divided in 1° and 6° and numbered in 6s (6—90; 90—6). No attempt was made to divide the surface into four quadrants. Instead the entire upper half is filled untidily with a numerical table. Ten concentric semi-circles are drawn and these are divided unevenly into cells. The first, third, fifth, seventh and ninth semicircles carry the numbers from 1 to 73, obviously the degrees of solar altitude and the remaining semicircles contain values related to the solar altitude. It is difficult to decipher the badly engraved numbers. The remaining part of the table, from 74 to 90, is engraved in the lower half in 17 columns and three rows, as reproduced below. Probably what this table contains are the shadow lengths of a gnomon of 7 feet, corresponding to each degree of the solar altitude, valid for the latitude of 26°, roughly the latitude of Jodhpur.[702]

Table C003-1 Table of Shadow Lengths

74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
3	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
0	51	45	33	28	22	14	7	59	51	44	36	29	23	15	8	0

In the lower half, just above this table, is a shadow square, on the left for a gnomon of 12 digits and on the right for a gnomon of 7. The cells are not numbered, nor are the scales labelled. It looks as if an attempt was made to rub off the shadow squares.

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[702] For a table of shadow lengths for a gnomon of 12 units, see the astrolabe of 1643 (C006).

INSCRIPTION

The inscription engraved on the crown and continued on the edge for about three quarters reads:

> *śrīsaṃ. 1682 varṣe mārgaśira śu 1 ravau mahārājādhirāja-mahārāja-śrī-gajasiṃhajī-vijayarājye pokaraṇī-jñātīya-pra. śrī-viśvanāthātmaja-śrī-cakrapāṇinā kṛtam idaṃ [sic! read kṛto 'yaṃ] yantrarājaḥ ‖śrī‖*
>
> 'In the glorious Saṃvat year 1682, on Sunday, the first day of the bright half of Mārgaśira, in the victorious reign of Mahārājādhirāja Mahārāja Gajasiṃha-jī, this astrolabe was made by the glorious Cakrapāṇi, son of the glorious Viśvanātha of the Pokaraṇī-jñāti.'

The date corresponds to 30 November 1625.

David Pingree notes that 'the signature indicates that the maker was a member of the Pokaranajnati, a social / tribal group of Brahmanas (Brahmins), one of whose occupations was astrology. Gajasimhaji was Raja of Mewar in Jodhpur from 1619-1638.'[703]

PROVENANCE

It came up for auction in 2002 at Skinner, Bolton, and is now with Tesseract.

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703 Skinner 2002, p. 38.

C004⊙ SANSKRIT ASTROLABE MADE BY ṬHĀKURA MURĀRAJĪ KUARAJĪ FOR JOSĪ HARANĀTHA

1638, Varanasi

Diameter 158 mm

Pune, Bhandarkar Oriental Research Institute (# 1502 of 1887-91)



Figure C004.1 – Front of the astrolabe (photo by Dr Devangana Desai)

According to the inscription on the circular edge, this astrolabe was made by Ṭhākura Murārajī Kuarajī Vaiṣṇava on Friday, 3 December 1638 at Varanasi. Another inscription on the front of the crown declares that the astrolabe belongs to the astrologer Haranātha Vāṃchaḍā of Burhanpur. It is indeed remarkable that an artisan by name Ṭhākura Murārajī Kuarajī Vaiṣṇava makes an astrolabe at Varanasi for an astrologer Haranātha Vāṃchaḍā, who belongs to Burhanpur in Central India, and engraves on it two inscriptions regarding the owner and the maker, mainly in Sanskrit language, but mixed with Gujarati! There are also other Gujarati influences. The suffix –jī in the maker's name is characteristic of Gujarat. The letters *ja* and *la* have greater affinity to the Gujarati script. Many place names are from Gujarat. Remarkable also is the fact that this astrolabe contains as many as 10 plates, the largest number known so far. The plates are of copper, the rest is made of brass.

Components

Mater (d. 158, h. 188, t. 14) with the crown, shackle and ring, rete (d. 134) for 16 stars, 10 plates (d. 134), alidade; original pin and wedge are missing.

Front

The astrolabe has a solid and well-crafted body. There is an intricately lobed crown with circular indents at the top. The shackle has ornate terminals. The ring is small. There is a degree scale on the limb, with single degrees marked in the inner band and groups of 6° numbered clockwise from 6 to 360 in the outer band.



Figure C004.2 – Rete, the lower half (photo by S. R. Sarma)

RETE

The rings of Capricorn and equator are joined by the equinoctial bar without counter change. The equator is represented by a small segment of arc in the lower half. There is an ornate turning knob on the equatorial ring at the left end. The small ring around the central hole is joined to the ecliptic ring below with an elegant trifoliate piece. A similar piece joins the equatorial circle to that of Capricorn on the left. The symmetry is disturbed on the right by a piece of a different shape which contains the pointer for Sirius. The star pointers are of diverse shapes. An elegant bird shape soars down towards the centre from the upper part of the ecliptic; its beak is the pointer for α Ophiuchi, while its wing is the pointer for α Aquilae. There must have been a matching form of a bird soaring up from the central ring, containing the pointer for α Lyrae but that is broken. At the tip of each star pointer, there is a dot to mark the exact position of the star.

The ecliptic is divided into the 12 signs and labelled with the initial syllables (in three cases with 2 initial syllables) of the names of the signs, followed by the serial number. Each sign is further subdivided into 5 parts and labelled as 1, 2, 3, 4, 5 (and not as 6, 12, 18, 24, 30 as is the general practice). The letters, numerals and the division marks on the rete are rather untidy.

There are 16 named star pointers, 9 outside the ecliptic and 7 inside. Some pointers are wrongly placed (shown with * in the list below).

Table C004-1 Stars on the Rete

	Star Name	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Manuṣasī*	*Manuṣyaśīrṣa*	β Persei
3*	*Kratita*	*Kartita-kara*	β Cassiopieae
4	*Rohaṇī*	*Rohiṇī*	γ Tauri
5	*Mithunapāda*	*Mithunapāda-dakṣiṇa*	κ Orionis
6*	*Ṣaḍāsra*	*Ṣaḍasra*	α Aurigae
7	*Lubdhaka*		α Canis Majoris
8	*Punava*	*Punarvasu*	β Geminorum
9	*Maghā*		α Leonis
10	*Hasta*		δ Corvi
11	*Citrā*		α Virginis
12	*Svāti*		α Bootis
13	*Viśākhā*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
14	*Dhanakoṭi*	*Dhanuṣkoṭi*	α Ophiuchi
15	*Śravaṇa*		α Aquilae
16	*Satatārā*[704]	[*Kukkuṭapuccha*]	α Cygni

PLATES

There are ten plates to serve every degree of latitude from 18° to 36°, besides 11°. Instead of separate projections for 28° and 29°, there is one for 28;39°, which is the

[704] Wrongly labelled as *Satatārā* λ Aqr; it is *Kukkuṭa-puccha* α Cyg.

latitude of Delhi. All the plates have a small tooth at the top which fits into the slot in the limb just below the south point. Altitude circles are drawn for each 6° and labelled as 6, 12, 18 on both sides of the meridian, but there are no azimuth lines. In the lower half there are lines for unequal hours which are numbered from 1 to12 starting at the western horizon. The two ends of the horizon are marked as *pū[rva]* (east) and *pa[ścima]* (west) respectively on the left and right. On the plates, the latitude is mentioned with the label *akṣāṃśā,* but not the duration of the longest day. In the plate for multiple horizons, the horizons for all latitudes from 18° to 48° are arranged in the four quadrants.

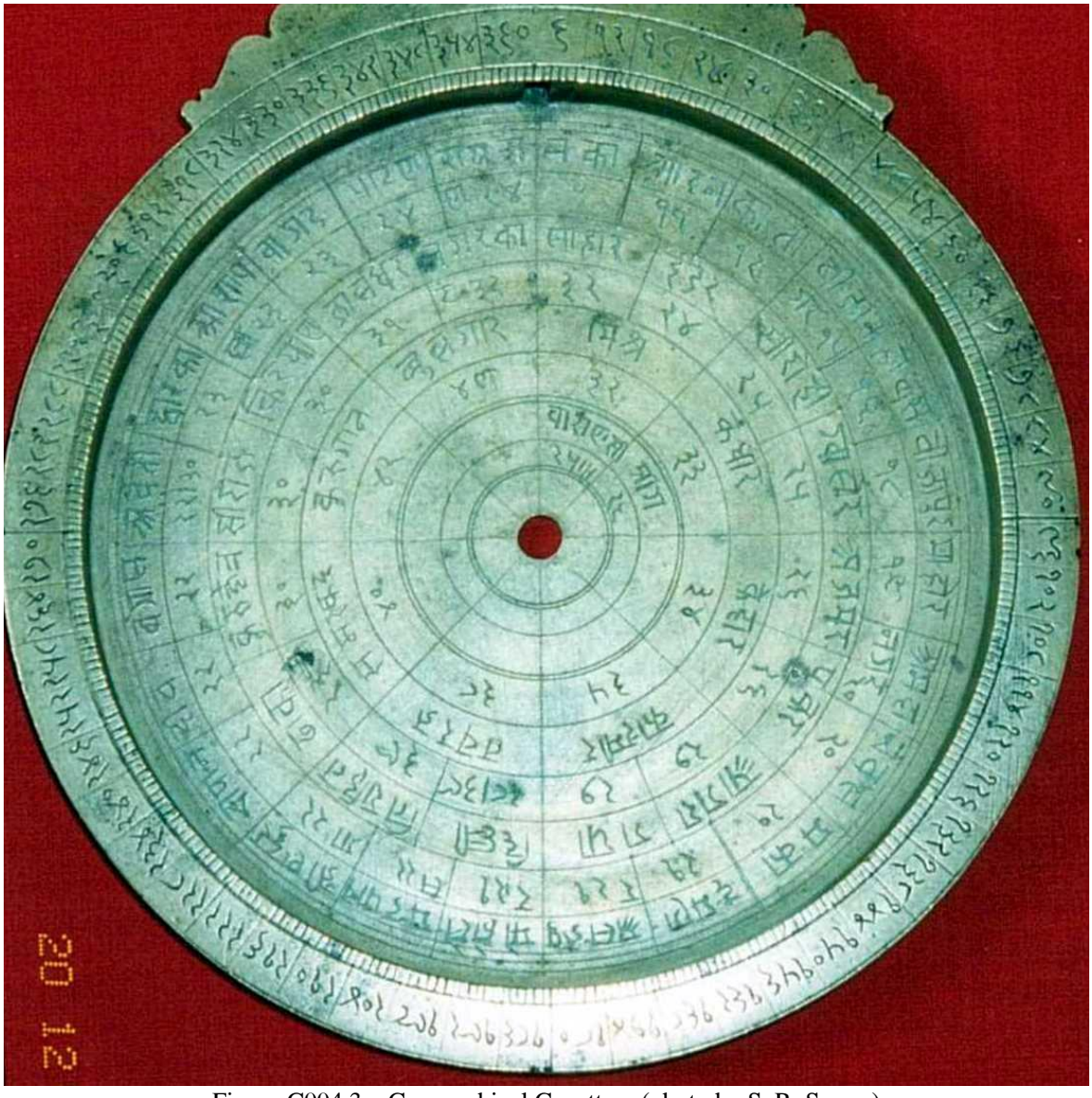


Figure C004.3 – Geographical Gazetteer (photo by S. R. Sarma)

GEOGRAPHICAL GAZETTEER

On the inner side of the mater is engraved a geographical gazetteer in four circles, containing names and latitudes of 50 localities. These are read from the top, proceeding clockwise.

Table C004-2 Geographical Gazetteer

	Place name	φ	Modern name
	First Circle		
1	Laṃkā	0	Equator
2	Ādana	11	Aden
3	Kātī	12	Kanchi
4	Bījānagara	15	Hampi, Vijayanagar
5	Hābasa	16	?
6	Vījāpura	18	Bijapur
7	Māhora	19	?
8	Amadānagara	20	Ahmednagar
9	Caṃvala	20	(Chambal??)
10	Makā	21	Mecca
11	Damaṇa	21	Daman
12	Asajapura	21	?
13	Mohosera	21	?
14	Maḍapācala	22	Mandu
15	Jīṇaduragā	22	Junagadh
16	Cāpāne[ra]	22	Champner
17	Dīva	22	Diu
18	Baṃgala	22	Dhaka??
19	Avaṃtī	22;30	Ujjain

	Place name	φ	Modern name
20	Dvārakā	23	Dwaraka
21	Āśāpallī	23	Ahmedabad
22	Vāgaḍa	23	Region in Southern Rajasthan, also in Kutch, Gujarat
23	Pāṭaṇa	24	Patan
24	Rāyaśaṇa	24	Raisen, Madhya Pradesh?
	Second Circle		
25	Lāhora	32	Lahore
26	Īḍara	24	Idar
27	Sīrohī	25	Sirohi
28	Gvālera	25	Gwalior
29	Ajamara	26	Ajmer
30	Phakara	26	Pushkar
31	Āgarā	27	Agra
32	Gayā	27	Gaya
33	Dillī	28;39	Delhi
34	Tirāhita	39 !	Tirhut = Muzaffarpur
35	Ḍhākā	23	Dhaka
35	Kurukṣetra	30	Kurukshetra
37	Sīroja	30	Sironj?
38	Kirayāṇa	30	?
39	Jalaṃdhara	31	Jalandhar
40	Nagarakāṭa	32	Nagarkot ?

	Place name	φ	Modern name
	Third Circle		
41	Miśra	32	Cairo
42	Kaṃdhāra	33	Qandahar
43	Kedāra	34	Kedarnath?
44	Kāśmīra	35	Srinagar
45	Tavaraja	38	Tabriz
46	Samarakada	40	Samarqand
47	Kurugāna	42	Khurasan??
48	Bulagāra	49	Bulghars
	Fourth Circle		
49	Vārāṇasī	25 ¾	Varanasi
50	Prāga	26	Prayāga

There are many common features in this gazetteer and in that engraved on the astrolabe of 1638 (C002); especially significant are common errors like, e.g. Gayā 27.



Figure C004.4 – Back of the astrolabe (photo by S. R. Sarma)

Back

The rim of the upper half carries the altitude scale divided in 1° and 6° and is numbered in 6s separately for each quadrant (6—90; 90—6). The upper left quadrant is filled by 30 equidistant horizontal lines. The other three quadrants are nearly blank.

The rim of the lower right quadrant is filled with a table. A label below informs that it is a table of declinations (*krāṃti*). The rim on the lower right is filled with a table of sines and the label below reads *jyā* (sine).

Table C004-3 Table of Declinations

6	12	18	24	30	36	42	48	54	60	66	72	78	84	90
2½	5	7	9	11½	13½	15½	17¼	19	20¼	21¼	22½	23	23¼	23½

Table C004-4 Table of Sines

6	12	18	24	30	36	42	48	54	60	66	72	78	84	90
12½	25	37	49	60	70	80	90	97	104	110	114	118	119	120

ALIDADE

The alidade is a straight bar without any counter change and without any graduations. It has a very ornate centre piece and pointed terminals. But it is rather short with a length of 133 (width 16.5, thickness 3.5); it does not quite reach up the degree scale on the rim. The original pin and wedge are lost. The alidade, mater, plates and the rete are held together by means of a bolt and nut.

INSCRIPTIONS

An inscription engraved on the edge of the astrolabe reads as follows:

> *śrīsaṃvat 1695 varṣe mārgasiravadi 13 śukre vārāṇāsīmāṃ ṭhākura murārajī*
>
> *kuarajī vaiṣaṇau kīḍho jaṃtrarāja pātaśāha śrīśāhajāhā vijayarājye sanah ‖11‖ śrī ‖*
>
> ‘In the glorious Saṃvat year 1695, on Friday, the thirteenth day of the dark half of Mārgaśira, in the [regnal] year (*sanah*) 11 in the victorious kingdom of the emperor (pātaśāha), the glorius Shāh Jahān, Ṭhākura Murārajī Kuarajī Vaiṣṇava made (*kīḍho*) this astrolabe (*jaṃtrarāja*) at Varanasi.’

The date translates to Friday, 3 December 1638.

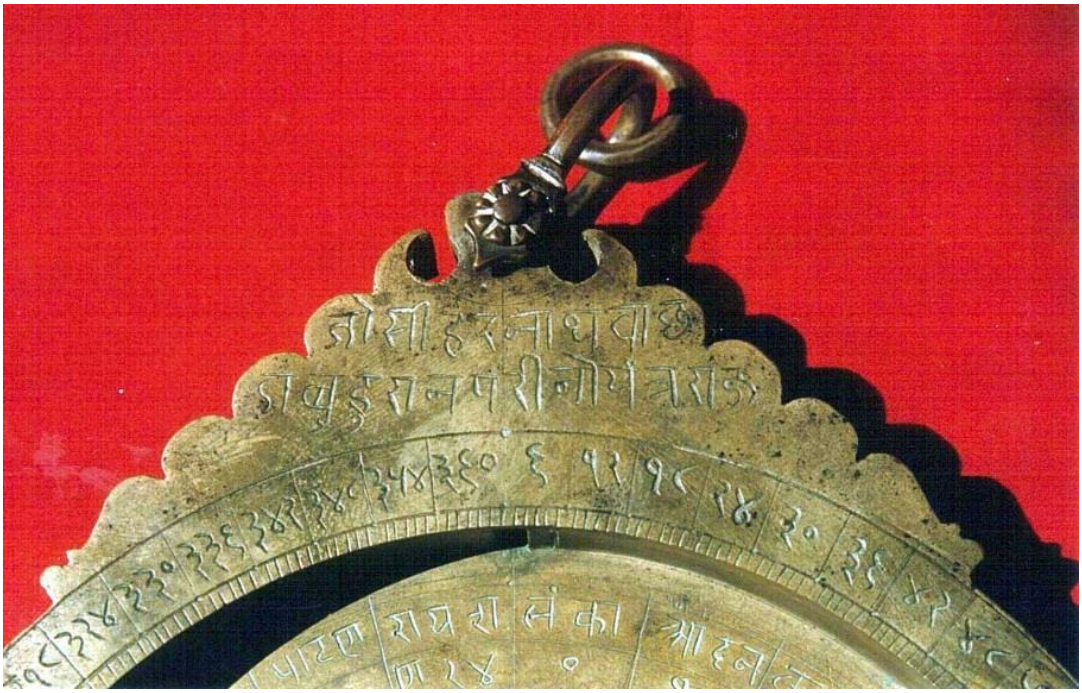


Figure C004.5 – Inscription on the front of the crown (photo by S. R. Sarma)

An inscription on the front side of the crown proclaims the ownership thus:

josī haranātha vāṃchaḍā buhurānapurīṇo yaṃtrarāja.

‘The astrolabe (*yaṃtrarāja*) is of (belongs to) Josī Haranātha Vāṃchaḍā of Burhanpur.’

C005 SANSKRIT ASTROLABE MADE BY KALYĀṆA FOR PURUṢOTTAMA

1642, Gujarat

Diameter ?

PLU

In the archives of the Museum of the History of Science, Oxford, there is a sheet of paper with an outline diagram of a Sanskrit astrolabe which appears to have been drawn by the late Alain Brieux during his visit to Jaipur. The astrolabe has a remarkable throne flanked by two parrots. On this sheet there is much writing in French in a very small script which is difficult to decipher.

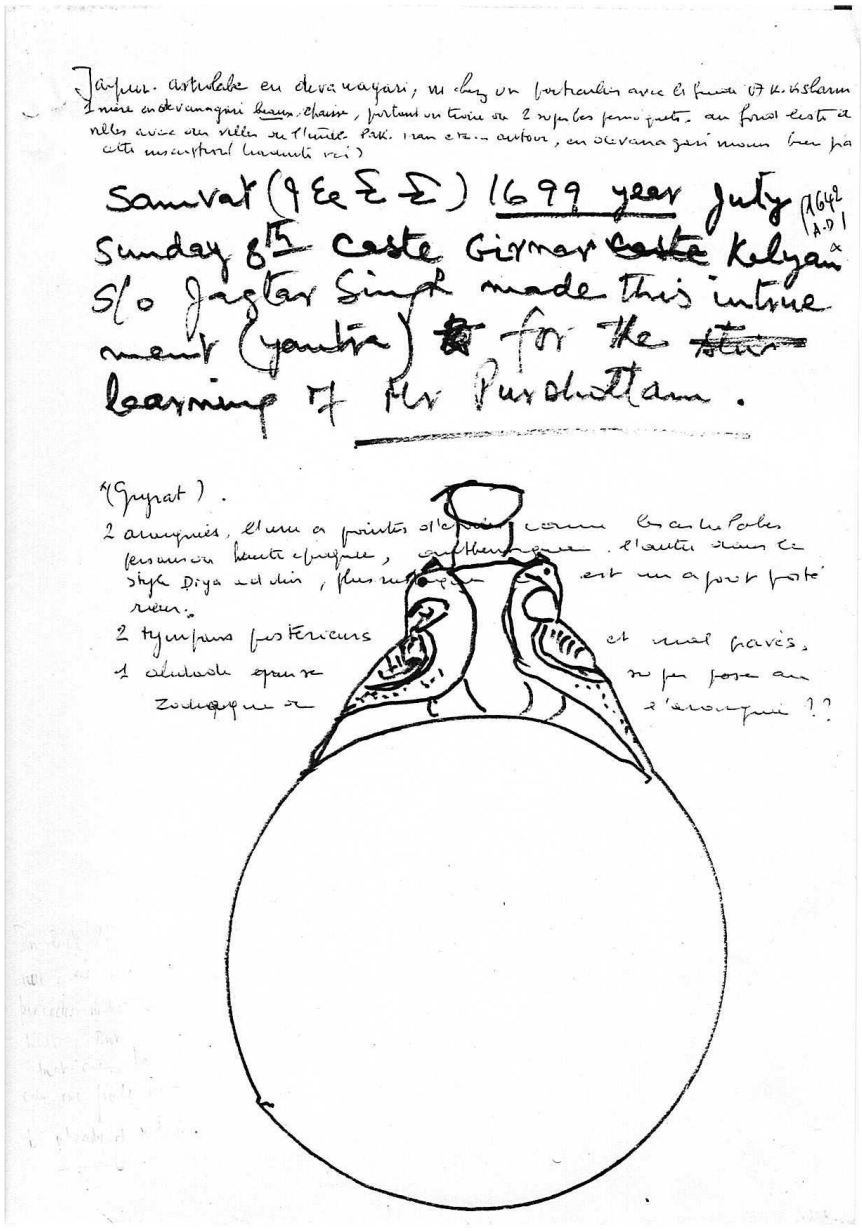


Figure C005.1 – sketch of an astrolabe drawn by Alain Brieux

The English text in larger letters is apparently the translation of the inscription on the astrolabe: 'Samvat (1699 in Devanagari numerals) 1699 year July (1642 AD) Sunday 8th, caste Girnar[705] Kalyan s/o Jagtar Singh made this instrument (yantra) for the learning of Mr Purshottam.'

8 July 1642 is not a Sunday, but Tuesday. Therefore, '8' in the translation is not the date in July but the number of the lunar day in the Sanskrit month which corresponds to July, viz. *Āṣāḍha*. The eighth day in the bright half of the month of *Āṣāḍha* in the *Saṃvat* year 1699 translates to 5 July 1642, but it is a Saturday. Therefore, we consider the 8th lunar day in the dark half; it is Sunday, 20 July 1642, on which the astrolabe must have been completed.

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[705] 'Caste Girnar' does not make sense; probably the Sanskrit has *girinārāyaṇa-jñāti,* referring to a particular clan of Brahmins.

C006⊙ SANSKRIT ASTROLABE MADE FOR MAṆIRĀMA[706]

1644, Gujarat

Diameter 128 mm

Edinburgh, National Museums of Scotland (# 1986.20)



Figure C006.1 – Astrolabe made for Maṇirāma (photo by S. R. Sarma)

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[706] For a detailed study, see Sarma 2011b.

On the front side of the suspension bracket, there are two inscriptions engraved one below the other. The first inscription in three lines reads: *Saṃvat 1700 caitra kṛṣṇaikādaśyāṃ maṇirāmeṇa kāritaṃ,* 'caused to be made by Maṇirāma on the 11th day of the dark half of [the month] Caitra in Saṃvat [year] 1700.' This implies that an astronomer named Maṇirāma prepared the technical design and got it made for his own use by an unnamed metal worker. The date translates to 2 April 1644.

Below this inscription, there is a second one, in a different hand and cut more deeply into the metal: *śrīlīlānāthajyotirvido 'yam,* 'this [instrument is the property] of the illustrious astrologer (*jyotirvid*)[707] Līlānātha.' He must be a subsequent owner, but we do not know when he lived. On the plate calibrated for the latitude of Jodhpur, there is an addition, which resembles the calligraphy of this line and is cut likewise more deeply than the rest. This too must have been an addition caused to be engraved by Līlānātha. The addition reads *nepāle 'pi* 'also in Nepal,' that is to say, the plate could be used also in Nepal, or more precisely in the capital city Kathmandu. The modern values of the latitudes of Jodhpur and Kathmandu are 26;18° N and 27;42° N respectively. Therefore, it was a reasonable approximation to say that these two cities lie on the same latitude. Līlānātha's addition on this plate suggests that he may have been from Kathmandu and may have used the plate there. If this hunch is correct, then this would be the only known astrolabe that was ever used in Nepal. About Maṇirāma, the original owner of the astrolabe, we have no other information. But it is quite certain that the astrolabe, like many other early Sanskrit astrolabes, was produced in Gujarat.

It is a neatly crafted piece, but there are some lacunae in execution. For some unknown reason, the astrolabe was left unfinished in three places: on the inner side of the mater the astrolabe maker drew a grid but did not fill it in with the geographical gazetteer; on the back, a grid was drawn likewise on the upper right quadrant, but was not filled in; the upper left quadrant was left completely blank, where a sine-cosine graph is generally engraved.

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[707] *Jyotirvid,* 'knower of the celestial luminaries,' is a common title of astrologers.

COMPONENTS

Mater with crown (d. 128), rete (d. 108) for 12 stars, 6 plates (d. 108), alidade (length 110.5), pin and wedge.

FRONT

The ring and the shackle of this astrolabe are missing; otherwise it is in a good state of preservation. The crown is high and solid; its left and right profiles are artistically contoured with a succession of lobes. A decorative hole is bored in each of the two top lobes. There is another hole at the very top of the crown. Into this was inserted the shackle, which is now missing. The meridian line drawn on the body is extended on to the crown on both the sides. Otherwise the back of the crown is blank. The front of the crown bears the two inscriptions mentioned above.

The limb is divided in 1° and 6° and numbered in 6s separately for each quadrant from 6 to 90, starting from the east and west points and reaching up to the south and north points (6—90; 90—6; 6—90; 90—6).



Figure C006.2 – Rete of the Astrolabe (photo by S. R. Sarma)

RETE

In the rete, the equatorial ring is not completely shown; only a small segment is shown in the lower half, but there it is bent in the middle, for decorative reasons, to meet an upturned tulip flower. The rings of Capricorn and the ecliptic are held together by the equinoctial bar without any counter changes. The ecliptic circle is divided into 12 unequal divisions to represent the signs of the zodiac, which are named, but not always correctly inscribed. Each sign is further subdivided into 6° and numbered. On the bevelled edge of the ecliptic ring, these are further halved to form divisions of 3° each. The divisions are not always uniform.

There are 12 named star pointers, joined by a tracery which produces a characteristic 'bird in the cage' pattern.[708] The star names are abbreviated and, interestingly enough, these are followed by the serial numbers assigned to these stars by Mahendra Sūri in his *Yantrarāja.*[709] In the ecliptic circle, at the first point of Capricorn, there is a small triangular denticle of Capricorn. On the north point of the rete at the intersection of the meridian is a turning knob. The named stars are listed below in the order of increasing right ascension.

Table C006-1 Stars on the Rete

	Star name as engraved	Full/Correct Form	Identification
1	*Kṛtti 5*	[*Samudra-pakṣī*]	β Ceti
2	*Manu 7*	*Manuṣyapārśva*	α Persei
3	*Ro 8*	*Rohiṇī*	α Tauri
4	*Ā 14*	*Ārdrā-lubdhaka*	α Canis Majoris
5	*Lu 16*	*Lubdhaka-bandhu*	α Canis Minoris
6	*Ma 17*	*Maghā*	α Leonis
7	*Kāka 19*	*Kāka-skandha-pakṣa*	γ Corvi
8	*Ci 20*	*Citrā*	α Virginis
9	*Svā 21*	*Svāti*	α Bootis
10	*Dhanu 26*	*Dhanuḥ-śarāgra*	μ^{12} Sagittarii
11	*Śrava 28*	*Śravaṇa*	α Aquilae
12	*Samu 32*	[*Kartitakara*]	β Casseopieae

708 Cf. Sarma 2011a, pp. 108-110, figure 8.

709 Mahendra Sūri, 1.22-39, pp. 25-28; see Pingree 1978b, 628, Table XI.3.

The engraver, by mistake, interchanged the names of two stars. What is labelled as *kṛtti 5* (= *kartitakara*, β Cassiopieae) does in fact point to the star *samudra-pakṣī* (β Ceti), and that which is inscribed as *samu 32* pertains to *kartitakara*, β Casssiopieae. Otherwise, the star pointers are correctly positioned for the time when the astrolabe was made.

There are 8 more pointers which are not named. These are α Leonis, β Geminorum, α Coronae Borealis, α Librae, α Lyrae, ζ Cygni, δ Capillae, δ Aquarii. Notable among these is *Abhijit* (α Lyrae, Vega). In the Islamic tradition this star is named *al-nasr al-wāqi*^{c} (falling eagle), for it is seen as a falling eagle. Therefore, the star pointer is occasionally shaped like a bird as in the present astrolabe. With *Abhijit* in the shape of a bird, the rete displays a distinct pattern which we call 'bird in the cage pattern'.[710]

PLATES

Below the rete are stacked six plates. These are endowed with a tooth at the southern point which fits into a slot cut into the side of the rim. Altitude circles are drawn for each 6° and labelled along the periphery on the left hand side as well as on the right. In the lower half are drawn the unequal hour lines which are numbered from the western horizon. Azimuth lines are not drawn on the plates.

In the space between the horizon and the tropic of Cancer are engraved three items of data: the locality for which this face of the plate is calibrated, its latitude and the duration of the longest day at this latitude (*paramadina*) in *ghaṭīs* and *palas*. The plates are locality-specific rather than latitude- or climate-specific. They are calibrated for 12 different localities, ranging from Devagiri in the south (lat. 20;34° N) to Kāśmīra in the north (lat. 35° N). The geographical data given on the 12 sides of the 6 plates is tabulated below.

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710 On this, see Sarma 2011a.



Figure C006.3 – Plate for Kāśī on Latitude 24;36° (photo by S. R. Sarma)

Table C006-2 Geographical Data on the Plates

	Place Name	φ	Longest Day	Modern Name
1a	Devagiri	20;34	33;4	Daulatabad
1b	Dhākā	23	33;41	Dhaka
2a	Vūḍhanapura	21	33;21	Burhanpur
2b	Khambhāici	22	33;30	Cambay
3a	Yodhapura	26;51	34;16	Jodhpur
	Nepāla	26;51	34;16	Kathmandu, Nepal

	Place Name	φ	Longest Day	Modern Name
3b	Ajamera	26;34	34;9	Ajmer
4a	Kurukṣetra	30	34;48	Kurukshetra
4b	Ḍhillī	28;39	34;35	Delhi
5a	Āgarā	26;27	34;14	Agra
5b	Kāśī	25;36	34;5	Varanasi
6a	Kaśmīra	35	35;34	Srinagar
6b	Lahora	32	35;6	Lahore

On the inner side of the mater, ten concentric circles were drawn to accommodate a geographical gazetteer, but the blank spaces have not been filled in.



Figure C006.4 – Back of the astrolabe (photo by S. R. Sarma)

BACK

The rim of the upper half carries two altitude scales divided in 1° and 6° and numbered in 6s separately for each quadrant (6—90;90—6). The upper left quadrant is blank. In the upper right quadrant, there are concentric arcs, creating eight bands alternately broad and narrow. Each pair appears to form a particular scale. The upper two are divided into 15 cells each; the next two into 13 cells each, the next two into 10 cells each; and the last two into 6 cells each. But these cells are not filled. Probably this grid was meant for a table as in the two quadrants below, but it was left empty.

The lower left quadrant contains a table of shadow lengths for a gnomon of 12 digits (*aṅgulas*). This was engraved in four rows, starting from the outer periphery and reaching up to the centre. Around the hole at the centre is the label: *dvādaśāṃgulaśaṃko[ś] chā[yāh]*, 'shadows of the gnomon of 12 *aṅgulas*.' The first row shows the degrees of solar altitude of every 2° from 1° to 89°; the second and third rows the corresponding lengths of the gnomon shadow in *aṅgulas* and their sexagesimal submultiples. The table is reproduced below.

Table C006-3 Table of Gnomon Shadows

1	3	5	7	9	11	13	15	17	19	21	23	25	27	29
687	228	137	97	75	61	51	44	39	34	31	28	25	23	21
38	57	9	44	46	44		46	15	55	16	16	43	41	40
31	33	35	37	39	41	43	45	47	49	51	53	55	57	59
19	18	17	15	14	13	12	12	11	10	9	9	8	7	7
58	28	8	59	48	48	52	0	11	26	43	3	24	46	13
61	63	65	67	69	71	73	75	77	79	81	83	85	87	89
6	6	5	5	4	4	3	3	2	2	1	1	1	0	0
38	6	36	7	34	8	48	12	46	20	54	38	7	36	12

The lower right quadrant has inscribed on it a table of declinations for each 2° from 1° to 89°. The table is inscribed upside down, i.e. starting from the circumference and going down up to the centre, in four concentric rows. Around the hole near the centre is the label *krāntayah* , 'declinations'.

This table of declinations is derived from Malayendu's commentary on Mahendra Sūri's *Yantrarāja*, where the declinations are given for each degree from 1° to 90°; the maximum obliquity being 23;35°. The declinations are in minutes and seconds; these are followed by the differences (*antara*) between each two successive values of declinations. On the astrolabe, this table is abridged. The values are given for each 2

degrees and the differences are omitted. While Malayendu gives the declinations in minutes and seconds of arc, the astrolabe has them in degrees, minutes and seconds.

The table is carefully engraved on the very small area of the astrolabe, but there are some errors. These are indicated at the appropriate places in the footnotes. The table format is reproduced below. The first row shows the degrees of solar longitude, and the next three rows display respectively the degrees, minutes and seconds of the sun's declination.

Table C006-4 Table of Declinations

1	3	5	7	9[711]	11	13	15	17	19	21	23	25[712]	27	29
0	1	1	2	3	4	5	5	6	7	8	8	9	10	11
24	11	59	47	11	22	9	56	43	29	14	59	44	27	11
0	59	54	40	30	42	48	37	2	2	36	36	5	54	3
31	33	35[713]	37	39	41	43	45	47	49[714]	51	53	55	57	59
11	12	12	13	14	15	15	16	17	17	18	18	19	19	20
43	35	15	55	34	13	50	26	0	34	6	38	7	36	3
28	9	59	55	59	1	2	1	48	49	53	2	50	19	20
61	63[715]	65	67	69	71	73	75	77	79	81	83	85	87	89
20	20	21	21	21	22	22	22	22	23	23	23	23	23	23
28	52	15	36	55	13	29	44	56	7	16	23	29	32	34
57	1	35	34	54	37	42	1	35	27	32	50	18	58	47

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711 This is actually the value for 8°; the correct value for 9° is 3;35,18.

712 Malayendu Sūri, 9;44,4.

713 Malayendu Sūri, 12;55,59.

714 Malayendu Sūri,17;34,29.

715 Malayendu Sūri, 20;53,1

Bibliography

Sarma 2011b

Christie’s, London, auction catalogue of 1986, lot 358, p. 66.

C007⊙ SANSKRIT ASTROLABE OF JĪVATĀPA, SON OF JĀNĪ HARAJĪ

1651, Gujarat

Diameter 135 mm

Vadodara, M. S. University of Baroda, Oriental Institute (# 20735)



Figure C007.1 – Front of the astrolabe (photo by S. R. Sarma)

An inscription engraved on the circular edge mentions the date of manufacture as Tuesday, 4 April 1651, and the owner as Jīvatāpa, son of Jānī Harajī. The engraved lines, legends and numerals in this astrolabe are filled with a white substance so that these stand out clearly.

Components

Mater (d. 135, h. 168, t. 8) with crown, shackle and ring; rete (d. 109) for 20 stars, 3 plates (d. 109), alidade, pin and wedge. A modern aluminium chain is attached to the top ring.

Front

The crown is solid and high. The left and right profiles of the crown are contoured with a succession of lobes and two decorative holes. The meridian line, drawn on the body, is extended on to the crown on both the sides. Otherwise the front and the back of the crown are blank. The ring and the shackle are neatly crafted with diamond-shaped cross-sections.

The limb is divided in 1° and 5° and numbered in 5s from 5 to 360. The inner side of the mater is completely blank. A pin at about 113° holds the plates firmly in position, when the holes in the plates slide over the pin. The pin ought to have been located on the meridian, as is done on the astrolabes of 1605 (C001). Then, when the plate is reversed, the same hole slides over the pin. But in this astrolabe the pin is placed away from the meridian on the right. When the reverse side of a plate has to be used, the hole will be on its left side and the pin will not fit into it. Therefore a second hole had to be drilled into each plate, so that the plate could be turned around whenever it is necessary.

Rete

The celestial equator is shown partially by a small arc in the lower half. The Tropic of Capricorn, the ecliptic ring and a circular ring at the middle of the plate are held together by the equinoctial bar without any counter change. The short segment of the equatorial ring is held in position by struts at its two ends and in the middle, which join the arc to the ecliptic on one side and to the Tropic of Capricorn on the other side.

The ecliptic is divided into the 12 signs of the zodiac. The signs are not marked by their names but only by their serial numbers from 1 to 12. Each sign is divided into 5 divisions, the markings of division running down the sloping edge. There are 20 flame-

shaped star pointers, 9 outside the ecliptic and 11 inside. The star names are engraved on these pointers, often in an abbreviated form. There is a short turning knob on the left of the horizontal bar, between the Tropic of Capricorn and the ecliptic. The marks of division on the ecliptic band and the star names are engraved rather crudely. The stars inscribed on these pointers are listed below in the order of increasing right ascension, starting from the vernal equinox and proceeding clockwise.



Figure C007.2 – Rete of the Astrolabe (photo by S. R. Sarma)

Table C007-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Sa.pa.*	*Samudra-pakṣī*	β Ceti
2	not named	[*Rañjita-kara*]	β Cassiopieae
3	*Pre*	*Pretaśiras*	β Persei

	Star Name as engraved	Full/Correct Form	Identification
4	*Bra.hṛ.*	*Brahma-hṛdaya*	α Aurigae
5	*Rohi*	*Rohiṇī*	α Tauri
6	*Mi.vā.*	*Mithuna-vāma-skandha*	γ Orionis
7	*Mi.ha.*	*Mithuna-hasta*	α Orionis
8	*Mi.pā.da*	*Mithuna-pāda-dakṣiṇa*	κ Orionis
9	*Lubdhaka*		α Canis Majoris
10	*Lubdhakava*	*Lubdhaka-bandhu*	α Canis Minoris
11	not named	[*Pūrva-phālgunī*]	δ Leonis
12	*Ka*	*Kāka-skandha*	γ Corvi
13	*Citrā*		α Virginis
14	*Svāti*		α Bootis
15	*Mātṛ*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
16	illegible	[*Sarpa-dhārī-śira*]	α Ophiuchi
17	*A*	*Abhijit*	α Lyrae
18	*Śravaṇa*		α Aquilae
19	*Ku*	*Kukkuṭa-puccha*	α Cygni
20	*A*	*Aśva-mukha*	ε Pegasi

PLATES

The three plates contain projections for six cities located between latitudes 21° and 29°, viz. Burhanpur, Ahmedabad, Patan, Sirohi, Agra and Delhi. On these plates, altitude circles are drawn for each 6° and numbered on the left as well as on the right. Azimuth arcs are drawn for each 9° on the plate face calibrated for Burhanpur, but not

numbered. On the remaining five faces, there are no azimuths. Lines for unequal hours are drawn on all plates and numbered from the western horizon from 1 to 12. On the faces relating to Burhanpur and Ahmedabad, these are drawn as straight lines; on other faces these are correctly drawn as arcs of the circle.



Figure C007.3 – Plate for Yoginīpura, i.e., Delhi (photo by S. R. Sarma)

The data engraved below the central hole on each face of the plates contains the following information: the name of the city, its latitude in degrees, the length of the noon equinoctial shadow in *aṅgulas,* the duration of the longest day in *ghaṭīs* and *palas,* and also in hours and minutes. Here the noon equinoctial shadow is designated as *bhā* (short for *akṣabhā* or *palabhā*) and the longest day is indicated as *parama-dina* or by its abbreviation *pa.di.* The latitude and the longest day in hours are indicated by a symbol that resembles the symbol for the *avagraha* which is used to indicate the elision of the initial vowel *a* in the Devanagari alphabet. (We shall represent it here with the italicized

S). This is for the first time that the longest day is given both in *ghaṭīs* and hours. The inscriptions are reproduced below.

1a. Burhanpur

The inscription engraved below the central hole reads as follows:

bhā 4|38 pa. *buhurānāpure*
di. 33|14 *S 21|6*
S 12|5

'At Burhanpur, [the latitude is] 21;6°; noon equinoctial shadow (*bhā*) 4;38 [*aṅgulas*]; the longest day (*pa.di.*) 33 [*ghaṭīs*] and 14 [*palas*]; [or] 12 [hours] and 6 [minutes]."

1b. Ahmedabad

After engraving the projections on face a, the astrolabe maker reversed the plate and, by mistake, also turned the plate upside down by 180° and engraved the almucantars and hour lines. Later, realizing the mistake, he once again turned the plate by 180° and engraved once again the almucantars and hour lines, and then engraved the numbers and the inscription. Technically then this plate can be used in both directions. Therefore, two holes had to be bored in the upper and lower halves to fit into the pin. The inscription below the central hole reads thus:

bhā 5|6 parama *amadāvāda*[716]
dina 33|36 *S horā (?)*
S 13|4 *S 23|1*

'Ahmedabad, [latitude] 23;1°, noon equinoctial shadow 5;6 [*aṅgulas*], longest day (*parama-dina*) 33 [*ghaṭīs*] and 36 [*palas*]; [or in] hours (*horā*) 13 [hours] and 4 [minutes].'

2a Patan

Here the equator and some almucantars were drawn carelessly first and had to be redrawn a second time. The inscription below the central hole:

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[716] It is customary in this context to mention the name of the city in the locative case, but this was not done for Ahmedabad.

bhā 5|20 *pattane*
pa.di. 33|48 *S 23|43*
S 13|8

'At Patan, [latitude] 23;43°, noon equinoctial shadow 5;20 [*aṅgulas*], longest day 33 [*ghaṭīs*] and 48 [*palas*]; [or] 13 [hours] and 8 [minutes].'

2b Śīrohī-nagara

Here several circles were redrawn a second time because the first attempt was faulty. The inscription:

bhā 5|29 pa. śīrohīnagare
di. 33| 54 S 24|30
S 13|13

'At the city of Sirohi, [latitude] 24;30°; noon equinoctial shadow 5;29 [*aṅgulas*]; longest day 33 [*ghaṭīs*] and 54 [*palas*]; [or] 13 [hours] and 13 [minutes].'

3a. Agra

The inscription:

bhā 6|0 pa.di. *āgarā na[gare]*
34|16 S 13 *a 26|32*
|25

'At the city of Agra, [latitude] (*a* = *akṣāṃśa*) 26;32°; noon equinoctial shadow 6;0 [*aṅgulas*]; longest day 34 [*ghaṭīs*] and 16 [*palas*]; [or] 13 [hours] and 25 [minutes].'

3b. Delhi

As in plate no. 1, here also after engraving the projections on face a, the astrolabe maker turned the plate around and, by mistake, turned the plate upside down by 180° and engraved the almucantars and hour lines. Unlike in plate 1, here he kept the wrong orientation and made one more hole in the upper half. The inscription:

bhā. 6|33 parama *yoginīpure*
di. 34|35 *S 28|34*
S 13|41

> "At Yoginīpura (i.e. Delhi), [latitude] 28;34°; noon equinoctial shadow 6;33 [*aṅgulas*]; longest day 34 [*ghaṭīs*] and 35 [*palas*]; [or] 13 [hours] and 41 [minutes]."

Here the numerals are not uniform and follow different styles: 4 is engraved in two distinctly different ways, 6 in several slightly different ways, 8 in two distinct styles, 9 in two distinct methods but in several slightly different styles. Also while numbering the hour lines, on some plates the numbers are oriented towards the centre (1b, 2b, 3a, 3b) and on some others towards the rim (1a, 2b). The geographical data on the plates is tabulated in Table 3 below.

Table C007-2 Geographical Data on the Plates

	Place Name as engraved	**Modern Name**	**φ**	**Equi-noctial Shadow**	**Longest day in *ghaṭīs***	**Longest day in hours**
1a	Buhurānā-pura	Burhanpur, Madhya Pradesh	21;06°	4;38	33;14 (=13;17,36 *h*)	12;05 (=30;12,30 *gh*)
1b	Amadāvāda	Ahmedabad, Gujarat	23;01°	5;06	33;36 (=13;26,24 *h*)	13;04 (=32;40 *gh*)
2a	Pattana	Patan, Gujarat	23;43°	5;20	33;48 (=13;31,12 *h*)	13;08 (= 32;50 *gh*)
2b	Sirohīnagara	Sirohi, Rajasthan	24;30°	5;29	33;54 (=13;33,36 *h*)	13;13 (=33;02,30 *gh*)
3a	Āgarānagara	Agra, Uttar Pradesh	26;32°	6;0	34;16 (13;42,06 *h*)	13;25 (=33;32,30 *gh*)
3b	Yoginī-pura	Delhi	28;34°	6;33	34;35 (=13;50 *h*)	13;41 (=34;12,30 *gh*)

But strangely the values given in *ghaṭīs* and hours do not match. For example, the longest day at Burhanpur is stated to be 33 *ghaṭīs* 14 *palas* or 12^h5^m. But these two values are not equal; 33 *ghaṭīs* 14 *palas* are equal to $13^h17^m36^s$, whereas 12 hours 5 minutes are tantamount to 30 *ghaṭīs* 12 *palas* 30 *vipalas.* Thus there is a mismatch in all the six cases.

Now the question arises as to which of the values are correct, those in *ghaṭīs* or those in hours? When we compare these with similar values given in other sources, it is

apparent that the values in *ghaṭīs* are the correct ones. Malayendu Sūri, in his commentary (*ca.* 1382) on Mahendra Sūri's *Yantrarāja* (1370) gives the following values to some of the towns mentioned above. Aṇahillapattana: latitude (*akṣāṃśa*) 24°, longest day (*paradi[na]*) 33;48 *ghaṭīs*; noon equinoctial shadow (*viṣuvatī*) 5;20. Dillī: latitude 28;39°, longest day 34;34 *ghaṭīs*; noon equinoctial shadow 6;33.[717] Clearly the astrolabe maker (or the one who designed it) made grave errors in converting *ghaṭīs* and *palas* into hours and minutes.

In the sixth column of the table, below the *ghaṭī* value as engraved on the plate, we have given the exact equivalent in hours, minutes, and seconds in parenthesis; likewise in the seventh column, below the hour value as engraved on the plate, we have given the exact equivalent in *ghaṭīs*, *palas* and *vipalas* in parenthesis.

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717 Malayendu Sūri, pp. 21, 23.



Figure C007.4 – Back of the astrolabe (photo by S. R. Sarma)

BACK

The rim of the upper half carries altitude scales, divided in 1° and 5° and numbered 5s (5—90; 90—5), separately for each quadrant. The upper left quadrant has 12 horizontal parallel lines, almost corresponding to the divisions of 5° in the rim. These provide the sines of the angles measured on the circular scale. The upper right quadrant has 5 concentric quarter circles, producing 6 annuli, each one for two opposite signs of the zodiac. But it was not filled in, nor was it labelled. In the lower half, shadow squares are drawn, on the left for a gnomon of 12 units, and on the right for a gnomon of 7 units,

but not labelled. Within the shadow squares, there is a grid of 16 x 4 cells which is not filled in.

Alidade

Pivoted to the centre at the back is a plain alidade with two sights. No graduations are engraved on the alidade. The pin has a broad head shaped like a stylized lotus. A wedge holds the pin tightly in position. As in the Islamic astrolabes, one end of the wedge is shaped like a horse's head for a better grip. There is a hole in the horse's head, though which a ring passes and a small chain is attached to the ring. Probably the chain connected the wedge to the ring on the top, in order to prevent the misplacement or loss of the wedge, which often happens.



Figure C007.5 – Inscription on the edge of the astrolabe (photo by S. R. Sarma)

Inscription

On the circular edge of the mater, there is an inscription which reads:

> *saṃvat 1708 varṣe śāke 1574 pravarttamāne caitra śudi 15 bhaume jānī harajī suta jīvatāpa no yaṃtrarāja che* ‖
>
> 'In Saṃvat year 1708 [expired], in Śaka 1574 current, in the month of Caitra, in the bright half, on the 15th day, on Tuesday, [this] astrolabe is of (belongs to) Jīvatāpa, son of Jānī Harajī.'

The date corresponds to Tuesday, 4 April 1651. The inscription is mainly in Sanskrit, but the genitive particle *no* (of) and the verb *che* (is) are in Gujarati.

Bibliography

Sarma 2009b

C008 SANSKRIT ASTROLABE OF RĀGHAVAJIT[718]

1669, Surat

Diameter ?

PLU



Figure C008.1 – Astrolabe made for Rāghavajit at Surat
(courtesy Museum of the History of Science, Oxford)

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[718] Entry based on the detailed drawings in Raikva 1936.

The inscription on the back of the crown states that this astrolabe was made on a day corresponding to 5 July1669 for Rāghavajit. R. K. Raikva of Surat reproduced 13 outline drawings of this astrolabe (back, front, both sides of the 5 plates, and rete) in his edition of Mahendra Sūri's *Yantrarāja* (Bombay 1936). In the Sanskrit introduction to this edition, Raikva records that he had in his possession this astrolabe made for Rāghavajit as well as a manuscript of Mahendra Sūri's *Yantrarāja* which was copied in Śaka 1590 (= AD 1667-68) by the same Rāghavajit, son of Viśvanātha, of Sūryapura (i.e. Surat).[719] For his edition, Raikva used this manuscript along with two other manuscripts.

Thus Rāghavajit copied the manuscript of Mahendra Sūri in Śaka 1690 and a year later got an astrolabe made for his own use, the technical drawings for which were presumably drawn by him so that a metal worker could carry them out. In this astrolabe Rāghavajit incorporated several features which are to be found in the Indo-Persian astrolabes made about this time by the members of the Lahore family of astrolabe makers.

Indeed this is the first extant Sanskrit astrolabe to display several instances of influence of the Lahore astrolabes. As in the Lahore astrolabes, this one too has a separate plate for ecliptic coordinates and multiple horizons, double projection on one of the plates and mentions the longitudes (*deśāntara*) of places in the geographical gazetteers. The Lahore astrolabes carry curves for the sun's meridian altitudes for Agra, Delhi and Lahore. In imitation of this, a similar curve was drawn on the back of the present astrolabe for the latitude of 22°, which is roughly the latitude of Surat where Raghavajit resided. Moreover, as in the Lahore astrolabes, the crown has a trifoliate finial.

COMPONENTS

Mater with crown and shackle, no ring, rete for 23 stars, 5 plates; no information about the alidade, pin and wedge; no measurements are available.

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719 Raikva 1936, pp. 10-11.

FRONT

The lobed crown is high and culminates in a trifoliate finial as in the Lahore astrolabes. Its front is decorated with a pattern of intertwined creepers in relief. The rim on the back of the crown is raised and provides an ornate frame for the inscription engraved there. There is a simple shackle, but the ring is missing. The limb carries three bands of scales, of 1°, 2° and 6°, and is numbered in 6s, separately for each quadrant from 6 to 90 (6—90; 6—90; 6—90; 6—90). The three scales suggest that this may have been a fairly large astrolabe.

RETE

The celestial equator is not represented on the rete. The rings of the Tropic of Capricorn and the ecliptic are joined by the equinoctial bar with two counterchanges and by series of intertwined creepers. There is a small rectangular arch, in the place of a pointed tip, to represent the Capricorn index. The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names. Each sign is divided into groups of 6° and labelled in an anti-clockwise direction. There are 12 star pointers outside the ecliptic and 11 inside. The names are occasionally abridged. It is noteworthy that the stars *Uttara-samudrapakṣī* (ι Cet) and *Jyeṣṭhā* (α Scorpii) are rarely marked on other Sanskrit astrolabes.

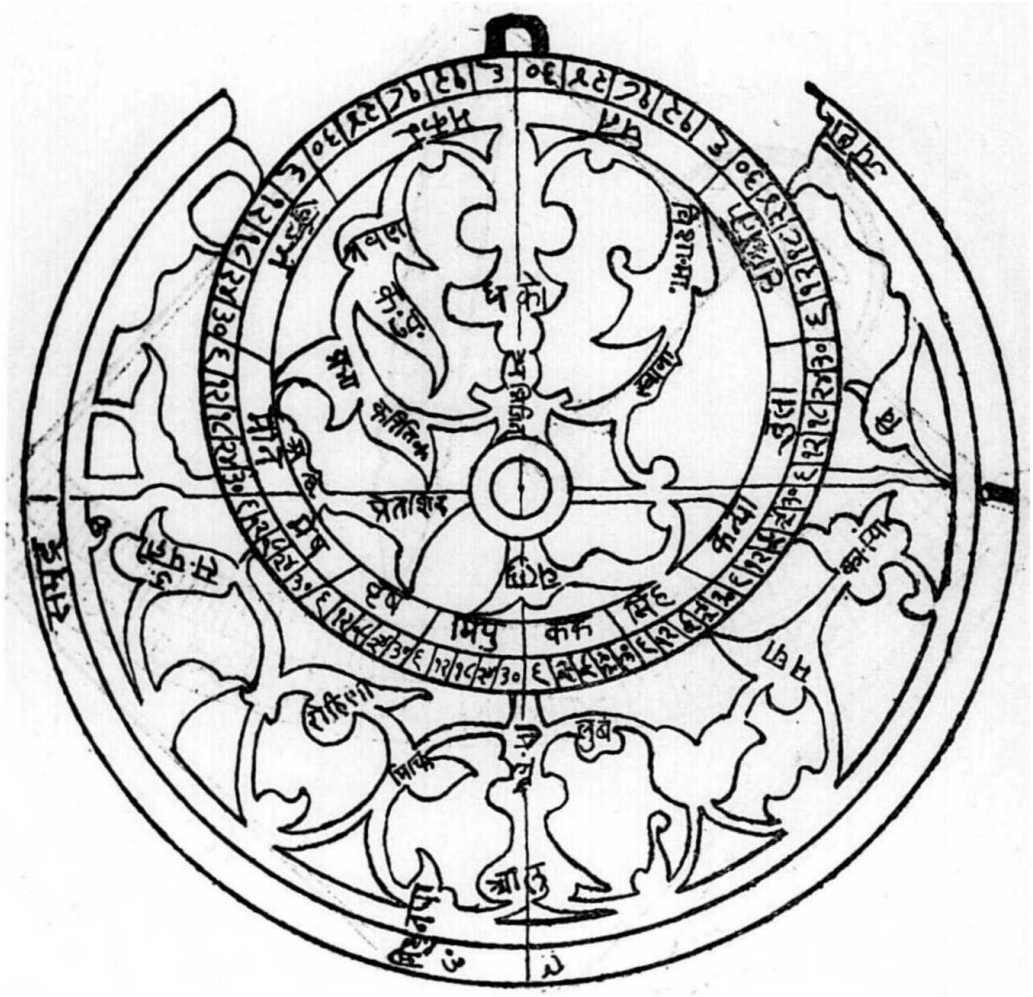


Figure C008.2 – Rete of the astrolabe (drawing from Raikva 1936)

Table C008-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudra*	*Samudra-pakṣī*	β Ceti
2	*Pretaśira*		β Persei
3	*Vaṇmu*	*Ṣaṇmukha*	α Aurigae
4	*Rohiṇī*		α Tauri
5	*Mithuna.pā.*	*Mithuna-vāma-pāda*	β Orionis
6	*Mi.ska.*	*Mithuna-vāma-skandha*	γ Orionis
7	*Mi.ha.*	*Mithuna-dakṣiṇa-hasta*	α Orionis

	Star Name as engraved	Full/Correct Form	Identification
8	*Ā.lu.*	*Ārdrā-Lubdhaka*	α Canis Majoris
9	*Lu.ba.*	*Lubdhaka-bandhu*	α Canis Minoris
10	*Maghā*		α Leonis
11	*Kā.ska.*	*Kāka-skandha*	γ Corvi
12	*Ci.*	*Citrā*	α Virginis
13	*Svānā*	*Svāti*	α Bootis
14	*Viśā. mā.*	*Viśākhā-mātṛmaṇḍala*	α Coronae Borealis
15	*Jyeṣṭhā*		α Scorpii
16	*Dha.ko.*	*Dhanuḥkoṭi*	α Ophiuchi
17	*Abhijit*		α Lyrae
18	*Śravaṇa*		α Aquilae
19	*Ka.pu.*	*Kukkuṭa-puccha*	α Cygni
20	*aśva.*	*Aśva-mukha*	ε Pegasi
21	*a. da?*	*Aśva-nābha*	δ Pegasi
22	*Karttitaka.*	*Karttita-kara*	β Cassiopeiae
23	*U. sa. pakṣī*	*Uttara-samudra-pakṣī*[720]	ι Ceti

[720] I.e., The Northern [tip of the] tail of Cetus, *Dhanab al-qayṭus shamālī.*

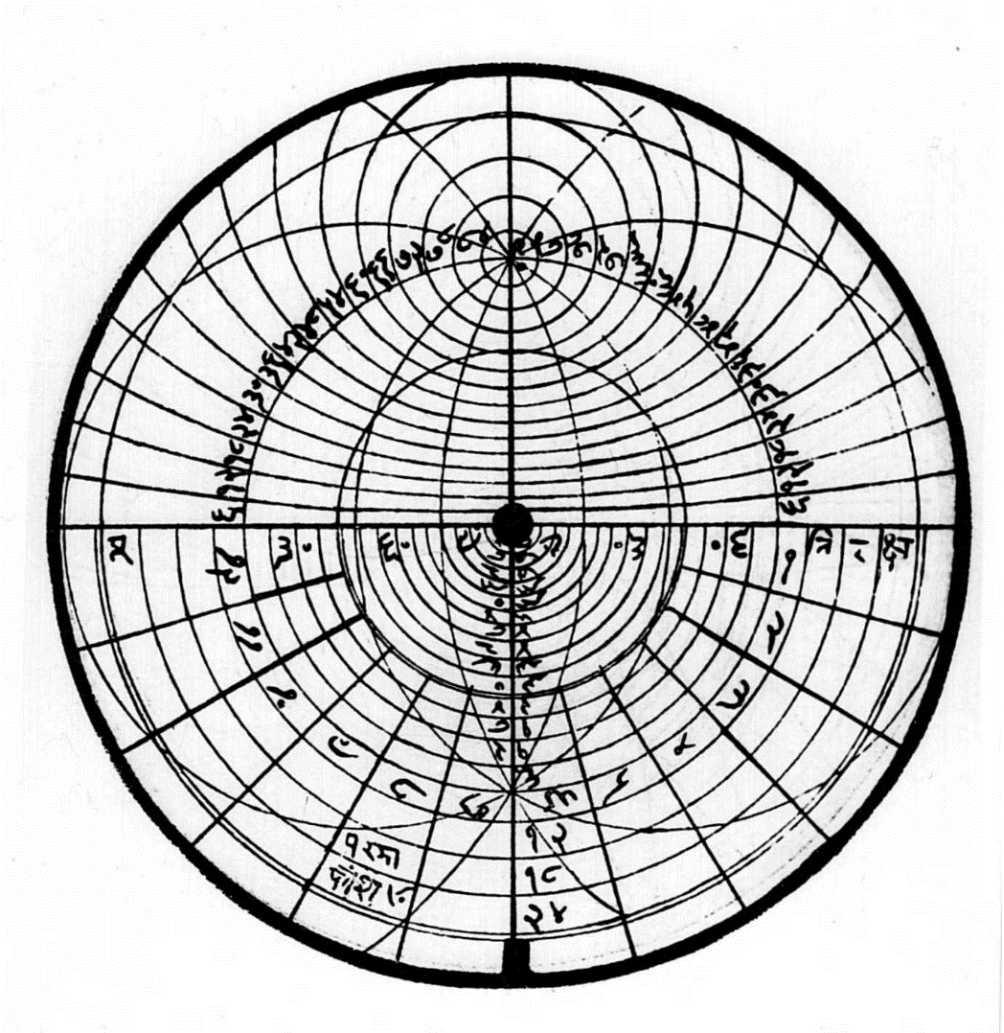


Figure C008.3 – Plate with projections for 0° and 90° (drawing from Raikva 1936)

Plates

On four of the five plates, altitude circles are drawn for each 6°, azimuth arcs for each 15° below the horizon, lines for unequal hours and dotted lines for equal hours counted from the western horizon. On the plate for 32° there are dotted lines for unequal hours counted from the western and eastern horizons. The eastern and western parts of the horizon are labelled respectively as *pū[rva]* and *pa[ścima]*. The latitude (marked as *akṣāṃśa, akṣā* or *akṣa*) for which the plate is calibrated and the longest day in hours (*horā*) and minutes are engraved in the middle of each side of the plates. It is not certain which two sides belong to a particular plate. Therefore, the plate faces are arranged below in the order of increasing latitudes.

Table C008-2 Plates

	φ	Longest Day
1	*akṣāṃśa 20*	*horā 13;13*
2	*akṣāṃśa 22*	*horā 13;21*
3	*akṣāmśa 25*	*horā 13;33*
4	*akṣāṃśa 27*	*horā 13;42*
5	*akṣa 29*	*horā 13;51*
6	*akṣāṃśa 32*	*horā 14;8*
7	*akṣāṃśa 18* *akṣa 72*	*horā 13;4* (double projection)
8	*paramākṣāṃśa 90* + *nirakṣa* (= 0)	(double projection)
9	*akṣāṃśa* 66	(plate of ecliptic coordinates)
10	*sarvadeśa*	(plate of horizons)

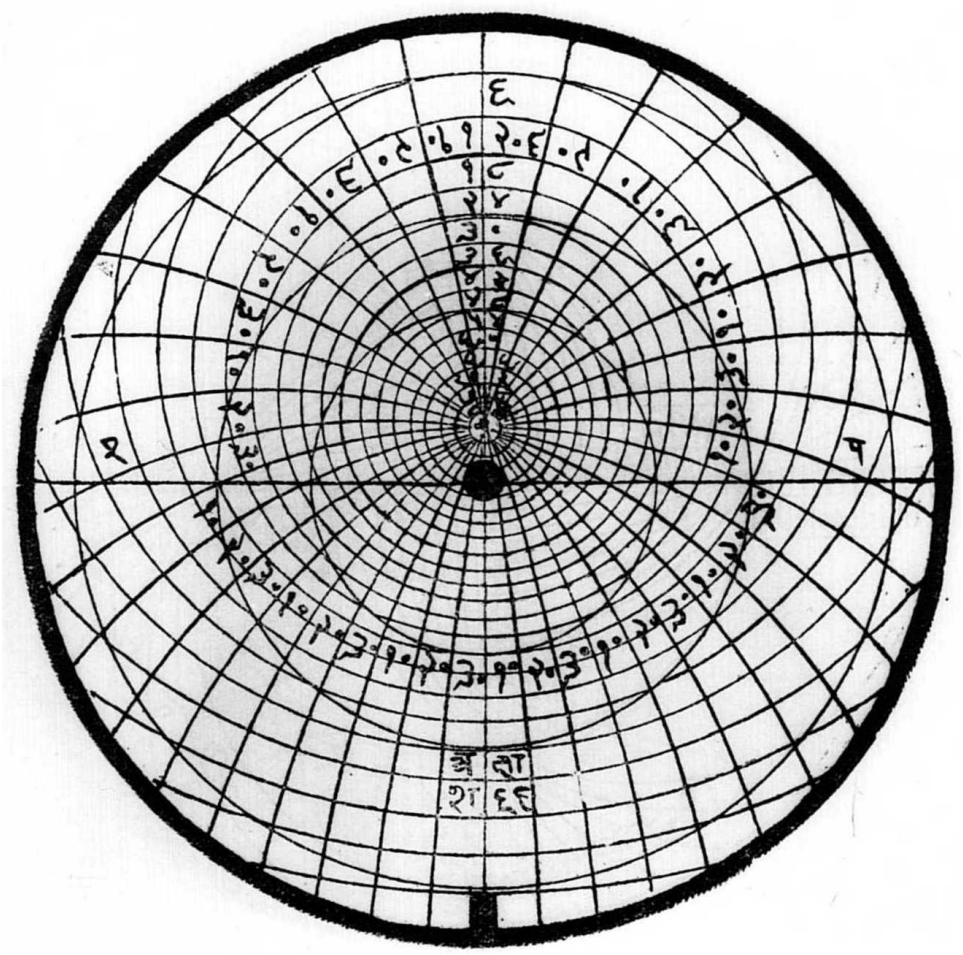


Figure C008.4 – Plate of Ecliptic Coordinates (drawing from Raikva 1936)

9: Plate of Ecliptic Coordinates

It carries, in addition to the projections of the two tropics, the equator and the ecliptic, altitude circles at intervals of 6° and azimuth circles at intervals of 10°. The altitude circles are numbered along the meridian line; the azimuths are numbered separately for each sign, as 10, 20, 30 along the ecliptic; from Aries to Virgo outside the ecliptic and from Libra to Pisces inside the ecliptic circle. There are no other labels, besides the numbers of the two sets of circles. In the lower part of the plate is the label *akṣāṃśa 66,* 'latitude 66 [degrees].'

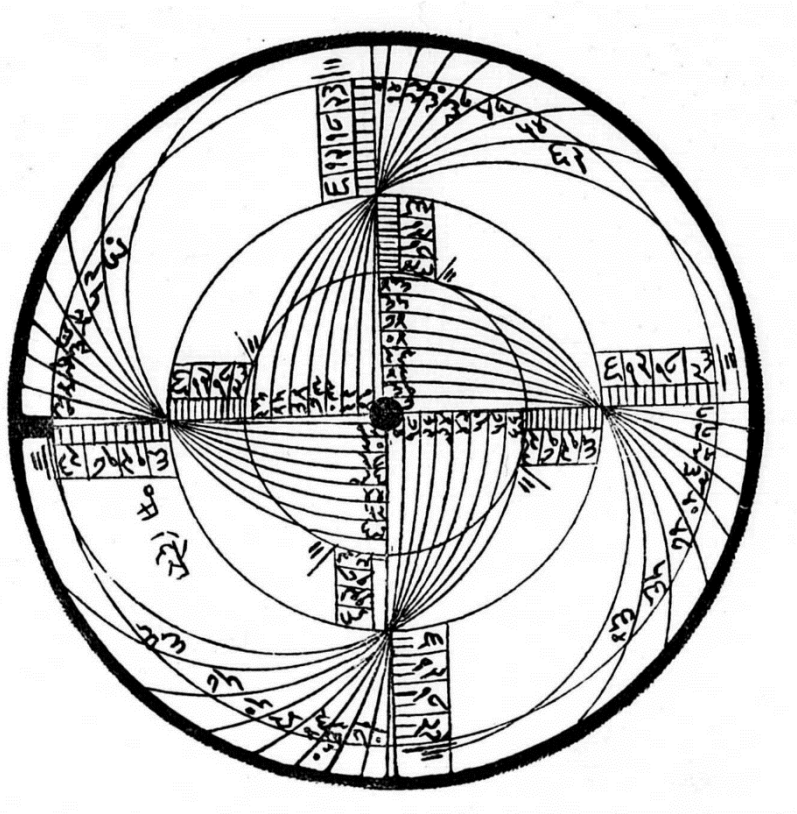


Figure C008.5 – Plate of Horizons (drawing from Raikva 1936)

10. Plate of Horizons

It is engraved probably on the reverse side the plate of ecliptic coordinates. It carries four sets of horizons, seven or eight for each quadrant, which are labelled twice along the vertical or horizontal radius and along the arc of the quadrant.

6	14	22	30	38	46	54	62
8	16	24	32	40	48	56	64
10	18	26	34	42	50	58	66
12	20	28	36	44	52	60	

Along the radii are also given the scales of declination, with the divisions reading 6, 12, 18, 23 ½ . The last value is the maximum declination ε. In one of the quadrants is engraved the legend *sarvadeśa* (more correctly *sarvadeśī*), '[usable at] all latitudes'.

GEOGRAPHICAL GAZETTEER

On the inner surface of the mater is engraved a geographical gazetteer in three concentric circles which are divided into 24 cells by radial lines. The last cell contains the argument *nagarāṇi* (towns), *deśāntara* (L) and *akṣāṃśa* (φ). The names, longitudes and latitudes are read clockwise from the top centre. It is significant that the gazetteer commences with Surat, the place where the astrolabe was possibly made.

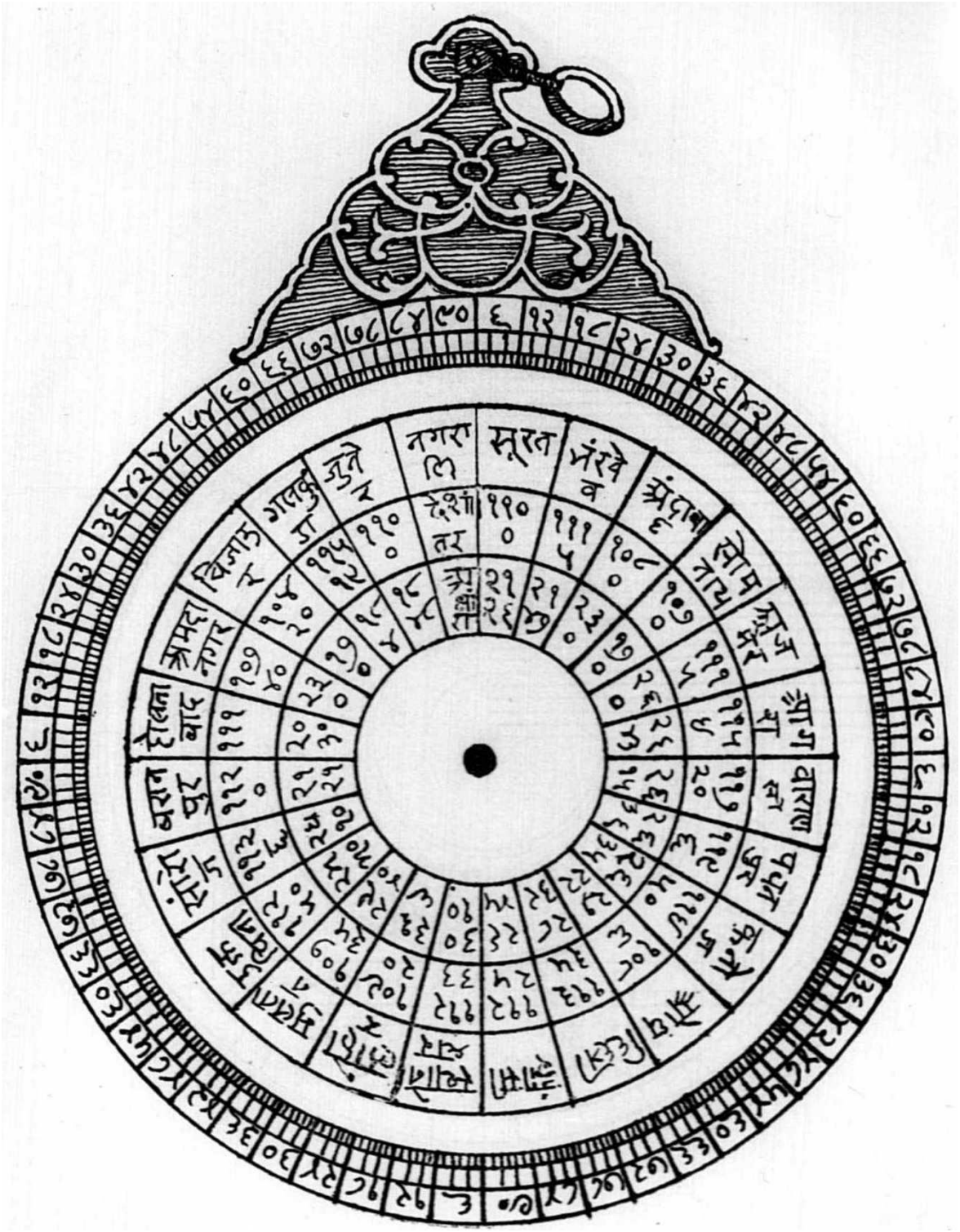


Figure C008.6 – Geographical Gazetteer (drawing from Raikva 1936)

Table C008-3 Geographical Gazetteer

	Town Name *nagarāṇi*	**L** *deśāntara*	**φ** *akṣāṃśa*	**Modern Name**
1	Sūrata	110;0	21;26	Surat
2	Bhamkheva	111;5	21;47	Broach
3	Aṃdābāda	108;0	23;0	Ahmedabad
4	Somanātha	107;0	17;0	Somnath
5	Ajamera	111;5	26;0	Ajmer
6	Āgarā	115;9	26;43	Agra
7	Vārāṇāsī	117;20	26;15	Varanasi
8	Yavanapura	112;6	26;36	Jaunpur
9	Kanoja	119;50	26;34	Kannauj
10	Odha	108;6	27;22	Avadh = Faizabad
11	Dillī	113;35	28;32	Delhi
12	Jhāṃsī	112;25	26;45	Jhansi
13	Sthāneśvara	112;33	30;10	Thenesar
14	Lāhora	109;20	31;6	Lahore
15	Mulatāna	107;35	29;40	Multan
16	Ujjayinī	112;50	23;30	Ujjain
17	Sāṃroja	113;6	26;10	Sironj?
18	Barānapura	112 0	21;21	Burhanpur
19	Hosanābāda!	111	20;30	Hoshangabad
20	Amadānagara	107;40	23;0	Ahmednagar
21	Vijāura	104;20	17;0	Bijapur
22	Galakuṃḍā	115;12	18;4	Golconda=Hyderabad
23	Junera	110;0	18;48	Juner ?

Town Name *nagarāṇi*	L *deśāntara*	φ *akṣāṃśa*	Modern Name

BACK

The rim of the upper half has three scales for 1°, 2° and 6° as on the front; but the groups of 6° are numbered as 6—90; 90—6. The upper left quadrant carries a sine graph with 30 horizontal parallels; three lines are divided transversally into 28 parts and numbered upside down in groups of three.[721]

The upper right quadrant has six declination arcs, each for two signs of the zodiac. These are labelled along the two radii. Along the horizontal radius, starting from the periphery and proceeding towards the centre, the signs are labelled from the winter solstice to the summer solstice as *Makara, Kuṃbha, Mīna, Meṣa, Vṛṣa, Mithu[na].* Along the vertical radius, starting from the centre and proceeding towards the periphery, the signs are labelled from the summer solstice to the winter solstice as *Karka, Siṃha, Kanyā, Tulā, Vṛści[ka], Dhanuḥ.* A graph of the solar meridian altitude is engraved on it with the label *madhya rekhā* (for *madhyāhna-rekhā,* midday-line), followed by the Devanagari symbol for *avagraha* and the numeral 22.[722] Accordingly the label here informs that this is the graph of solar meridian altitude at the latitude of 22 degrees, which is roughly the latitude of Surat (in the geographical gazetteer, the latitude of Surat is given as 21;26°), the place from which Rāghavajit hails.

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721 See also nos. C009, C012, C013.

722 In the astrolabe of 1651 (C007), the Devanagari symbol for *avagraha* was used to indicate sometimes the latitude and sometimes the longest day. Here it is used as the symbol for the latitude.

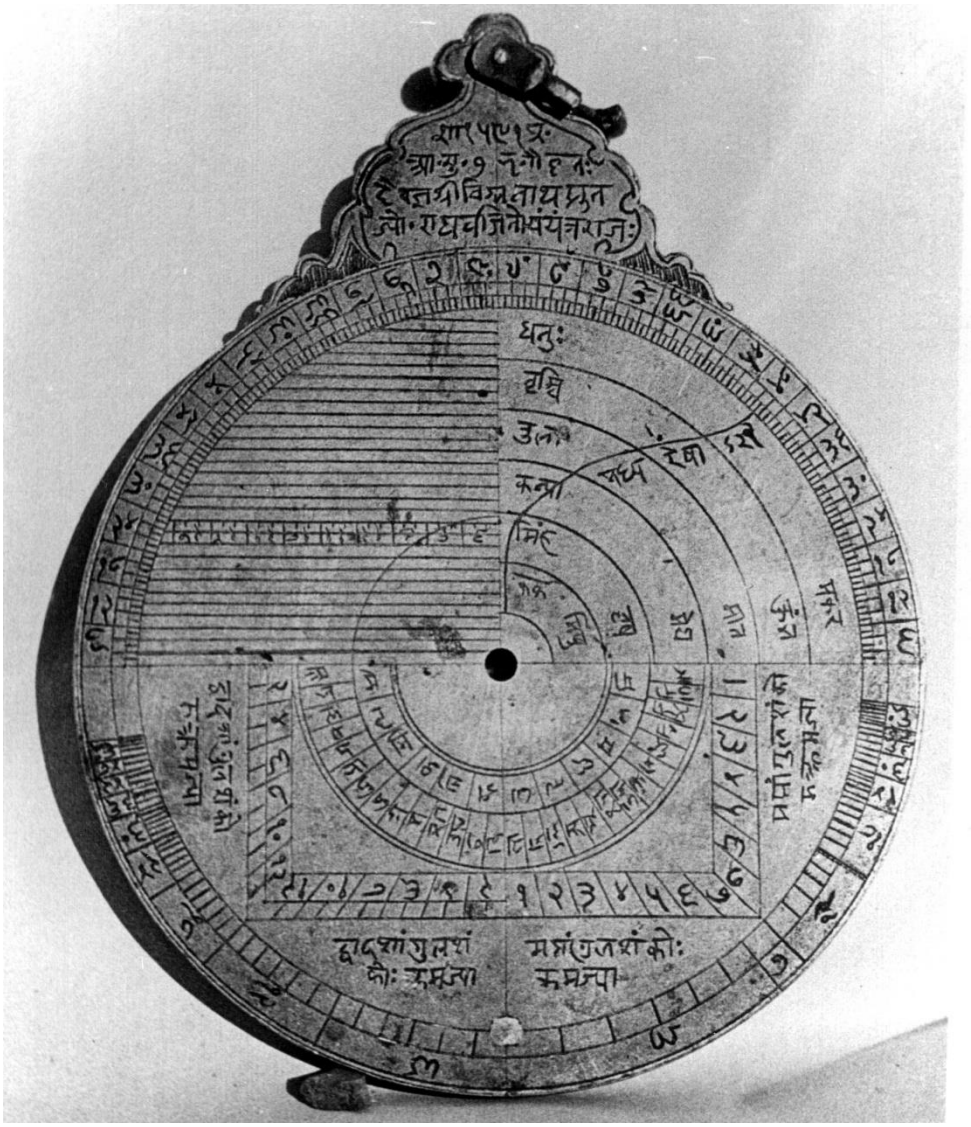


Figure C008.7 – Back of the astrolabe (photo courtesy Museum of the History of Science, Oxford)

In the lower half are engraved the shadow squares, on the left for a gnomon of 12 digits and on the right for a gnomon of 7 digits. On the left each two divisions are numbered as 2, 4, and so on in both the scales. On the right each division is numbered. The following are the labels.

Vertical scale on the left: *dvādaśāṃgulaśaṃkoḥ sakramajyā* (! *utkramacchāyā,* umbra versa of the gnomon of twelve digits)

Horizontal scale on the left: *dvādaśāṃgulaśaṃkoḥ kramajyā* (! *kramacchāyā,* umbra recta of the gnomon of twelve digits)

Horizontal scale on the right: *saptāṃgulaśaṃkoḥ kramajyā* (! *kramacchāyā,* umbra recta of the gnomon of seven digits)

Vertical scale on the right: *saptāṃgulaśaṃkoḥ sakramajyā* (! *utkramacchāyā,* umbra versa of the gnomon of seven digits)

Inside the shadow squares are two semicircular scales with the initial syllables of the names of the 12 signs of the zodiac together with the names of the 28 corresponding lunar mansions. The rim of the lower half carries a cotangent scale as in the Lahore astrolabes.

Inscription

The inscription engraved on the back of the crown reads as follows:

śā 1591 pra. (?)[723]
ā[ṣāḍha] śu[kla] 7 bhṛgau kṛtaḥ [.]
daivajña śrī viśvanātha suta
jyo. Rāghavajito 'yaṃ yaṃtrarājaḥ

'Made on Śaka 1591 first Āṣāḍha, bright half, seventh day, Friday. This *Yantrarāja* is of (belongs to) Jyo[tirvid] Rāghavajit, son of Daivajña Viśvanātha.'

This date translates to 5 July1669.

Provenance

In early twentieth century, this astrolabe was in the possession of R. K. Raikva of Surat, who published 13 drawings of this astrolabe in his edition of Mahendra Sūri's *Yantrarāja*, Bombay 1936. Subsequently, sometime in the second half of the twentieth century, it seems to have been offered for sale by one Krishna of Bombay, for in the archives of the Museum of the History of Science, there are two photos of this astrolabe on back of which is a pencilled note 'Krishna, Bombay'. It is not known what happened thereafter.

Bibliography

Raikva 1936.

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723 The syllable *pra.* is problematic. It appears to be an abbreviation for some term like *prathama* (first) or *pravartamāna* (current). If it is *prathama,* it would imply that there was an intercalation in that year and that the lunar month Āṣāḍha was repeated, but there was no intercalation in that year. *Pravartamāna* would mean that the Śaka year 1591 is current; in that case the weekday would be Monday and not Friday as stated here.

C009 SANSKRIT ASTROLABE, NOT SIGNED, NOT DATED[724]

Ca 1670, Surat, Gujarat

Diameter 119 mm

PLU



Figure C009.1 – Front of the astrolabe (from Linton 1980)

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[724] Entry based on Linton 1980, item no. 228, p. 182.

COMPONENTS

Mater (d. 119, h. 157, t. 9) with crown, shackle and ring; rete for 28 stars, 5 plates; alidade missing; pin and wedge are replacements.

FRONT

High crown without any decorations but with upraised rim in the front, as on the back of the previous astrolabe (C008). The limb is divided in 1° and 6° and numbered in 6s, separately for each quadrant from 6 to 90, starting from the east and west points and reaching south and north points (6—90; 90—6; 6—90; 90—6).

RETE

The equator is not represented in the rete. The other two rings of Capricorn and ecliptic are held together by the equinoctial bar, by the solstitial bar which is interrupted below the ecliptic ring and by a crude tracery. The ecliptic ring is divided into the 12 signs and labelled with the initial syllables of their names. The signs are further divided into groups of 6° and numbered. In the published photographs, it is difficult to decipher the names on the 28 star pointers which are said to be in the rete. Those that can be seen here, which do not normally occur in other Sanskrit astrolabes, are *makara[puccha]* δ Capricorni, *jyeṣṭā* α Scorpii and an undecipherable name for ι Cet.[725]

PLATES

Moscowitz catalogue describes and illustrates the front and back of the five plates with small and faint photos, from which the following particulars can be discerned.[726]

1a: lat 30°, altitude circles; azimuths above and below the horizon

1b: an unusual plate with the sine-cosine graph in the upper right quadrant; shadow square in the lower right quadrant, multiple horizon graphs in the upper and lower quadrants.

2a: lat 20°, altitude circles, azimuth arcs below the horizon, unequal hour lines.

2b: double projection apparently for the latitudes 24° and 28°

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725 These three stars are shown in Indraji's astrolabe of 1673 (C010); α Scorpii and ι Ceti are in Rāghavajit's astrolabe of 1669 (C008); α Scorpii and δ Capricorni are on the undated astrolabe (C012), the three stars appear to be also in the astrolabe of 1678 (C011).

726 Moskowitz 1984, no. 144, pp. 34-35.

3a: lat 28°, altitude circles, azimuth arcs below the horizon, unequal hour lines.
3b: lat 45° (?), altitude circles, no azimuth arcs, lines for unequal hours and equal hours counted from the western horizon.
4a: quadruple projection, difficult to decipher the four elements.
4b: quadruple projection, difficult to decipher the four elements
5a: lat 18°, altitude circles, azimuth arcs above and below the horizon, no hour lines
5b: lat 66°, i.e. ecliptic coordinates

Geographical Gazetteer

In the inner surface of the mater is engraved a gazetteer which contains the arguments and the names, longitudes and latitudes of 23 towns. There is an unmistakable similarity between this and the gazetteer in Rāghavajit's astrolabe of 1669, but it could not be copied completely from the catalogue photos.

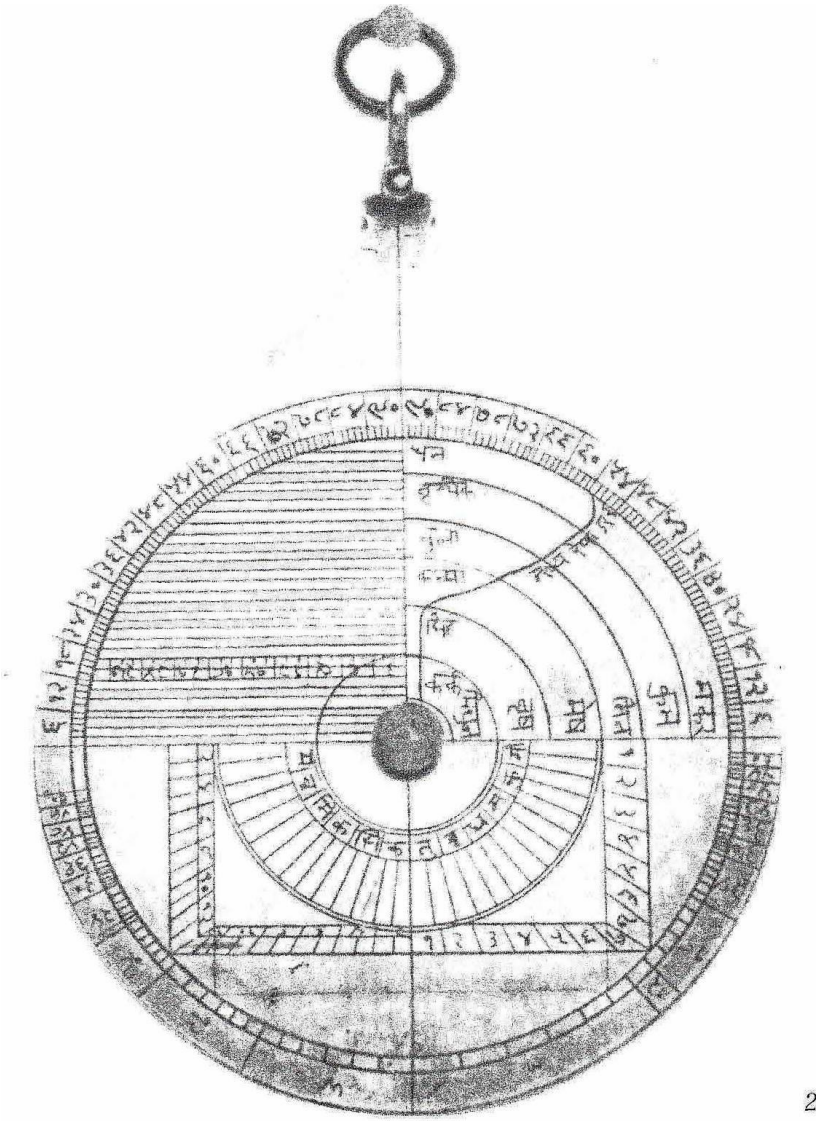


Figure C009.2 – Back of the astrolabe (photo from Linton 1980)

BACK

The back is almost identical with the same in Rāghavajit's astrolabe with insignificant differences. The rim in the upper half carries altitude scales in 1°, 6° (Rāghavajit has an intermediate division of 2°). The rim on the lower half contains, in both astrolabes, a complete cotangent scale as in the Lahore astrolabes. The upper left quadrant, in both astrolabes, has a sine graph with 30 horizontal parallels, with divisions of cosines marked on three parallel lines (see nos. C008, C012, C013). The upper right quadrant, in both, has the same zodiac scale with the same labels. In both, there is the solar meridian altitude graph with the legend *madhya rekhā* followed by an *avagraha* symbol for latitude and 22. In the lower half, in both astrolabes, there are shadow squares, on the right for 12, on the left for 7; in both the divisions are numbered in the same way. In Rāghavajit's astrolabe, there are labels for the two vertical and two

horizontal scales, but here there are no labels. Inside the squares is a semicircular scale, drawn exactly in both; in Raghavajit's astrolabe, the upper band has the initials of the names of zodiac signs, and the lower band the initials of the names of the corresponding lunar mansions. Here, the cells for the lunar mansions are not filled in.

Conclusion

It is fairly certain that Rāghavajit's astrolabe of 1669 and the present astrolabe were designed by the same astronomer and fabricated by the same metal worker at Surat.

1. In both, the crown is high; in Rāghavajit's the trifoliate terminal is more emphasized and the front is decorated with a foliate pattern in high relief.
2. The rete, the gazetteer and the back are exactly the same.
3. In the plates, the present astrolabe is more adventurous and makes quadruple projections on some plates while Rāghavajit's astrolabe has a double projection for 72°+18°; and for 0°+90°.

Bibliography

Linton 1980, item no. 228, p. 182 (photos of the front and back)

Moskowitz 1984, no. 144, pp. 34-35 (photos of the front, back and of all parts).

Sotheby's, London, auction catalogue of 18 June 1986, lot 128, pp. 26-27.

C010⊙ SANSKRIT ASTROLABE OF JOŚĪ INDRAJĪ

1673, Gujarat

Diameter 115 mm

Oxford, Pitt Rivers Museum of Ethnology (# 1893.4514)

CCA 79



Figure C010.1 – Astrolabe made for Indrajī (photo by S. R. Sarma)

The inscription on the back of the crown states that the astrolabe was manufactured on 17 October 1673 and that it belonged to the astrologer Indrajī.

Components

Mater (d. 115, h. 147) with crown, shackle and ring; rete (d. 104) for 23 stars; 5 plates; the original alidade, pin and wedge are missing. The parts are now held together by a modern bolt and nut.

Front

The crown is solid; its front is decorated with 'lightly chased foliate ornament'. The back is plain and carries the inscription. The shackle and ring have diamond-shaped cross sections. The limb is divided in 1°, 2° and 6° and numbered in 6s, separately for each quadrant, from 6 to 90 clockwise (6—90; 6—90; 6—90; 6—90).

Rete

The rete resembles to some extent that on the previous two astrolabes. Here also, the celestial equator is not represented; the rings of the Tropic of Capricorn and the ecliptic are joined by the equinoctial bar with two counter changes and by series of intertwined creepers. The solstitial bar is almost completely represented. There is a small rectangular arch, in the place of a pointed tip, to represent the Capricorn index. An ornate turning knob is affixed to the Capricorn ring, a little below the west point. The ecliptic is divided into signs and labelled with the initial syllables of their names. Each sign is divided into groups of 6° and numbered in an anti-clockwise direction. There are 23 named star pointers. These are crudely cut and are not well defined. They are labelled rather briefly with the initial letters of the star names; some of these are indecipherable.

Table C010-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
01	*Pusapāda*	*Samudrapakṣī*	β Ceti
02	?		γ Ceti ?
03	*Preta*	*Pretaśira*	β Persei

	Star Name as engraved	Full/Correct Form	Identification
04	*Ṣaṇmukha* ?	α Aurigae	
05	*Rohiṇī*		α Tauri
06	*Mipā*	*Mithuna-vāma-pāda*	β Orionis
07	*Miska*	*Mithuna-vāma-skandha*	γ Orionis
08	*Miha*	*Mithuna-dakṣiṇa-hasta*	α Orionis
09	*Ālu*	*Ārdrā-lubdhaka*	α Canis Majoris
10	*Luba*	*Lubdhaka-bandhu*	α Canis Minoris
11	*Ma*	*Maghā*	α Leonis
12	*Pāka*	*Kāka-skandha*	γ Corvi
13	*Ci*	*Citrā*	α Virginis
14	*Svātī*	*Svāti*	α Bootis
15	*Viśā*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
16	*Jye*	*Jyeṣṭhā*	α Scorpii
17	*Dhanu*	*Dhanuṣkoṭi*	α Ophiuchi
18	*Abhi*	*Abhijit*	α Lyrae
19	*Śrava*	*Śravaṇa*	α Aquilae
20	*Mapra*	*Makara-puccha*	δ Capellae
21	*Aśvamukha*?		ε Pegasi
22	*Kartitakara*?		β Cassiopeiae
23	*Sapra sapra*	*Samudrapakṣī-uttara*	ι Ceti

PLATES

There are five plates, for eight different latitudes; and for multiple half-horizons and ecliptic coordinates. At the north point on all the plates is cut a rectangular slot which fits into the tooth on the limb. On each side of the first four plates, altitude circles are drawn for every 6°. Azimuth lines are drawn below the horizon for every 30°; in three cases (2a, 3a, 4a) for every 15°. There are lines for equal hours and unequal hours; the latter dotted and numbered from the western horizon. The eastern and western parts of the horizon are labelled respectively as *pū[rva]* (east) and *pa[ścima]* (west). In the middle of the plate are inscribed the latitude with the abbreviation (*akṣā[ṃśa]*) and the maximum duration of the daylight in hours (*horā* and not the usual *paramadina*). However, strangely the duration is given as 13 hours for all latitudes (except for 32°).[727] The following are the inscriptions on the plate faces.



Figure C010.2 – Plate for the Latitude of 23° (photo by S. R. Sarma)

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727 Also in C012

Table C010-2 Plates

	φ	Longest Day
1a	*akṣā 18*	*horā 13*
1b	*akṣā 26*	*horā 13*
2a	*akṣā 20*	*horā 13*
2b	*akṣā 23*	*13*
3a	*akṣā 24 30*	*horā 13*
3b	*akṣā 27*	*horā 13*
4a	*akṣā 29*	*horā 13*
4b	*akṣā 32*	*horā 14*
5a	ecliptic coordinates	
5b	*sarvadeśī* (plate of horizons)	

The plate of horizons is designated as *sarvadeśī,* i.e., that which belongs to all places / latitudes, i.e., universal; it carries four sets of horizons, seven or eight for each quadrant, which are labelled twice along the vertical or horizontal radius and along the arc of the quadrant.

12	20	28	36	44	52	60	
14	22	30	38	46	54	62	
16	24	32	40	48	56	64	
10	18	26	34	42	50	58	66

Along the radii are also given the scales of declination, with the divisions reading 6, 12, 18, 23. The last value is the maximum declination ε.



Figure C010.3 – Geographical Gazetteer (photo by S. R. Sarma)

GEOGRAPHICAL GAZETTEER

On the inner surface of the mater is engraved a gazetteer of 31 towns together with their latitudes and longitudes in two annular rings. The first ring is divided into 24 cells and carries the argument and the names and coordinates of 23 towns. The second, inner ring is divided into 12 cells, of which only 8 are filled and the remaining 4 are left blank. The names of the towns are not carefully written, often omitting the last syllable. Some are unidentifiable. The information is reproduced in the table below.

Table C010-3 Geographical Gazetteer

	Place Name *nagarāṇi*	**φ** *akṣāṃ[śāḥ]*	**L** *deśāṃta[rāṇi]*	**Modern Name**
1	Kṣela	20	111;5	?

	Place Name *nagarāṇi*	**φ** *akṣāṃ[śāḥ]*	**L** *deśāṃta[rāṇi]*	**Modern Name**
2	Ahamada	19;0	115;0	Ahmednagar
3	Golaku[ṃḍa]	18;8	115;19	Golconda = Hyderabad
4	Vilāpura	17;10	114;40	?
5	Varāvṛpa	21;20	113;0	?
6	Ujjaya[nī]	23;30	110;50	Ujjain
7	Gavāler	26;29	114;8	Gwalior
8	Āgarā	26;42	115;0	Agra
9	Kāśī	26;15	117;20	Varanasi
10	Yavana[pura]	26;36	115;5	Jaunpur
11	Ayodh[yā]	26;32	118;6	Ayodhya= Faizabad
12	Vadāvara	21;22	114;55	Vadodara
13	Dillī	29;0	113;0	Delhi
14	Lāhora	31;50	109;20	Lahore
15	Mulatā[na]	30;40	8*;28	Multan
16	Ajame[ra]	26;0	111;5	Ajmer
17	Amadā[bāda]	23;0	108;*0	Ahmedabad
18	Kaṃbhāi[ta]	22;0	109;0	Khambhat
19	Sūrata	21;30	110	Surat
20	Kālapa[pī?]	28;17	113;5	Kalpi
21	Kurukṣe[tra]	30;10	112;30	Kurukshetra
22	tra?pāla?me?	33;0	109;0	?
23	Se??ra	30;30	102;25	?
24	Purī??	24;30	----	?

	Place Name *nagarāṇi*	**φ** *akṣāṃ[śāḥ]*	**L** *deśāṃta[rāṇi]*	**Modern Name**
25	Saranadī[pa]	10;0	120;0	Sri Lanka
26	Kanoja	26;10	114;50	Kannauj
27	Kāvīla	34;20	104;40	Kabul
28	Paśamī	35;0	108;0	?
29	Ka[ṃ]dhar	33;0	107;0	Qandahar
30	Vajaṣa	36;11	61	Balkh
31	Samarakaṃ[da]	36;39	99;35	Samarqand



Figure C010.4 – Back of the astrolabe (photo by S. R. Sarma)

BACK

The rim of the upper half carries two altitude scales divided in 1°, 2°, 6° and numbered in 6s (6—90; 90—6). The rim of the lower left carries the arguments of the declination table engraved in that quadrant. On the rim of the lower right quadrant are drawn four concentric arcs, producing three bands; but these are neither graduated nor numbered.

The upper left quadrant has a sine-cosine grid, with 30 equidistant horizontal and vertical parallels. In the upper right quadrant, declination circles are drawn, not

consistently, for zodiac signs which are labelled along the vertical and horizontal radii. Along the horizontal radius, starting from the circumference and proceeding towards the centre, are the labels *ma[kara], ku[ṃbha], mī[na], me[ṣa], vṛṣa[bha],i* ? (*mithuna*), i.e. the signs from winter solstice to summer solstice. Along the vertical axis, however, are just the serial numbers of the signs 4, 5, 6, 7, 8, 9, i.e. the signs from the summer solstice to the winter solstice, starting from the centre and proceeding towards the circumference. On these declination arcs is superimposed a universal horary quadrant with six curves for unequal hours which are numbered from 1 to 12.

The lower right quadrant contains a single shadow square; the vertical side is inscribed for shadows of the gnomon of 7 divisions, with the brief legend *saptāṃgula* (seven digits) and the horizontal side for shadows of the gnomon of 12 divisions with the short legend *dvādaśāṃgula* (twelve digits). The quadrant on the lower left contains a table of declinations in minutes and seconds at intervals of 6° of the sun's longitude, in descending order starting with 90° at the top and reaching up to 6° at the bottom. There is a legend stating that this table pertains to *parama-krāṃti* (maximum declination, i.e. obliquity). This table is derived from Malayendu Sūri's commentary on Mahendra Sūri's *Yantrarāja* (pp. 7-9,) where the declinations are given for each degree.

Table C010-4 Table of Declinations

Sun's longitude degrees	**Declination** minutes	seconds
90	1415	0
84	1406	46
78	1382	14
72[728]	1341	53
66	1286	10
60	1216	20
54	1133	6

[728] Malayendu Sūri 1134;53. This is a printing mistake; the correct value is 1341;53 as given by Indrajī.

Sun's longitude degrees	**Declination** minutes	seconds
48	1037	49
42	931	44
36	816	4
30	692	22
24[729]	561	54
18	426	5
12	286	17
6[730]	146	49

INSCRIPTION

On the back of the crown is an inscription in two lines which reads

jośi iṃdrajīkasya yaṃtraṃ

saṃvat 1730 varṣa kārtika sudi 6 bhau

'Instrument of the astronomer/astrologer Indrajīka. Tuesday, the sixth day of the bright half in the month of *Kārtika* in the Saṃvat year 1730.'

The owner's name is probably Indrajit or Indrajī.[731] The date corresponds to 17 October 1673.

BIBLIOGRAPHY

Gunther 1923, vol. II, pp. 198-199.

Gunther 1932, no. 79, p. 211, Fig. 110 (mater with gazetteer and the horizon tablet).

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729 Malayendu Sūri, correctly 561;55.

730 Malayendu Sūri, correctly 143;49.

731 In Sanskrit, the declension of the word 'Indrajī' or 'Indrajit' is somewhat difficult. Therefore '*ka*' was added to make it a word with the simple '*a*' base, and then the genitive particle '*sya*' was added.

C011 SANSKRIT ASTROLABE, NOT SIGNED[732]

1678, Gujarat

Diameter ?

PLU



Figure C011.1 – Astrolabe dated 1678 (photo courtesy Museum of the History of Science, Oxford)

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[732] Entry based on the photos of the front and back in the archives of the Museum of the History of Science, Oxford, and a photocopy of the mater with five plates with Anthony J. Turner, Paris. No dimensions of the instrument are available.

According to the inscription at the back, this astrolabe was made on 22 February 1678. Therefore, the three astrolabes C009, C010 and C011, must have been designed by the same astronomer and produced by the same instrument maker in the 1670s in Gujarat. The letters and numerals on this astrolabe are far superior to those in the other two astrolabes. Possibly these were engraved by a different artisan.

Components

Mater with crown, shackle, ring, rete, 5 plates. Alidade, pin and wedge are not shown in the available photos. Dimensions are not known.

Front

The body is surmounted by a rather high lobed crown which rises almost vertically and then tapers sharply to culminate in a trifoliate terminal. There are two decorative holes at the two upper corners. On the front of the crown is an ornate floral design in bas relief. The unusually wide limb is divided in 1° and 6°, and numbered in 6s, separately for each quadrant (6—90; 6—90; 6—90; 6—90).

Rete

The rete has a close resemblance to those in astrolabe nos. C008, C009, C010 and C012. Like these, the present rete is also formed of broad rings of Capricorn and the ecliptic which are joined by an untidy equinoctial bar and a solstitial bar and a series of scrolls. There is no equatorial circle. The Capricorn index is represented by a rectangular piece. There is a turning knob on the Capricorn ring at 125°. The ecliptic ring is divided into signs and labelled with the initial syllables of their names. Each sign is further subdivided into groups of 6° and numbered. The star pointers are not clearly defined and their names cannot be deciphered in the available photos; but *Makara* [*puccha*] δ Capricorni, Jyeṣṭhā α Scorpii and *Samudrapakṣī uttara* ι Ceti can be seen.

Plates

There are five plates. The available photocopy of an original photo is not very sharp; it shows just one side of the plates. Four are calibrated for different latitudes and the fifth shows a family of horizons. On the four plates are drawn almucantars for 6° each and the lines of equal and unequal hours; no azimuths can be seen. On one plate can be read faintly *akṣā 28 horā 13* (φ 28°, longest day 13 hours), on another *akṣā 36*

horā 13 (φ 36°, longest day 13). It appears that, like in the astrolabe of Indrajī (C010) and that at Victoria & Albert Museum, London (C012), here also the duration of the longest day is recorded erroneously as 13 hours at all latitudes.

Geographical Gazetteer

The photocopy shows faintly the geographical gazetteer engraved on the inner side of the mater. All that can be seen is the spiral arrangement as in the astrolabe C012.

Back

The back of this astrolabe closely resembles that of Indrajī's astrolabe (C010). Here the altitude scales are divided, as in the front, in 1° and 6°. The upper left quadrant carries a sine-cosine grid with 30 horizontal and vertical parallels. Semicircles are traced on the two radii. No circle of the obliquity is drawn on this quadrant, as it ought to be, but it is extended into the upper right quadrant, as it need not be. Above this extended circle in the upper right quadrant, declination arcs are drawn and labelled along the two radii.

In the lower left quadrant is a table of declinations as in C010 and C012. As in those two astrolabes, here also the legend reads *paramā krāntiḥ* (maximum declination), the table enumerates the values in descending order, and more important, it carries the same errors for the values of declinations corresponding to the solar longitude of 6° and 24°.

In the lower right quadrant, as in the other two astrolabes, there is a shadow square, the vertical scale for a gnomon of 7 digits with the legend *saptāṃgulachāyā* (shadow of seven digits) and the horizontal scale for a gnomon of 12 digits with the legend *dvādaśāṃgulachā[yā].*

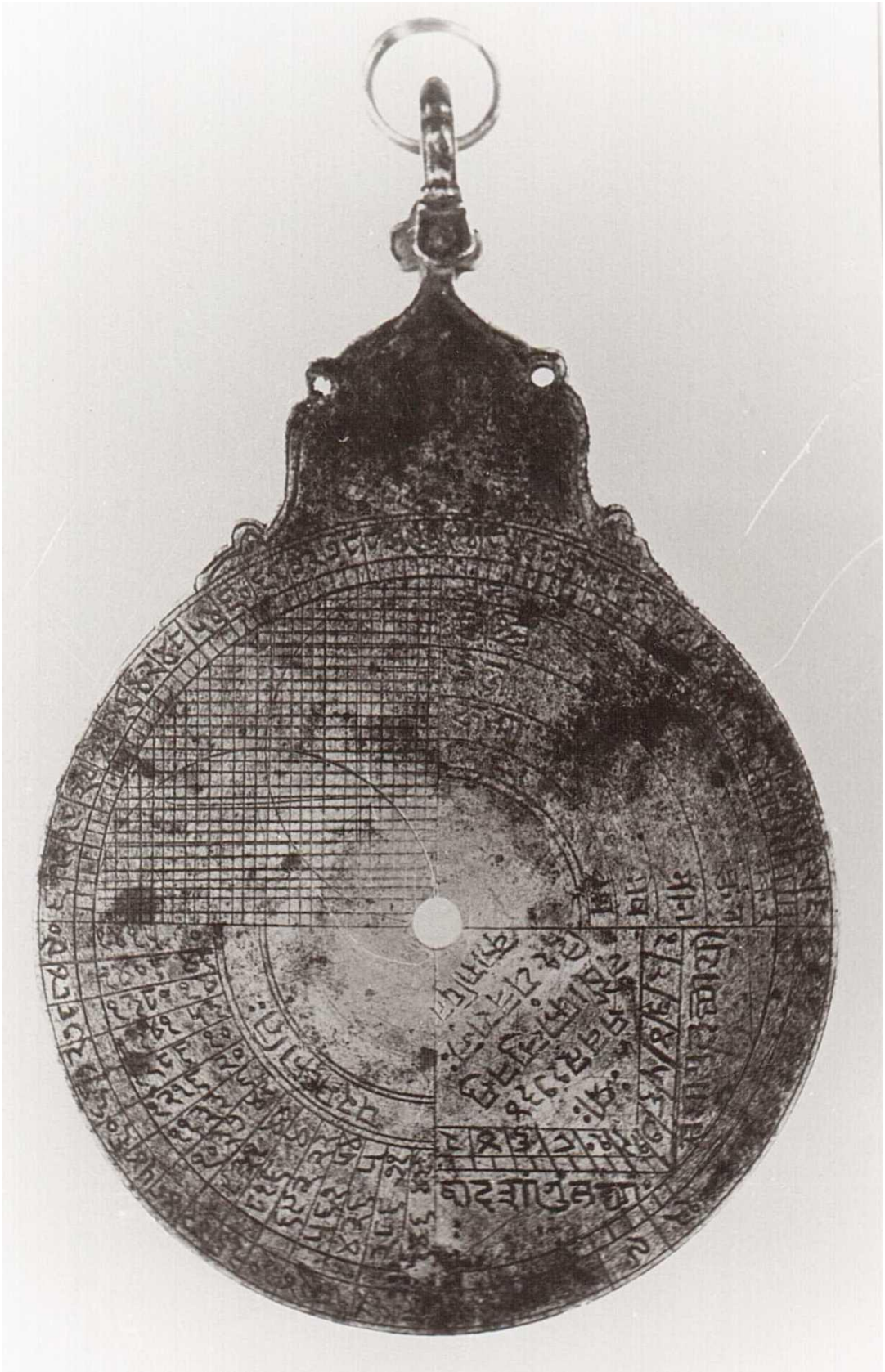


Figure C011.2 – Back of the astrolabe (photo courtesy Museum of the History of Science, Oxford)

INSCRIPTION

In the space between the two scales of the shadow square is engraved an inscription which reads

> *śrīḥ. saṃvat 1738 varṣe phālguna su di 1 yaṃtrarājaḥ kārāpitaḥ*
>
> '[Let it be] auspicious. [This] astrolabe was caused to be made in the Saṃvat year 1738, on the first day in the bright half of [the month] Phālguna.'

The date translates to 22 February 1678. For once, this inscription is couched in correct Sanskrit and correctly transcribed. The inscription does not state for whom the astrolabe was made.

C012⊙ SANSKRIT ASTROLABE, NOT SIGNED, NOT DATED

17th Century, Gujarat

Diameter 87 mm

London, Victoria & Albert Museum (# I.M. 407; the four plates are marked IPN 2467)[733]

CCA 96

This is one of the Sanskrit astrolabes to be studied quite early by the modern scholarship. In his monograph on the *Description of a Persian Astrolabe constructed for Shah Husain Safawi*, William Morley gave a fairly detailed description of it in 1856, where he even printed the Sanskrit legends in Devanagari script.[734] Morley rightly notes that 'the inscriptions which are in the Devanagari character, are exceedingly ill-written, and the workmanship throughout is coarse and clumsy.'

COMPONENTS

Mater (d. 87, h. 107, t. 9) with crown, shackle and ring; rete (d. 75.5) for 19 stars, 7 plates (d. 76), alidade (98), held together by modern bolt and nut.

FRONT

The small lobed crown is lightly chased in the front to produce a pleasing pattern. The shackle and the ring have diamond cross sections. The limb is graduated in 1° and groups of 6° are labelled separately for each quadrant from 6 to 90 (6—90; 6—90; 6—90; 6—90).

RETE

The celestial equator is not represented in the rete. The rings of the Tropic of Capricorn and the ecliptic are joined by the equinoctial bar with two counterchanges and by series of intertwined creepers. The solstitial bar is also almost completely represented, but for one interruption. There is a long finger-like projection to represent the Capricorn index, and a turning knob on the Capricorn ring at 90°. The ecliptic is

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733 Victoria and Albert Museum wrote to me to say that they do not permit publication of private photography of their objects. Therefore, I cannot, regretfully, include my photos with this entry.

734 Morley 1856, pp. 42-44, Pl. XX, Figs. 19, 20; Gunther 1932, I, no. 96, pp. 225-226.

divided into signs and numbered from 0 to 11. Each sign is divided into groups of 6° and numbered. The 20 named star pointers are crudely cut out and are not well defined. The labels are rather brief, occasionally with the initial syllables of the star names. Some names are indecipherable.

Table C012-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Pucharī*	*Samudra-pakṣī*	β Ceti
2	*Musarī*	(?)	γ Ceti
3	*Nivana*	*Nadyantaka*	θ Eridani
4	*Ro*	*Rohiṇī*	α Tauri
5	*Mithunapāda*	*Mithuna-vāma-pāda*	β Orionis
6	*Ārdrā*		α Canis Majoris
7	*Lubdhaka-baṃdhu*		α Canis Minoris
8	*Maghā*		α Leonis
9	*Kaphajñaphara*	*Kākaskandha*	γ Corvi
10	*Citrā*		α Virginis
11	*Svā*	*Svāti*	α Bootis
12	*Mātṛ*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
13	*Jyeṣṭhā*		α Scorpii
14	*Dhanakaṭa*	*Dhanuṣkoṭi*	α Ophiuchi
15	*A*	*Abhijit*	α Lyrae
16	*Kā*	*Kukkuṭapuccha*	α Cygni
17	*Śravaṇa*		α Aquilae
18	*A*	*Aśvamukha*	ε Pegasi
19	*Makarapuccha*		δ Capricorni

Star Name as engraved	Full/Correct Form	Identification

PLATES

There are 7 plates, with a tooth at the north point to fit into the slot in the limb. On all plates (but one) are drawn almucantars for each 6° and labelled on both sides; azimuths for 30° above and below the horizon; on the plate for 21°, however, these are drawn for each 15°. There are two sets of hour lines: unequal hours lines numbered 1 2 3 4 5 6 6 5 4 3 2 1 and dotted equal hour lines counted from the western horizon from 1 to 12.

Five plates serve the latitudes 17°— 18°; 20° — 21°; 23° — 24°; 26° — 27°; 29°— 32°. One face of the sixth plate is calibrated for latitude of 0°, i.e. the equator. It carries the label *akṣā purana horā 12*. Here *horā 12* means that the longest day at this latitude is of 12 hours, but what does *akṣā purana* mean? Morley understands it to mean the 'complete latitude'.[735] One expects, however, that the 'complete latitude' (in correct Sanskrit *akṣāṃśāḥ pūrṇāḥ*) will be 90° and not 0°. Zero latitude is expressed in Sanskrit *nirakṣa* (without latitude) and the expression engraved on the astrolabe plate does not occur anywhere in Sanskrit literature on astronomy.

The reverse side of this plate is designed for 72°.[736] It is a rare plate; it does not occur in any other Sanskrit astrolabe.

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735 Morley 1856, p. 13: 'Fig. 19 is a projection for a place without latitude, copied from the Hindu astrolabe in the Museum of East-India House. It contains the two diameters; the three circles, the Almucantars inscribed and numbered by tens, commencing from the east and west above the straight horizon; the Azimuths both above and below the horizon, shewing the Nadir as well as the Zenith, where the equinoctial, which is the prime vertical, is inserted by the Azimuths, numbered by thirties only below the horizon; and the lines of the hours, numbered from the east and the west respectively, from one to six. Immediately under the horizon, on the left side of the perpendicular diameter at *a,* are the words *akṣā purana, the complete latitude,* and on the right at *b hora 12, hours twelve.*'

736 Morley 1856, p. 13: 'Fig. 20 is the reverse of the tablet last mentioned, and contains an inscription differing in arrangement from any that I have seen elsewhere. It is a projection of the sphere for a latitude of 72°, and comprises the two diameters; the three circles; the Almucantars numbered by tens, the numbers commencing at the top of the meridian line under the circle of the oblique horizon. Outside this horizon are the arcs of the unequal hours, numbered from one to six in both ways, commencing from either end of the straight horizon, and traced above as well as below the latter; and the arcs of equal hours, distinguished by being dotted, traced both above and beneath

All the six plates carry the value of latitude and the duration of the longest day with the labels *akṣā[ṃśa]* and *horā* respectively. Strangely the longest day for all latitudes from 17° to 29° is stated to be 13 [hours], and that for the latitude of 32° as 14 hours and for 72° as 23 hours.

The seventh plate carries on one side the ecliptic coordinates and on the other multiple horizons. The plate of ecliptic coordinates carries, in addition to the projections of the two tropics, the equator and the ecliptic, altitude circles for each 6° and azimuth circles at intervals of 10°. The altitude circles are numbered along the meridian line; the azimuth arcs are numbered separately for each sign, as 10, 20, 30, anti-clockwise along the ecliptic; from Aries to Virgo outside the ecliptic and from Libra to Pisces inside the ecliptic circle. As on the rete, here also the signs are numbered from 0 to 11. The circles of longitude at the beginning of each zodiac sign are dotted. Besides the numbers of the two sets of circles, there are no other labels.

The plate of horizons carries four sets of horizons, eight for each quadrant, which are labelled twice along the vertical or horizontal radius and along the arc of the quadrant.

10	18	26	34	42	50	58	66
12	20	28	36	44	52	60	
14	22	30	38	46	54	62	
8	16	24	32	40	48	56	64.

Along the radii are engraved the scales of declination, with the divisions reading 6, 12, 18, 24. The last value is the maximum declination ε. There is no legend.

GEOGRAPHICAL GAZETTEER

On the inner surface of the mater are drawn a series of concentric circles. The spaces in between the circles are divided, not by radial lines as in other Sanskrit astrolabes, but by curved lines to form a spiral, as in some Indo-Persian astrolabes. The

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the straight horizon, and numbered from one to twenty-two, beginning from the west below the latter. At the foot of the tablet at *a* are the words *akṣā 72, latitude seventy-two,* and at *b horā 23, hours 23.*'

data engraved here is read clockwise from the top.[737] The arguments are engraved in the first row along with the name and the coordinates of Daulatābad.

Table C012-2 Geographical Gazetteer

	Place Name	φ *akṣāṃ[śa]*	L *deśāntara*	Modern Name
01	Dālatābad	20	111	Daulatābad
02	Javanapura	26;36	119;6	Jaunpur
03	Ayodhyā	26;32	118;6	Faizabad
04	Vadāu	27;32	114;50	Badaun
05	Golakuṃḍā	18;4	115;19	Hyderabad
06	Khaṃvāita	22;0	109;0	Khambhat
07	Alāhābād	23;0	108;40	Allahabad
08	Ujjeyanī	23;30	110;50	Ujjain
09	Goyālūr	26;29	114;0	Gwalior
10	Āgarā	26;43	115;0	Agra
11	Dillī	29;00	113;0	Delhi
12	Lāhera	31;50	109;20	Lahore
13	Burhānāpura	21;21	110;0	Burhanpur
14	Amadanagara	19;0	115;0	Ahmednagar
15	Thāneśvara	30;10	112;30	Thanesar
16	Vanoraśa	26;15	117;20	Varanasi

737 Morley's transcription and identification has some errors as he was not familiar with the place names.

BACK

On the back, the altitude scales on the rim of the upper half are divided in 1°, 2° and 6° and numbered by 6s, separately for each quadrant (6—90; 90—6). The rim of the lower left carries the arguments of the declination table engraved in that quadrant. On the rim of the lower right quadrant are drawn four concentric arcs, producing three bands; but these are neither graduated nor numbered.

The upper left quadrant carries a graph of sines with 30 horizontal parallels. The arc of obliquity is traced and the sine line which touches its upper extremity is divided transversally into 9 x 3 parts.

The arc of the obliquity is extended into the upper right quadrant. Between this and the boundary arc are drawn 5 declination arcs so that the space between each two arcs represents a pair of zodiac signs. The signs are labelled here also with serial numbers from 0 to 11 along the two radii.

The lower right quadrant contains a single shadow square; the vertical side is marked for shadows of the gnomon of 7 divisions, with the legend *saptāṃguḷa śaṃku chayā* (shadow of the gnomon of seven digits) and the horizontal side for shadows of the gnomon of 12 divisions with the legend *dvādaśāṃguḷa śaṃku chayā* (shadow of the gnomon of 12 digits).

The quadrant on the lower left contains a table of declinations in minutes and seconds for intervals of 6° of the sun's longitude, in descending order starting with 90° at the top and reaching up to 6° at the bottom. There is a legend stating that this table pertains to *paramakrāṃti* (maximum declination, i.e. obliquity). This table is derived from Malayendu Sūri's commentary on Mahendra Sūri's *Yantrarāja*[738] where the declinations are given for each degree.

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738 Raikva 1936, pp. 7-9.

Table C012-3 Table of Declinations

48	**42**	**36**	**30**	**24**[739]	**18**	**12**	**6**[740]
1037	931	816	692	561	426	286	146
49	44	4	22	54	5	17	49
	90	**84**	**78**	**72**	**66**	**60**	**54**
	1415	1406	1382	1341	1286	1216	1133
	00	46	14	53	10	20	6

There are close similarities between this astrolabe and that of 1673 belonging to Indrajī.

1. Chased pattern on the front of the crown
2. The scale on the limb and on the upper half of Indrajī's astrolabe is graduated for 1°, 2° and 6°. The scale on the back of the present astrolabe has such a scale, but the limb is divided for 1° and 6° only.
3. The retes show close similarity.
4. Both carry a special plate for multiple horizons and ecliptic coordinates. On the rest of the plates, in both astrolabes, the maximum duration of daylight is given, erroneously, for all latitudes as 13 hours and for the latitude of 32° as 14 hours.
5. The arrangement of the gazetteer is different, but the values are from a common source. Indrajī has 31 towns. The present astrolabe mentons only 16 towns and omits the foreign towns.
6. The configuration at the back is almost the same. The circle of the obliquity, though not drawn on the upper left quadrant, is extended to the upper right quadrant in Indrajī's astrolabe as in the present case. The declination arcs in the upper right quadrant are exactly the same in both the astrolabes, though the labelling is different.

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739 Malayendu Sūri,correctly 561;55.

740 Malayendu Sūri,correctly 143;49.

7. The lower half of the back is nearly the same, except that the labels of the shadow square in Indrajī's astrolabe are shorter.
8. Finally, the table of declinations in the lower left quadrant in both the astrolabes are exactly alike; even the errors in the values of declinations of 24° and 6° are exactly the same in both cases.

Moreover, there is close affinity in workmanship, decorations on the crown, rete design, quality of engraving, shortening of words and so on. This leads us to conclude that the same artisan must have produced the two astrolabes. Since among Hindus/Jainas there is no tradition of artisans producing astrolabes on their own, the same astrologer/astronomer must have commissioned both the astrolabes and provided the technical designs, with slight variations in the upper left and right quadrants at the back.

There is also some connection between these two and Rāghavajit's astrolabe of 1669, because these three have a special plate for multiple horizons and ecliptic coordinates.

PROVENANCE

This astrolabe appears to have been collected in India by some servant of the East India Company and sent to London. It was first housed in the Indian Museum attached to the India House, London; later it was moved to the Royal Asiatic Society,[741] and then finally to the Victoria & Albert Museum.

BIBLIOGRAPHY

Morley 1856, pp. 42-44, Pl. XX, Figs. 19, 20.
Gunther 1932, I, no. 96, pp. 225-226.
Filippoupoliti 2013, p. 21.

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741 Writing about the 'very rare and choice Oriental specimens, illustrative of the arts, economy and antiquities of the Eastern world' in the collection of the Royal Asiatic Society in 1839, A. Boöth describes this astrolabe thus: '…Hindu astronomical instrument, called Junter Raje, which on operation shows the Sun's altitude, the hour and the situation of the planets' in his *The Stranger's Intellectual Guide to London*, for 1839–40; containing an Account of the Literary and Scientific Institutions; Exhibitions and Curiosities; Museums, Libraries, Public and Private Collections; Botanical, Horticultural, and Zoological Gardens of the Metropolis, London: Henry Hooper, 1839, pp. 73–4; cited in Filippoupoliti 2013, p. 21.

C013 SANSKRIT ASTROLABE, NOT SIGNED, NOT DATED[742]

Ca 1670, Gujarat

Diameter 87 mm

Qatar, Doha, Museum of Islamic Art (# MW.345.2007)



Figure C013.1 – Front of the astrolabe (courtesy Anthony J. Turner)

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[742] Entry is based on the description and photos in Linton 1980, no. 227, pp. 180-181, and additional photos with Anthony J. Turner, Paris, which are reproduced here.

COMPONENTS

Mater (d. 87) with crown, shackle, ring, rete for 25 stars, 4 plates, alidade, pin and wedge.

FRONT

The crown is high and lobed, and decorated with a design in relief against a chased background. The heavy shackle and ring have diamond cross sections. The limb is divided in 1° and 6° numbered in 6s, separately for each quadrant, from 6 to 90. Sometimes the second digit is placed somewhat higher than the first.

RETE

The rete closely resembles the retes in the three previous astrolabes (nos. C010-C012). Like them, the present rete is also formed of broad rings of Capricorn and the ecliptic which are joined by an untidy equinoctial bar and solstitial bar and by a series of scrolls. A rectangular piece represents the Capricorn index. There is a roundish turning knob on the Capricorn ring at 90°. The ecliptic is divided into signs and labelled with the initial syllables of their names and each sign is further subdivided into groups of 6° and numbered. The star pointers are not clearly defined and their names cannot be deciphered in the available photographs. There are said to be 25 star pointers. From the photos it is clear that these 25 stars include δ Capricorni (*Makara[puccha]*), α Scorpii (*Jyeṣṭā*) and ι Ceti (*Samudra-pakṣī uttara*).

PLATES

There are four plates for the latitudes 18°— 21°; 20°—26°; 23— 27°; 15° [sic! 25°]— 32°; with lines for unequal hours and equal hours counted from the western horizon.



Figure C013.2 – Geographical gazetteer (courtesy Anthony J. Turner)

GEOGRAPHICAL GAZETTEER

On the inner surface of the mater are drawn a series of concentric circles. The spaces in between the circles are divided by curved lines to form a spiral, as in C012. A geographical gazetteer is engraved here in two circles. In the outer circle are accommodated the argument and the names, latitudes and longitudes of 11 localities; perhaps the same number are in the inner ring. But the data is difficult to decipher and reproduce here completely.

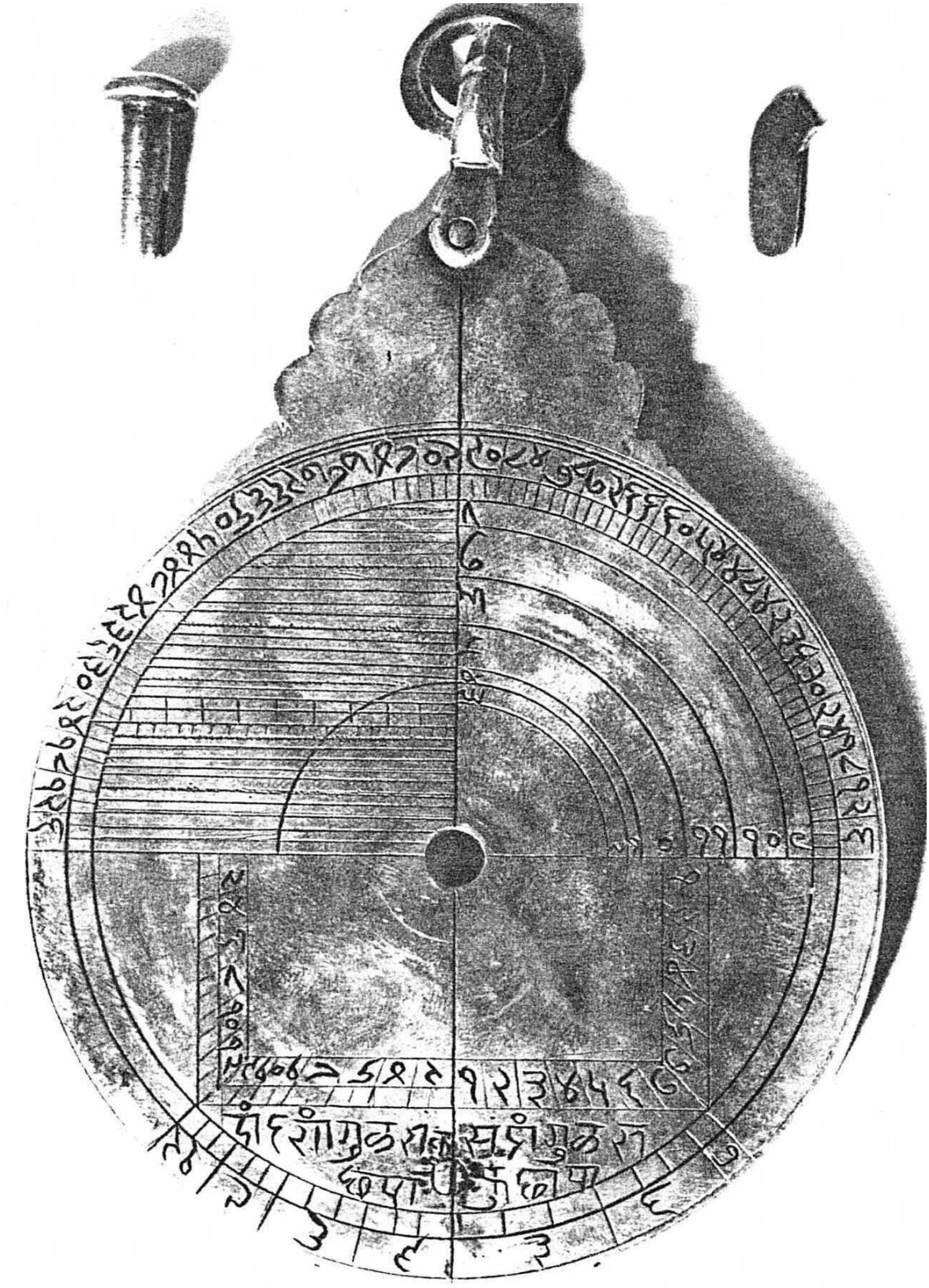


Figure C013.3 – Back of the astrolabe (courtesy Anthony J. Turner)

BACK

The upper half resembles the same in C012. The altitude scales on the rim of the upper half are graduated in 1° and 6°, and numbered in 6s (6—90; 90—6). However,

in the upper left quadrant the numerals are written upside down. The upper left quadrant carries a graph of sines with 30 horizontal parallels. Three of the sine lines are divided transversally into 9 parts, and the line below them into about 28 parts. The arc of obliquity of the ecliptic is traced on this quadrant and extended into the upper right quadrant as in the previous astrolabe. In the right quadrant are drawn 5 quarter circles, so that the space between each two arcs represents a pair of zodiac signs. The signs are labelled with serial numbers from 0 to 11 along the two radii.

In the lower half is a double shadow square, on the right for 12 and the left for 7. Below the left square is the legend *dādaśāṃguḷa śa[ṃ]ku chāyā* and under the right square the legend *saptāṃguḷa śa[ṃ]ku chāyā.* No legends along the vertical scales. On the rim below are drawn cotangent scales, as projected from the two horizontal scales.

The straight bar alidade appears to carry some graduations; there is a pin and a broken wedge. It is probable that this astrolabe is also produced in the same milieu as the three previous astrolabes (nos. C010, C011 and C012) and therefore it can be assigned to the 1670s and to Gujarat.

C014 ⊙ SANSKRIT ASTROLABE, NOT SIGNED, NOT DATED

17th century, Gujarat

Diameter 162 mm

Hyderabad, State Museum of Archaeology (# 3122)



Figure C014.1 – Front of the astrolabe (courtesy P. P. S. Hariprasad)

COMPONENTS

Mater (d. 162, h. 207, t. 13) with crown, rete (d. 139) for 15 stars , 7 plates (d. 139). The ring, shackle, alidade, pin and wedge are missing. A crude non-functional wooden alidade, without sights, is attached to the front with a modern bolt and nut. The seven latitude plates and the rete were coated with a layer of wax in recent times.

FRONT

The main body is heavy and massive. The crown is solid without any fretwork. The top of the crown culminates into a fig leaf like finial. The two profiles of the crown are artistically fashioned with lobes and scallops. Near both the profiles, there are two decorative holes. On the front side of the crown is engraved, in western Devanagari letters, *śrījagaccakṣuṣe namaḥ,* 'salutation to the eye of the world,' that is, the sun god.[743] The limb is graduated in 1° and 5°, and numbered in 5s, separately for each quadrant, starting from the east and west points and proceeding to the north and south points (5—90; 90—5; 5—90; 90—5).



Figure C014.2 – Rete of the Astrolabe (courtesy P. P. S. Hariprasad)

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[743] Compare this with the inscription on the crown of the astrolabe made for Damodara in 1605 (C001): *śrīdivyacakṣuṣe namaḥ.*

RETE

The elegantly crafted rete follows the characteristic ‘bird in the cage’ pattern. The ecliptic circle is divided into the twelve zodiac signs and labelled with Sanskrit names followed by serial numbers. Each sign is further subdivided into units of 6° each and labelled accordingly. On the edge, these divisions are halved, thus producing divisions of 3°. There is a plain turning knob a little above the north point. The rete contains 15 named star pointers, 7 to the north and 8 to the south of the ecliptic.

Table C014-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Mandupāśa*	*Manuṣya-pārśva*	α Persei
3	*Rohiṇī*		α Tauri
4	*Mithunapāda*	*Mithuna-vāma-pāda*	β Orionis
5	*Mithunavā*	*Mithuna-vāma-skaṃdha*	γ Orionis
6	*Ārdrā*	*Ārdrā-lubdhaka*	α Canis Majoris
7	*Maghā*		α Leonis
8	*Mandūranaṃda*	*Kākaskandha*	γ Corvi
9	*Citrā*		α Virginis
10	*Svāti*		α Bootis
11	*Viśākhā*		α Coronae Borealis
12	*Dhanukoṭi*	*Dhanuṣkoṭi*	α Ophiuchi
13	*Śravaṇa*		α Aquilae
14	*Pūrvābhādra*	*Pūrva-bhādrapadā*	β Pegasiasi
15	*Kṛttikā*	*Kartita-kara*	β Cassiopeiae

Plates

The seven latitude plates are calibrated for different latitudes ranging from 16° to 35°. On all the plates altitude circles are drawn for each 3°and numbered in 6s. There are no azimuth lines. Lines for seasonal hours are drawn and numbered from the western horizon. Only the latitude is mentioned on the plates, but no other parameters. The degrees of latitude (*akṣāṃśāḥ*) are marked with standard Devanagari numerals, two vertical strokes ‖ meaning half a degree or 30 minutes. The plates serve the following latitudes: 16°—28;30°, 19;30°—30;30°, 22°—22.30°, 24;30°—25;30°, 26;30°—multiple horizons, 28°—30°; 32°—35°. The rationale for selecting these latitudes is not clear. In the plate of horizons, just four sets of horizon segments are drawn without any labels. There are no declination scales.

Geographical Gazetteer

On the inner surface of the main body, there is geographical gazetteer of some 65 localities with their latitudes in six concentric circles. The first three circles as counted from the outside are divided into 16 cells each, the next two into 12 and the sixth circle into 8 cells. Thus there are 80 cells in total, but each cell is not devoted to one single locality. In the first two circles, each cell carries the name of one locality and its latitude. Later, names start spilling out of their cells and continue into the next. Sometimes two or three localities are mentioned together in one single compound (e.g. nos. 21-24) and then their common latitude, as was done by Malayendu. Also following Malayendu, the place names end in the locative case. Sometimes *nagara* (town, city) is suffixed to place names as in nos. 38 and 39; but some other times *deśa* (country) or *pradeśa* (region) is added to what are clearly towns such as Aden (no. 2), Mecca (13), Kannauj (41).



Figure C014.3 – Geographical gazetteer (courtesy P. P. S. Hariprasad)

Table C014-2 Geographical Gazetteer

	Place Name	φ	Modern Name
	First Circle		
1	Laṃkāyāṃ	0	Equator
2	Ādanadeśe	12	Aden
3	Kāṃtī	12	Kanchi
4	Vidyānagare	15	Hampi Vijayanagar
5	Hābasa	16	?

	Place Name	φ	Modern Name
6	Tilaṃgadeśe	18	Golconda =Hyderabad
7	Vijayāpure	18	Bijapur
08	Jāhmaṇa (?)pure	18;40	?
09	Devagirau	20;15	Daulatabad
10	Trya (ṃ)bake	20;15	Tryambakeshwar = Nashik
11	Damaṇe	21;20	Daman
12	Āseragirau	20;30	Asergarh
13	Makkāpradeśe	21;20	Mecca
14	Elajapure	20;25	?
15	Maṇḍapācale	22	Mandu
16	Dhārāyām	22;30	Dhar
	Second Circle		
17	Cāṃpanere	22	Champaner
18	Dīvapure	22	Diu
19	Stambhatīrthe	22	Khambhat
20	Bharua(ka?)ce	22	Bharuch
21	Amadābāda-	23	Ahmedabad
22	Nūtanapura-	23	?
23	Dvārakā-	23	Dwaraka
24	Ujaṃṇī-nagareṣu	23	Ujjain
25	Pāṭaṇe	24	Patan
26	Jīrṇadurge	22;30	Junagadh
27	Someśvare	22;15	Somnath
28	Rāyadhānapura-	24	?

	Place Name	φ	Modern Name
29	Jālore	24	?
30	Īḍare	24	Idar
31	Sīroje	25	Sironj?
32	Uḍasāpure	25;30	Orissa, Bhubaneshwar ?
	Third Circle		
33	Ajamere	26	Ajmer
34	Gopalagiri-	25;45	Gwalior ?
35	Naravare	25;45	Narwar
36	Kālapyāṃ	25;45	Kalpi
37	Puṣkare	26	Pushkar
38	Āgarānagare	26;24	Agra
39	Vārāṇasīnagare	26; 15	Varanasi
40	Kaḍānagare	26;29	Kara
41	Kānyakubjadeśe	26;35	Kannauj
42	Tirohite	27	Tirhut
43	Jājanagare Uḍīsā	27;15	Jajnagar[744]
	Fourth Circle		
44	Ayodhyānagare	27;22	Ayodhya = Faizabad
45	Kolajalālyāṃ	28;8	Aligarh and Jalali
46	Yoginīpure	28;39	Delhi
47	Rohitake	28;45	Rohtak
48	Meraṭhe	29	Meerut

[744] Jājnagar is an ancient capital of Odisha; overrun by Fīrūz Shāh Tughluq in his eastern campaign.

	Place Name	φ	Modern Name
49	Mūlasthāne	29;40	Multan
50	Hāsyāṃ	29;45	Hansi
51	Pīrojābāde	29;48	Firozabad
	Fifth Circle		
52	Kurukṣetre	30;10 !	Kurukshetra
53	Kapisthale	30;30	Kaithal, Haryana
54	Jālaṃdhare	30;30	Jalandhar
55	De(Ne)pālapure	31;25	Nepal city = Kathmandu
56	Lāhora	31;15	Lahore
57	Mūdhapure	31;15	?
58	Badakhasāna	35	Badakhshan, Afghanistan
	Sixth Circle		
59	Tūsa	36	Tus, Iran
60	Dāmagāṃ	36;30	Damghan, Iran
61	Pośaja	36;40	?
62	Balaṣa	36;40	Balkh, Afghanistan
63	Nayasābūra-nagare	37;10	Nishabur, Iran
64	Kāśmīra	37;20	Kashmir = Srinagar
65	Cigānī	37;50	?

BACK

On the back, the rim of the upper half carries altitude scales divided in 1° and 5° and labelled in 5s (5—90; 90—5), but the rim of the lower half is blank. The upper left quadrant has a grid of sixty equi-distant horizontal parallel lines. The upper right

quadrant carries 11 declination arcs. Radial lines from the centre to the rim are drawn for each 5°.

There are crude shadow squares drawn in the lower half, on the left in 12 divisions and on the right in 7 divisions, but neither the divisions are numbered nor are there any labels along the horizontal and vertical scales. Inside the shadow squares is drawn a grid of 8 x 4 cells but it is empty.

C015 ⊙ SANSKRIT ASTROLABE WITH THE KAṬAPAYĀDI NOTATION, NOT SIGNED, NOT DATED[745]

17th century, Gujarat ?

Diameter 202 mm

Varanasi, Sampurnanand Sanskrit University, Sarasvati Bhavan Library



Figure C015.1 – Front of the astrolabe (photo by S. R. Sarma)

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745 See Sarma 1999b for a detailed description.

On this astrolabe, the altitude circles on the latitude plates are numbered in the *Kaṭapayādi* system of alphabetic notation (Figure C015.2), clearly in imitation of the Islamic astrolabes where the numbers are represented by the *Abjad* system. This is one of the two astronomical instruments where this notation is used.[746] It also contains certain features which are common in Lahore astrolabes but not in Sanskrit astrolabes: viz. the graph of the sun's meridian altitude for 32°, cotangent scale on the lower rim of the back, a table of correspondence between 12 zodiac signs and 28 lunar mansions on the back, azimuth lines on the plates, a separate plate for ecliptic coordinates and multiple horizons, longitudes in the geographical gazetteer, the trifoliate finial of the crown and trifoliate terminals of the shackle.

COMPONENTS

Mater (d. 202, h. 249, t. 9) with crown, shackle and ring, rete (d. 181) for 18 stars, 5 plates, alidade; these are held together with a modern bolt and nut. One of the sighting plates attached to the alidade is broken and lost. Plate no. 2 has a crack running across two-thirds of the width parallel to the diameter. Otherwise, the astrolabe is in a good state of preservation.

FRONT

The mater is surmounted by a high lobed and scalloped crown which terminates in a trifoliate finial. The trifoliate motif is repeated in the terminals of the shackle as well. The front and back of the crown are plain without any surface decoration. On the front side of the crown is engraved the name *Paṃ. Rāmayatna Ojhā.*[747] This engraving is somewhat broader in comparison to the other engraved forms of writing on the astrolabe. It is obviously a later addition, indicating the name of a subsequent owner of this astrolabe and not necessarily of the one who got it originally manufactured for his use. Leaving this aside, there are yet three distinct styles of engraving of letters and numerals, to be found respectively in (i) the geographical gazetteer, (ii) altitudes written

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746 The second is a Sanskrit celestial globe made by Bulhomal in 1837; cf. Sarma 1999b, Sarma 2012d, Sarma 2015b.

747 Upadhyaya 1994, p. 307, mentions a Rāmayatna Ojhā (d. 1938) who became the first head of the department of Jyotiṣa at the Banaras Hindu University. He may or may not have been the owner of this astrolabe.

in the *Kaṭapayādi* notation on the plates, and (iii) the rest. The first two styles are somewhat akin to one another with a common characteristic form of the letter *ra.*

The limb is divided in 1° and 5° and numbered in 5s, separately for each quadrant, starting from the east and west points and reaching up to the south and north points (5—90; 90—5; 5—90; 90—5).

RETE

The rings of the Tropic of Capricorn, the ecliptic and the almost complete equatorial circle are held together by the equinoctial bar with two counter changes and by the solstitial bar with one counter change. There is a small knob at the north point of the Capricorn ring. The ecliptic circle is divided into the 12 signs of the zodiac and labelled with the respective names in Sanskrit. Each sign is further subdivided into five parts of 6° each and labelled as 1, 2, 3, 4, 5. There are 18 named star pointers, shaped like tiger's claws or lobed tiger's claws. With the exception of one or two cases, the star names are quite correctly engraved.

Table C015-1 Stars on the Rete

	Star Name	Identification
1	*Samudrapakṣī*	β Ceti
2	*Aśvinī*	β Arietis
3	*Pretaśirā*	β Persei
4	*Rohiṇī*	α Tauri
5	*Skanda*	α Aurigae
6	*[Mithuna]dakṣiṇapāda*	κ Orionis
7	*Ārdrā*	α Canis Majoris
8	*Lubdhakabandhu*	α Canis Minoris
9	*Maghā*	α Leonis

	Star Name	Identification
10	*Āryamā*[748]	β Leonis
11	*Citrā*	α Virginis
12	*Svāti*	β Bootis
13	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
14	*Dhanakoṭi* (*Dhanuṣkoṭi*)	α Ophiuchi
15	*Abhijit*	α Lyrae
16	*Śravaṇa*	α Aquilae
17	*Kukkuṭapakṣa* (°*puccha*)	α Cygni
18	*Pūbhā* (*Pūrva-bhādrapadā*)	β Pegasi

PLATES

There are five plates. One plate, slightly thicker than the others, carries the projections of the ecliptic co-ordinates on the obverse and multiple horizons on the reverse. The other four plates serve eight different latitudes The degrees of these latitudes are engraved at the centre of the plate concerned preceded by *akṣāṃśāḥ* (degrees of latitude). In three cases, the name of an important town situated on that latitude is also mentioned.

Table C015-2 Plates

	φ	Locality
1a	*akṣāṃśāḥ* 18	
1b	*akṣāṃśāḥ* 21	
2a	*akṣāṃśāḥ* 24	

[748] The star name is *Pūrva-phālgunī* with the regent *Āryamā.*

	φ	Locality
2b	*akṣāṃśāḥ* 27	
3a	*akṣāṃśāḥ* 28	*Vaṃśāvalīnagare* (?)
3b	*akṣāṃśāḥ* 25;39 (sic! 28;39)	*Yoginīpure* (= Delhi)
4a	*akṣāṃśāḥ* 30	
4b	*akṣāṃśāḥ* 32	*Lāhaura* (= Lahore)
5a	ecliptic co-ordinates	
5b	multiple horizons	

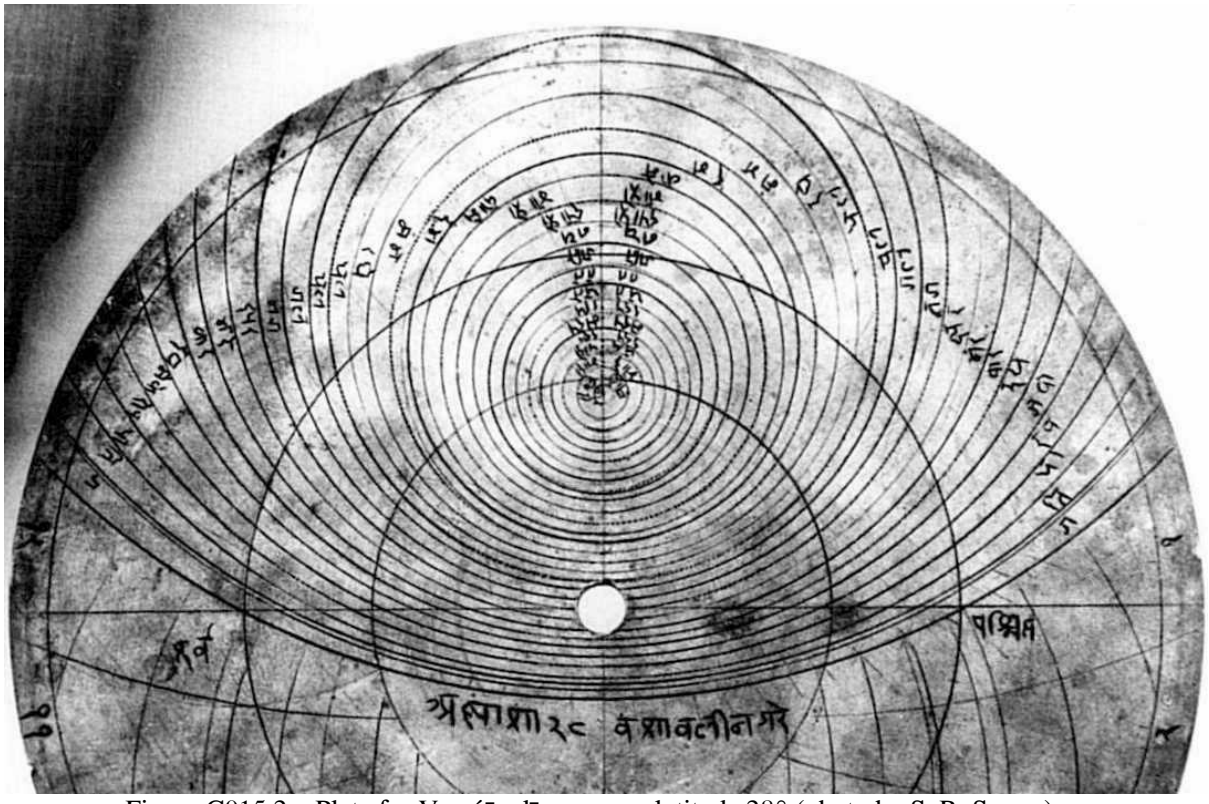


Figure C015.2 – Plate for Vaṃśāvalīnagara on latitude 28° (photo by S. R. Sarma)

On plates 1-4, altitude circles are drawn for each 6°, but on 3a for each 3°. Azimuth arcs are drawn below the horizon for each 10°. On the right hand side below the horizon is written *para* or *paścima* (west) and on the left *pūrva* (east). Lines of seasonal hours are drawn and numbered from the western horizon. On the plate of horizons, four sets of 10 segments of horizons are drawn, but these are not labelled.

There are two declination scales in each of the four quadrants, but these are labelled with serial numbers 1, 2, 3, 4 and not with the actual values of declination.

GEOGRAPHICAL GAZETTEER

The inner surface of the mater is divided into six concentric circles. The first three are divided into 48 cells, while the three inner rings are divided into 24 cells each. The 48 cells of the first three circles are filled respectively with the names (*nagara-nāma*), longitudes (*vistāra*) and latitudes (*akṣāṃśa*) of 47 towns of the Indian subcontinent, Afghanistan and Iran; the 48th cell contains the argument. The three inner circles are blank. The following table reproduces the gazetteer, reading from the top and proceeding clockwise.

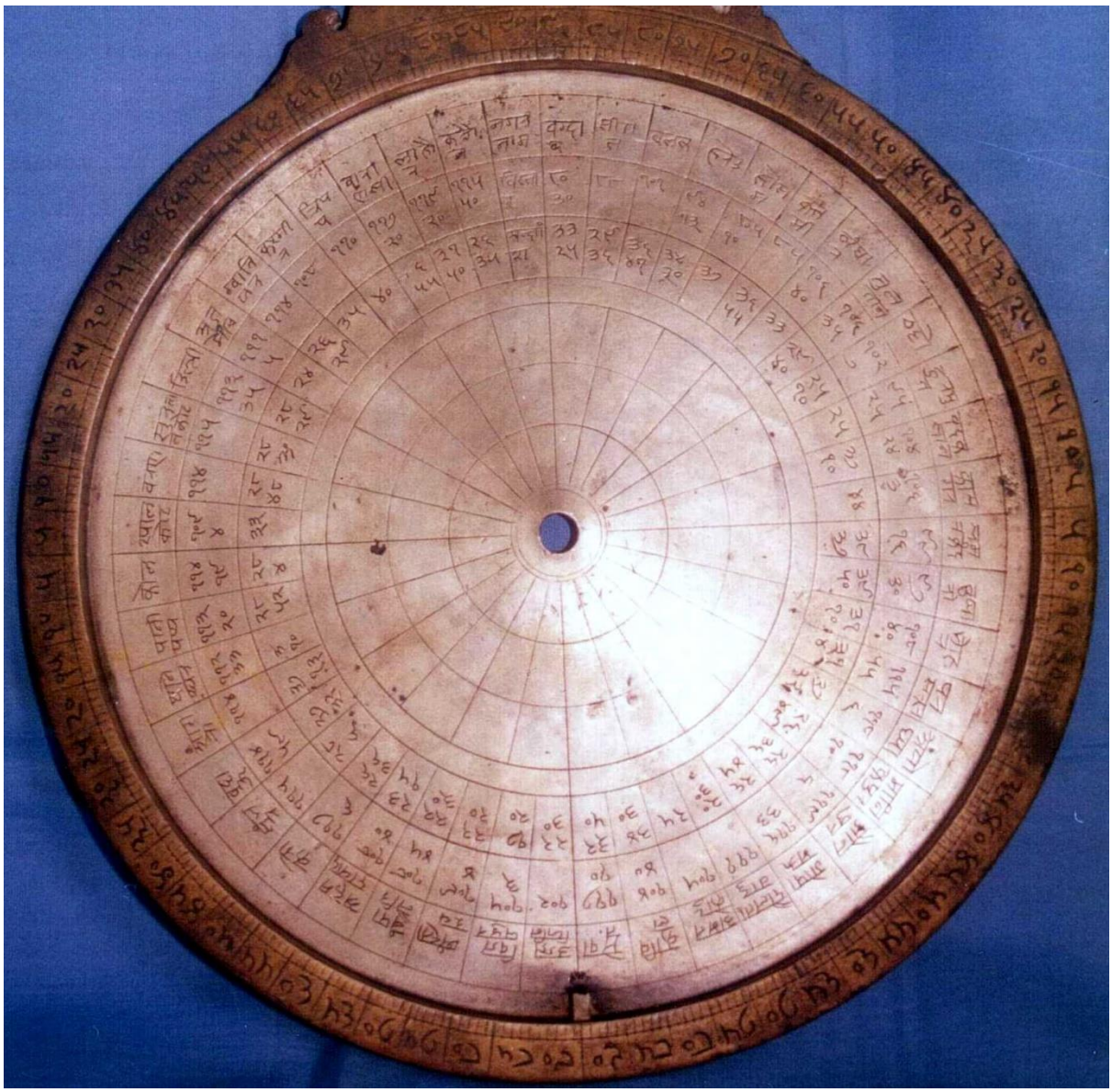


Figure C015.3 – Geographical gazetteer (photo by S. R. Sarma)

Table C015-3 Geographical Gazetteer

	Place Name *Nagara-nāma*	**L** *vistāra*	**φ** *akṣāṃśa*	**Modern Name**
1	Vāgadāda	80;30	33;25	Baghdad
2	Sīrāja	88	29;36	Shiraz
3	Valaka	101	36;41	Balkh
4	Hareu	94;13	34;30	Herat
5	Hosama	85;10	37	Hausam = Khuzem
6	Katamī	85	36;55	Kutom
7	Kaṃdhāra	106;40	33	Qandahar
8	Mulatāna	106;35	29;40	Multan
9	Thaho	102;7	25;10	?
10	Huramuja	95;25	25	Hurmuz
11	Vadakasāna	104;24	37;10	Badakshan
12	Kāsagara	106;3	44	Kashghar
13	Samarakaaṃda	99;15	39;37	Samarqand
14	Vukhāro	97;30	39;50	Bukhara
15	Bhorura	108;40	31;10	?
16	Parasanīra	115.55!	31.4	Peshawar
17	Ayodhyā	118;6!	37;22!	Ayodhya = Faizabad
18	Mānikapūra	118;10	26;49	Manikpur
19	Jaunapura	119;6	26;36	Jaunpur
20	Gopāmāu	116;33	26;45	Gopamau
21	Daulatāvādu	111	20;30	Daulatabad
22	Śamarakoṭu	105	25	?
23	Kāvila	104;40	34;30	Kabul

	Place Name ***Nagara-nāma***	**L** ***vistāra***	**φ** ***akṣāṃśa***	**Modern Name**
24	Sevāta	117;10	32;50	?
25	Ujjayinī	102!	22;30	Ujjain
26	Vijayapura	105;3	17;20	Bijapur
27	Bhī(?)haraica	109;4	22;20	Broach
28	Caṃpānairi	108;45	22;30	Champaner
29	Ahamadabada	108;40	23;15	Ahmedabad
30	Karo	117;6	26;35	Kara
31	Saṃbhara	115	28;6	Sambhal
32	Vadāū	114;59	27;32	Badaun
33	Āgarā	114	37;13	Agra
34	Thaneśvara	112;33	3[0];10	Thanesar
35	Pānīpatha	113;20	28;52	Panipat
36	Kola	114;19	28;4	Aligarh
37	Syālakoṭa	109;4	33	Siyalkot
38	Varana	114	28;48	Baran = Buland Shahar
39	Suratānakoṭa	115	28;30	Sultankot
40	Dillī	113;35	28;29(28;39)	Delhi
41	Ajameri	111;05	24	Ajmer
42	Gvāliyara	114	26;29	Gwalior
43	Kaśmīra	108	35	Kashmir
44	Tripapa	110	40	Tibet
45	Vārāṇasī	117;20	[2]6;55	Varanasi
46	Lāhaura	119;20	31;50	Lahore
47	Kannauja	115;50	26;35	Kanauj

Place Name *Nagara-nāma*	L *vistāra*	φ *akṣāṃśa*	Modern Name

BACK

The rim of the upper half carries altitude scales, divided in 1° and 5° and numbered in 5s (5—90; 90—5). The rim of the lower half contains cotangent scales as projected from the shadow squares, a feature rare in Sanskrit astrolabes. The upper left quadrant bears a sine graph with 60 parallel horizontal lines, each fifth being highlighted by a dotted line. From the centre are drawn 18 radial lines for each 5°.

In the upper right quadrant are drawn 17 equidistant and concentric quarter circles. The space between two successive circles represents 10° of the zodiac. These spaces are labelled along the vertical and horizontal radii with the serial number and the first letter of the name of the zodiac sign in the following manner. On the vertical radius, starting from the top, 9 *Dha[nuṣ],* 8 *Vṛ[ścika],* 7 *Tu[lā],* 6 *Ka[nyā[,* 5 *Siṃ[ha],* 4 *Ka[rka]* (that is from the winter solstice to the summer solstice); then on the horizontal radius, starting from the centre: 3 *Mi[thuna]*, 2 *Vṛ[ṣabha]*, 1 *Me[ṣa]*, 12 *Mī[na]*, 11 *Kuṃ[bha]*, 10 *Ma[kara]* (that is, from summer solstice to winter solstice).

Upon these arcs is projected the curve of the meridian altitude of the sun through the year for Lahore on the latitude of 32° and labelled *Lāhaura 32*.



Figure C015.4 – Back of the astrolabe (photo by S. R. Sarma)

The lower half is occupied by a double shadow square; on the left for a gnomon of 12 digits and on the right for a gnomon of 7 digits. There are, however, no labels on these squares. Within the shadow squares are two semi-circular scales; the outer one is divided into 12 parts in which the names of the 12 zodiac signs are written. The inner scale contains the names of the corresponding 28 lunar mansions.

Alidade

At the centre of the back is pivoted an ornate alidade. Arcs corresponding to those in the upper right quadrant are engraved over half the length of the alidade. One of the two sighting vanes attached to the alidade is broken. The alidade together with the plates and the rete are attached to the mater by means of a large broad-headed pin and a nut, which are modern replacements.

Besides the name of Pandit Rāmayatna Ojhā, the astrolabe does not carry any other inscription regarding its maker or the date of its manufacture. But, as has been mentioned above, there are many points of correspondence between this astrolabe and the Mughal astrolabes of the sixteenth and seventeenth centuries. Therefore, one is inclined to assign this astrolabe to the seventeenth century.

As noted above, in three plates the names of the towns have been mentioned, viz. Vaṃśāvalīnagara at 28° N; Yoginīpura, i. e. Delhi at 28;39° N and Lahore at 32°. Thus the maker laid stress on these three towns. Of these, Delhi and Lahore were Mughal imperial capitals. Moreover, in the upper right quadrant on the back, there is a curve for the sun's meridian altitude for Lahore at 32°. It may suggest that the maker is from Lahore. On the other hand, while all other plates were sexpartite, that one for Vaṃśāvalīnagara at 28° is tripartite, thereby allowing finer measurements of altitude at this place. Can it then be that the maker is from this Vaṃśāvalīnagara? However, in spite of painstaking search, it has not been possible to locate any mention of this place situated, roughly on 28° N, either in Gujarat, or in Rajasthan, or in western Uttar Pradesh. Probably the place is now known under a Middle Indic form of the name which is phonetically far removed from Vaṃśāvalīnagara.

Bibliography

Sarma 1999b

C016⊙ SANSKRIT ASTROLABE, UNSIGNED, UNDATED

17th Century, Gujarat

Diameter of the plates 122 mm

New Delhi, National Museum, Ajit Mookerjee Collection (# 82.298/1-6)

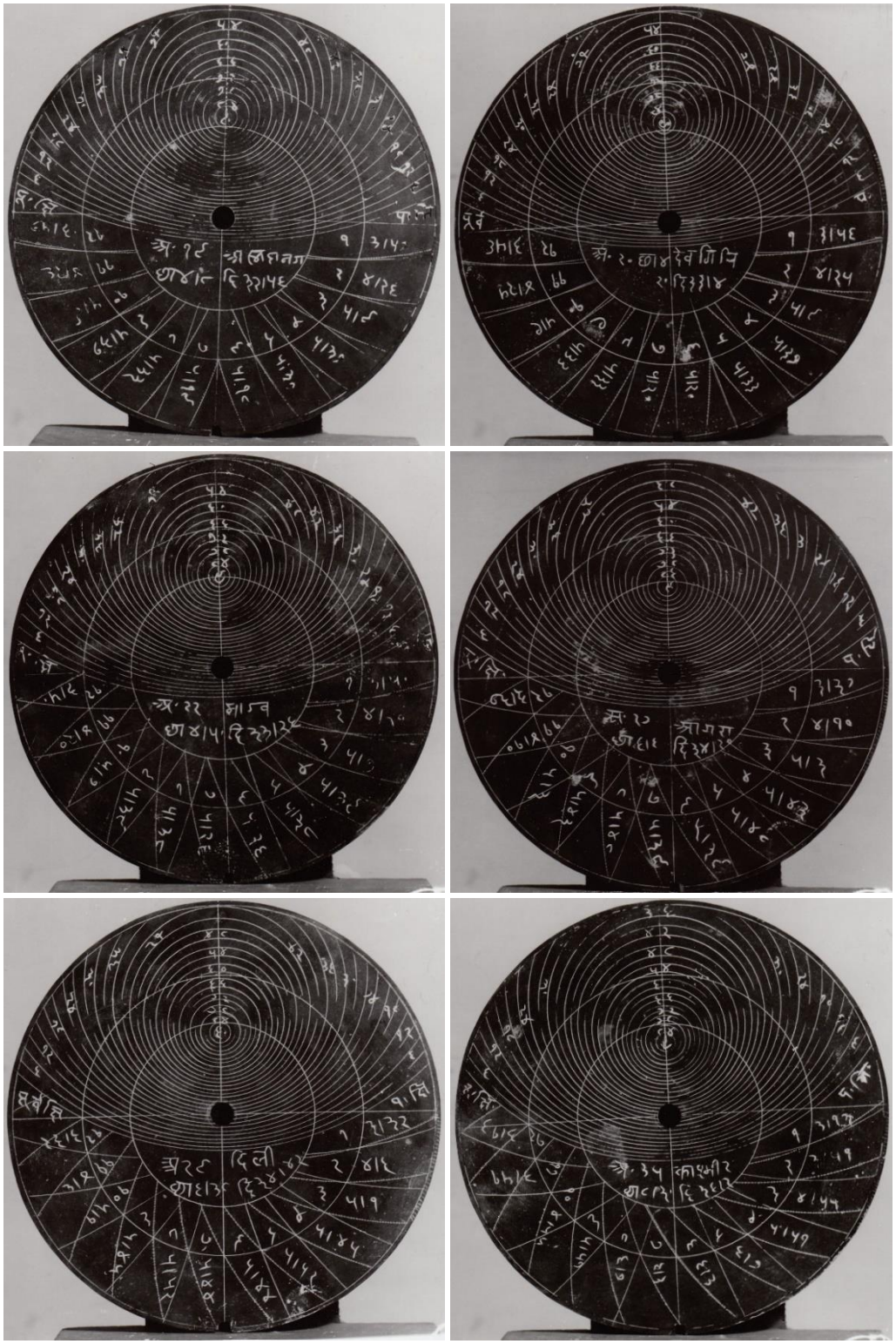


Figure C016.1 – Six Plates for latitudes 19°, 20°, 22°, 27°, 29° and 35°
(courtesy National Museum, New Delhi)

Of this astrolabe, there survive only the six plates. [749] These are quite unusual because on these are engraved the oblique ascensions or the rising times of the zodiacal signs (*svodaya*) in *ghaṭīs* and *palas* for the given latitude.[750] The only other instance of this nature is the Sanskrit astrolabe at Jodhpur (C019).

The plates serve the following latitudes: multiple horizons—20°; 21°—22°; 19°—25°; 26°—27°; 29°— 30°; 32°—35°. On the latitude plates, altitude circles are drawn for every 6°. Lines for seasonal hours are counted from the western horizon and numbered from 1 to 12. On four plates, dotted lines for equal hours are drawn from the western horizon; in two plates (1b for Devagiri and 3b for Ahmednagar), dotted lines show seasonal hour lines counted from both the eastern and western horizons. Azimuth arcs are not drawn on any plate. The eastern horizon is marked as *pūrva* (east) or *pū[rva]kṣi[tija]* (eastern horizon), and the western horizon as *pa[ścima]* (west) or *pa[ścima]kṣi[tija* (western horizon).

In the space between the oblique horizon and the Tropic of Cancer are engraved the latitude (*a[kṣāṃśa]*), the equinoctial shadow (*chā[yā]*), the name of the town situated on the latitude and the duration of the longest day at this latitude (*di= parama-dina*). The rising times of the 12 zodiac signs are engraved between the hour lines. Two toponyms are difficult to decipher. Gwalior is assigned the latitude of 25°, instead of the traditional 26°.

The information engraved on these plates, containing the names of the towns, their latitudes, the equinoctial shadows, the durations of the longest day, is shown in the table below.

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749 Some of these plates are illustrated in the following publications with not very accurate descriptions. Mookerjee 1966, pp. 79-80: astrolabe plates for Agra and multiple horizons; Mookerjee & Khanna 1977, p. 116: plates for Dillī and Amedanaga[ra]. Mookerjee 1966, pp. 79-80, assumes that this 'astrolabe [was] principally used by Jai Singh' and so locates it in Rajasthan and dates it to the 18th century. But it is reasonable to assume that it was made in Gujarat and perhaps already in the 17th century.

750 Ḍiyā' al-Dīn Muḥammad provides a table of rising times, in hours and minutes, for each degree of latitude between 20° and 39° on the back of a splendid astrolabe which he made in AH 1067/ AD 1656 and which is now at the Astronomical Observatory, Jaipur (Table A074-2). The table is reproduced in Kaye 1918, p. 23; Kaye adds (p. 120) that from these rising times, the ascendant can be calculated for any latitude, if the position of the sun is known; similar tables are engraved also on A092 and A093.

Table C016-1 Geographical Data on the Plates

	φ	Place Name	Equinoctial Shadow	Longest Day	Modern Name
1b	20°	Devagiri	4;20	33;4	Daulatabad
2a	21°	Sanjan?	4;39	33;36[751]	Sanjan, Gujarat?
2b	22°	Māgva ?	4;50	33;26	Mecca?
3b	19°	Amedānaga[ra]	4;8	32;56	Ahmednagar
3a	25°	Gvālera	5;39	34;0	Gwalior
4a	26°	Ajamera	5;51	34;8	Ajmer
4b	27°	Āgarā	6;6	34;20	Agra
5a	29°	Dilī	6;38	34;42	Delhi
5b	30°	Kurukṣetra	6;55	34;56	Kurukshetra
6a	32°	Lāhora	7;31	35;20	Lahore
6b	35°	Kāśmīra	8;3	36;2	Srinagar

The rising times for the eleven different latitudes are shown in the following two tables.[752] On the plates, the rising times in *ghaṭīs* and *palas* are mentioned for each of the twelve signs separately. In the tables below, signs with the same value are paired together.

Table C016-2 Rising Times of Zodiac Signs at Different Latitudes

Town	Latitude	Longest Day	Aries Pisces	Taurus Aquarius	Gemini Capricorn	Cancer Sagittarius	Leo Scorpiirpio	Virgo Libra
Ahmednagar	19°	32;56	3;57	4;26	5;9	5;37	5;30	5;19
Daulatabad	20°	33;4	3;56	4;25	5;9	5;37	5;33	5;20

751 This value is too high.

752 There are some errors in the values given for Ahmednagar, Sanjan, Daulatabad and Kurukshetra.

Town	Latitude	Longest Day	Aries Pisces	Taurus Aquarius	Gemini Capricorn	Cancer Sagittarius	Leo Scorpiirpio	Virgo Libra
Sanjan?	21°	33;36	3;53	4;23	5;8	5;38	5;35	5;23
Māgva?	22°	33;26	3;50	4;20	5;7	5;39	5;38	5;26
Gwalior	25°	34;0	3;42	4;14	5;4	5;42	5;44	5;34
Ajmer	26°	34;8	3;4	4;12	5;4	5;42	5;46	5;36
Agra	27°	34;20	3;37	4;10	5;3	5;43	5;48	5;39
Delhi	29°	34;42	3;32	4;6	5;1	5;45	5;52	5;44
Kurukshetra	30°	34;56	3;30	4;4	5;0	5;46	5;54	5;47
Lahore	32°	35;20	3;23	3;56	4;58	5;48	5;59	5;53
Kashmir = Srinagar	35°	36;2	3;13	3;51	4;55	5;51	6;7	6;3

In contradistinction to the abundance of data engraved on the latitude plates, the plate of horizons has hardly any inscriptions. Here four sets of nine horizons are drawn, too close together to allow any label. The first set carries the label 2 at both ends, the second 3 and the third and fourth 8! There are no other labels or legends.

PROVENANCE

Formerly in the private collection of Ajit Mookerjee (probably acquired in Jaipur), now donated to the National Museum.

BIBLIOGRAPHY

Mookerjee 1966.

Mookerjee & Khanna 1977.

C017 ⊙ SANSKRIT ASTROLABE, NOT SIGNED, NOT DATED

17th century, Gujarat

Diameter 177 mm

New Delhi, Red Fort, Mumtaj Mahal Museum (# 40.417)

CCA 97



Figure C017.1 – Front of the astrolabe (photo by S. R. Sarma)

COMPONENTS

Mater (d. 177, h. 240, t. 7) with crown, shackle and ring; rete (d. 159) for 23 stars, 2 plates (d. 158), alidade; no pin, no horse.

FRONT

The crown is rather large with very wide base (as in DamodaRās astrolabe C001) and perforated with large holes. Decorative lines are engraved on the front of the crown. The ring and shackle have diamond cross section. The limb is divided in 1° and 3° and numbered in 3s, most unusually, starting from the east point and proceeding counter-clockwise.

RETE

The rete has a coppery tint and displays the 'bird in the cage' pattern. The Tropic of Capricorn and the ecliptic are almost fully represented. The equator is shown only in the lower half. The three rings are joined by the equinoctial bar with two counterchanges and partly by the solstitial bar. The tracery is foliate, the tips of the leaves constituting the star pointers. The ecliptic is divided into 12 signs of the zodiac, labelled by the initial syllables of their names; the signs are further subdivided into groups of 6° and numbered. There are 23 named star pointers. The names are engraved quite correctly.

Table C017-1 Stars on the Rete

	Star Name	Full/Correct Form	Identification
01	*Samudrapakṣa*	*Samudrapaksī*	*β Ceti*
02	*Manuṣyaśīrṣa*		β Persei
03	*Manuṣyapārśva*		α Persei
04	*Rohiṇī*		α Tauri
05	*Ṣaṇmukha*		α Aurigae
06	*Mithunapādadakṣiṇa*		β Orionis
07	*Hasta*	*Mithuna-vāma-hasta*	γ Orionis

	Star Name	Full/Correct Form	Identification
08	*Mithuna*	*Mithuna-dakṣiṇa-pāda]*	κ Orionis
09	*Ārdrā lubdhaka*		α Canis Majoris
10	*Lubdhakabaṃdhu*		α Canis Minoris
11	*Maghā*		α Leonis
12	*Uttaraphālgunī*		β Leonis
13	*Kākaskandha*		γ Corvi
14	*Citrā*		α Virginis
15	*Svāti*		α Bootis
16	*Viśākhā-mātṛmaṇḍala*		α Coronae Borealis
17	*Dhanuḥkoṭi*	*Dhanuṣkoṭi*	α Ophiuchi
18	*Dhanuḥśarāgra*		μ^{1-2} Sagittarii
19	*Abhijit*		α Lyrae
20	*Śravaṇa*		α Aquilae
21	*Kukuṃdapuccha*	*Kukkuṭapuccha*	α Cygni
22	*Aśvanābha*	*Aśvanābhi*	δ Pegasi
23	*Pūrvābhādrapadā*		β Pegasi

PLATES

There is space for 3 plates, but only 2 are extant now which serve the latitudes 22°, 23°, 37° and the plate of horizons. On the latitude plates, almucantars are drawn for every 3° and alternate lines are numbered in 6s. There are no azimuth arcs. Lines are drawn for unequal hours and for equal hours, both of which are numbered from the western horizon. On the plate face for Ujjain, there are lines of unequal hours and of equal hours counted both from the eastern and western horizons. Below the horizon line

are written the latitude, the name of a town situated on this latitude, the duration of the longest day in *ghaṭīs* and *palas,* the lengths of the midday equinoctial shadow (*chāyā*) and its hypotenuse (*karṇa*) of the right-angled triangle formed by the gnomon and the midday equinoctial shadow. These inscriptions are tabulated below.

	Place Name	φ *palāṃśāḥ*	Equinoctial shadow *chāyā*	Hypotenuse *karṇaḥ*	Longest Day *Parama-dina*
1a	Ujjain (*avantikāyām*)	22°	5	13	33;30
1b	---	37°	9	15	36;24
2a	Ahmedabad (*amedāvāda*)	23°	5;6	13;3	33;50



Figure C017.2 – Plate for Ahmedabad on Latitude 23°, detail (photo by S. R. Sarma)
The reverse side of the second plate is engraved as the plate of horizons, but there are no labels.

MATER

The inner side of the mater is blank, but the following data are engraved there, perhaps as memoranda. The first two columns contain the names of four towns and their latitudes. It is not clear what the entries in the third column are.

Table C017-2 Geographical Data on the Mater

	Place Name	φ	?
1	*laṃkāyām* at the equator	0°	9;34
2	*ādane* at Aden	11°	30;38
3	*tilaṃge* at Golconda=Hyderabad	18°	
4	*devagirau* at Daulatabad	20;34°	

BACK

On the back, the rim of the upper half carries the altitude scale in 1° and 3° (3—90; 90—3). The rim of the lower half is empty. There is a sine graph in the upper left quadrant, 13 equidistant quarter circles in the upper right quadrant, shadow squares in the lower half, on the left with 6 divisions and on the right 7 divisions. But there are no numbers or labels in any of the four quadrants. There is a crude alidade.

BIBLIOGRAPHY

Kaye 1921, pp. 9-12, figs. 5-6.

Gunther 1932, no. 97, p. 226.

Behari & Govind 1980, pp. 100-101.

C018 SANSKRIT ASTROLABE, NOT SIGNED, NOT DATED[753]

17th century, Gujarat

Diameter 165 mm

Ahmedabad, PC



Figure C018.1 – Front of the astrolabe (photo by the owner)

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[753] The description is based on detailed photographs kindly provided by the owner.

The main body of this copper astrolabe appears to have been originally made as three separate components, viz. a thin sheet with the crown for the back, the full circular rim with the degree scale and the crown in the front and, in between these, a thick circular rim with the crown; then these three parts were nailed together. It is an unusual method of producing the mater. At some point these three parts came apart, the thick rim was lost and a part of the circular scale was broken and lost. Then a skilful carpenter attached the surviving pieces to a wooden board with a raised rim, covering in this process any engraving that may have been on the inner surface of the mater. The repair must have been done some time ago because the wooden board has aged and is cracked at places.

Components

Mater (d. 165, h. 207, t. 17), rete (d. 135) for 16 stars, 6 plates (d. 135), alidade, pin; wedge, shackle and ring are missing.

Front

The lobed crown with a broad base is plain. The circular finial of the crown, which holds the shackle and ring, is broken and the ring and shackle are lost. The circular scale is broken into two pieces; one piece is lost, the other is nailed to the wooden board, but it is much damaged. The engravings on it are hardly decipherable.

The limb with the degree scale is unusually wide. A very narrow inner band carries the scale of single degrees. Unlike on the back, the degree divisions here are not very uniform. The broader outer band is divided into groups of 6° and is numbered serially from 1 to 60, starting at the south point and proceeding clockwise (1—60).

Rete

The rete is constituted by a very narrow ring carrying the Tropic of Capricorn and a broader ring bearing the ecliptic. There is no equatorial ring. The two rings are held together by the equinoctial bar with one counter change and a series of vines and leaves. The narrow ring of Capricorn is slightly damaged; it is bent inwards in the Pisces segment. The circles representing the celestial equator and the Tropic of Cancer are partly visible on the surface of the rete.



Figure C018.2 – Rete of the astrolabe (photo by the owner)

The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names followed by serial numbers. Each sign is further subdivided into five parts of 6° each and numbered in an anti-clockwise direction.

The star-pointers are shaped like the leaves of a creeper. There are 16 named stars, 10 outside the ecliptic and 6 inside. The names are neatly engraved, with occasional errors.

Table C018-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Matsyodara*		β Andromedae
2	*Rohiṇī*		α Tauri
3	*Ṣaṇmukha kā tri*	*Ṣaṇmukha*	α Aurigae
5	*Mithuna vāma skaṃdha*		γ Orionis
4	*Manuṣā dakṣiṇa pāda*	*Mithuna dakṣiṇa pāda*	κ Orionis
6	*Ludhbaka*	*Lubdhaka*	α Canis Majoris
7	*Ludhbaka-baṃdhu*	*Lubdhaka-bandhu*	α Canis Minoris
8	*Maghā*		α Leonis
9	*Kākaskaṃdha*	*Kākaskandha*	γ Corvi
10	*Citrā*		α Virginis
11	*Svāti*		α Bootis
12	*Dhanuḥkoṭi*	*Dhanuṣkṭi*	α Ophiuchi
13	*Abhijit*		α Lyrae
14	*Śravaṇa*		α Aquilae
15	*Kukkuṭapuccha*		α Cygni
16	*Aśvamukha*		ε Pegasi

PLATES

There are six plates on which are drawn altitude circles for each 3˚ and labelled and unequal hour lines numbered from 1 to 12 from the western horizon. There are no azimuth arcs. A square incision is made at 180˚ which fits into a tooth in the limb. On each side of the six plates are mentioned the degrees of latitude (*akṣāṃśāḥ*) for which it is calibrated and the corresponding midday equinoctial shadow (*akṣabhā*), one below the other:

Table C018-2 Plates

	φ *akṣāṃśa*	Tan φ *akṣabhā*
1a	19;0	4;8
1b	21;0	4;36
2a	22;36	5;0
2b	24;0	5;21
3a	25;0	5;36
3b	26;0	5;50
4a	27;0	6;6
4b	28;39	6;36
5a	30;0	6;56
5b	32;0	7;30
6a	33;0	7;48
6b	35;0	8;24



Figure C018.3 – Plate for the Latitude of 25° (photo by the owner)

BACK

The rim of the upper half carries altitude scales, divided in 1° and 6° (6—90; 90—6). The rim of the lower half is blank. The upper left quadrant contains a sine-cosine graph, with 30 equidistant horizontal parallels and 6 equidistant vertical parallels. These are drawn very neatly and accurately but not numbered. In the upper right is the solar quadrant on which are drawn five concentric quarter circles dividing the quadrant into 6 zones. These are numbered along the horizontal radius as 10, 20, 30, 40, 50, 60, starting from the centre and proceeding towards the circumference. A half circle was drawn with the vertical radius as the diameter, apparently by mistake.

The two lower quadrants carry the shadow squares, on the left for a gnomon of 12 digits and on the right for a gnomon of 7 feet. The scales are neatly divided and numbered, but there are no labels.

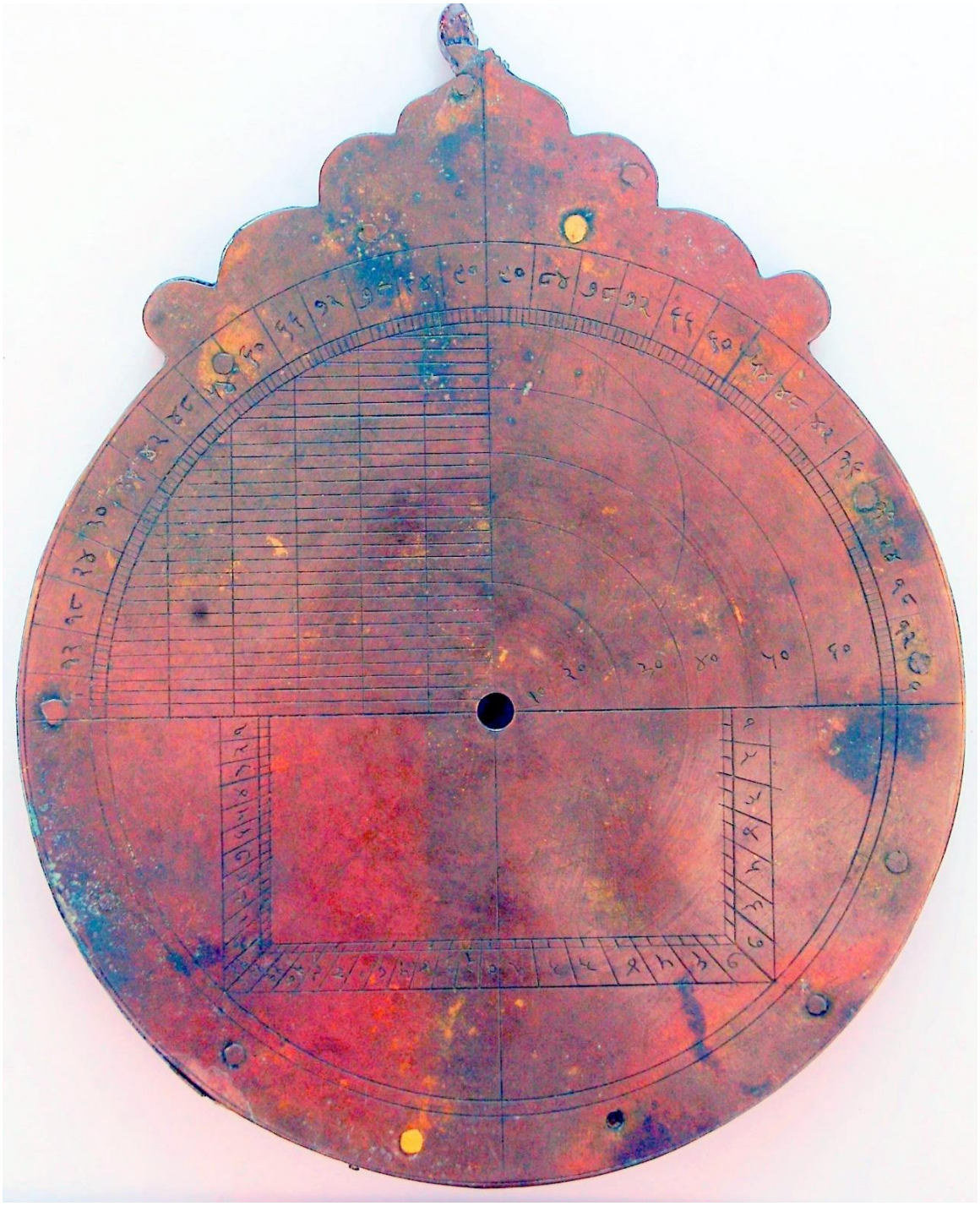


Figure C018.4 – Back of the astrolabe (photo by the owner)

ALIDADE

A heavy alidade with sights is pivoted at the centre. The right half is divided into 12 parts and numbered as 2, 4, …24, starting from the centre and proceeding to the tip.

Each of these units is subdivided into 2 parts on the edge. The left half is divided into 10 parts, and numbered as 3, 6, 9, … 30, starting from the centre and proceeding to the tip. Each of these units is divided into 3 parts on the edge. A pin with a broad head passes through the central hole of all the parts and holds them together. The wedge which should hold the pin tightly in position is missing.

Date and Provenance

There is no inscription on this astrolabe informing the date of manufacture or the name of the maker or of the person who commissioned it. However, on each side of the plates, in addition to the latitude (φ), the equinoctial shadow ($\tan \varphi$) is also mentioned. This is a practice followed in some of the early Sanskrit astrolabes of Gujarat. Therefore it is most likely that the present astrolabe was produced in Gujarat in the seventeenth century. The astrolabe was acquired by the father of the present owner around 1975 from an antique dealer in Ahmedabad.

C019 SANSKRIT ORNITHOMORPHIC ASTROLABE, NOT SIGNED, NOT DATED[754]

17th Century, Gujarat

Diameter ca 300 mm

Jodhpur, PC



Figure C019.1 – Front of the astrolabe (photo by Dr Alexander Walland)

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[754] The entry is based on the photos kindly provided by Dr and Mrs Walland, Ingelheim, Germany, who saw this astrolabe in spring 2005 in a shop inside Umaid Bhawan Palace, Jodhpur, Rajasthan.

This is a unique ornithomorphic astrolabe with the star pointers on the rete shaped like various kinds of birds. It is also remarkable that on the only surviving plate designed for the latitude of 20°, the legend mentions not just the latitude, but also the midday equinoctial shadow, the hypotenuse of the right-angled triangle formed with the gnomon and the equinoctial midday shadow, the duration of the longest day, the oblique ascensions or the rising times of the 12 zodiac signs at this latitude, and the names of seven other localities with approximately the same latitude where this plate face can be used for observation and computation. No other Sanskrit astrolabe is known where the plates contain so many parameters. The plates in the astrolabe C016 mention some of these parameters, viz., the latitude, equinoctial shadow, duration of the longest day and the oblique ascensions.

COMPONENTS

Mater (d. ca 300) with a shackle and ring, two plates, rete, alidade (pin and wedge are missing).

FRONT

The crown is very small and low, with an inscription *śrīmahāgaṇapataye namaḥ* , 'salutation to glorious great Gaṇapati.' The limb is neatly divided in 1° and 5°; groups of 5° are numbered serially from 1 to 15, separately in each quadrant, starting from the east and west points and proceeding to the north and south points (1—15; 15—1; 1—15; 15—1). The labels in Devanagari numerals are neatly engraved. The inner surface of the mater is blank.

RETE

The unique 'ornitho-morphic' rete is heavily damaged; almost the entire eastern half of the outer circle constituting the Tropic of Capricorn is broken; so too probably some star pointers in the vicinity. The design however is very interesting and unusual, the star pointers being constituted by the beaks[755] of peacocks and cranes, and a few tips of leaves or flowers.[756] The solstitial bar, counterchanged at the centre, and the

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755 In fact, the Sanskrit word for star pointer is *cañcu*, lit. bird's beak

756 For another rete with peacocks and parrots, see D015.

equinoctial bar, without counter change, are formed by densely joined lozenges with holes in the middle. Two large segments of the equator are shown, one below the ecliptic and the other inside the ecliptic. The ecliptic is fully represented; it is divided into the 12 signs of zodiac and labelled with the names of the signs together with their serial numbers. Each sign is further subdivided into ten divisions of 3° and numbered in 3s in an anti-clockwise direction. Perched on these rings are some 11 peacocks, cranes and other birds whose beaks constitute the star pointers; likewise about 10 leaf-clusters. These are positioned correctly where the star pointers are generally placed. However, no star names engraved on these birds or leaves can be seen in the photos. Without such names the rete loses some of its functional value.

PLATES

There are two plates. It is not clear whether they have projections engraved on both sides or only on one side. One of these is heavily damaged on the edge. It is probably calibrated for the latitude of 27°, which is the latitude of Jaipur. No clear photo is available of this plate.

In the other plate, one face is calibrated for 20 degrees. There are full circles of the tropics of Capricorn and Cancer, the equator and the prime meridian. Altitude circles are drawn for each 2° and labelled on the left hand side as well as on the right as 2, 4, 6 and so on. Below the oblique horizon are drawn unequal hour lines; these are numbered as 1, 2, 3 … 12, starting from the western horizon.

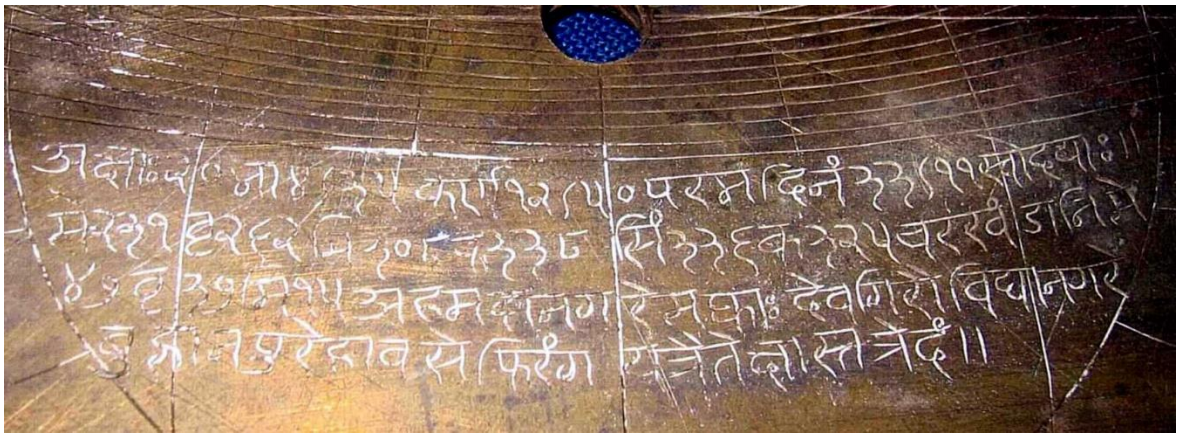


Figure C019.2 – Inscription on the plate for the latitude of 20° (photo by Dr Alexander Walland)

Within the circle of the Tropic of Cancer, just below the oblique horizon, there is an inscription in four lines.

akṣāh 20 bhā 4/35 karṇa 12/50 paramadinam 33/11 svodayāḥ ‖
me 231 vṛ 262 mi 308 ka 338 siṃ 336 ka 325 carakhaṃḍāni me
47 vr 37 si 15 ahamadānagare makkāh devagirau vidyānagare
buhrānapure h/dāvase phiraṃga yatraitekṣās tatredam ‖

'[Degrees of] latitude (*akṣa*) 20; [midday equinoctial] shadow (*bhā*) 4;35; hypotenuse (*karṇa*) 12;50; longest day (*parama-dina*) 33;11. Oblique ascensions (svodaya) [in *palas*]: Aries 231, Taurus 262, Gemini 308, Cancer 338, Leo 336, Virgo 325. Ascensional differences (*cara-khaṇḍa*): Aries 47, Taurus 37, Gemini 15. In Ahamadanagara, Makkā , Devagiri, Vidyānagara, Buhrānapura, H/Dāvasa, Phiraṃga, [and wherever] these [degrees of] latitude [prevail], this [latitude plate is to be used].'

The seven towns enumerated above should be situated on or close to the latitude of 20°. The last two cannot be identified.

1 Ahamadanagara = Ahmednagar
2 Originally sakkāh was written and then corrected to Makkāh =Mecca
3 Devagiri = Daulatabad
4 Vidyānagara = Hampi Vijayanagar
5 Buhrānapura = Burhanpur
6 H/Dāvasa ?
7 Phiraṃga ?

Oblique Ascensions and Right Ascensions

The inscription enumerates the oblique ascensions (*svodaya*) and the ascensional differences (*cara-khaṇḍa*) at latitude 20°. The former are given for the first 6 zodiac signs and they apply to the next 6 signs in the reverse order. By the addition or subtraction of the oblique ascensions and the ascensional differences, the right ascensions or the rising times of the signs at the equator are obtained as shown in the table below.

Table C019-1 Oblique and Right Ascensions

Signs	Oblique ascensions	Ascensional differences	Right ascensions
Aries Pisces	231	+ 47	278
Taurus Aquarius	262	+ 37	299
Gemini Capricorn	308	+ 15	323
Cancer Sagittarius	338	- 15	323
Leo Scorpio	336	- 37	299
Virgo Libra	325	- 47	278

OBLIQUE ASCENSIONS AT LATITUDE 20°

The values given on this plate are in *palas*; these are reproduced in column 2 in the table below. Plate 1a of the astrolabe C016 also gives the oblique ascensions for Devagiri on latitude 20°. Here the values are *ghaṭīs* and *palas*. These values are reproduced and converted into *palas* in column 3. A comparison of the two sets shows that there are small differences.

Table C019-2 Oblique Ascensions on C019 compared to those on C016

Signs	Oblique ascensions in the present astrolabe C019	Oblique ascensions in astrolabe C016
Aries Pisces	231	3;56 = 236
Taurus Aquarius	262	4;45 = 265
Gemini Capricorn	308	5;09 = 309
Cancer Sagittarius	338	5;37 = 337
Leo Scorpio	336	5;33 = 333
Virgo Libra	325	5;20 = 320

Back

On the back, the rim of the upper half carries altitude scales divided in 1° and 6° (6—90; 90—6). Inside the rim, altitude circles are engraved seven each above and below the horizon. It appears that the maker wanted to engrave here the projections for some latitude. But, absent-mindedly drew the altitude circles also below the horizon. When he realized his mistake, he gave up further engraving. The altitude circles appear to have been numbered on the left-hand side. In the middle, there are faint traces of the circle of the Tropic of Cancer. There are marks of division on the horizon and on the altitude circles below it, and these divisions appear to have been numbered.

Alidade

The alidade has pointed tips, and an exaggerated centre piece with a large circle. The length of the alidade is divided into two halves. The half towards the centre, i.e. the inner half, is graduated into 30 parts on either side of the centre and numbered accordingly starting from the centre. The sighting plates are however unusual; their width is twice that of the alidade. Consequently one half of the sighting plates rests beyond the surface of the alidade. Each sighting plate has two apertures. The larger aperture is correctly placed above the inner edge of the alidade which coincides with the diameter of the astrolabe. The smaller one is placed in the half which is jutting out. Consequently, the line joining the two smaller apertures does not pass through the centre of the astrolabe.

C020 SANSKRIT ASTROLABE, NOT SIGNED, NOT DATED, WITH A WOODEN CASE[757]

17th century, Gujarat

Diameter 148 mm

Jodhpur, PC



Figure C020.1 – Front of the astrolabe (photo by Dr Jean-Michel Delire)

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[757] Entry based on photos kindly provided by Dr Jean-Michel Delire who saw this astrolabe in a handicrafts shop at Jodhpur in August 2013.

This is a well-crafted astrolabe with very elegant numbers on the limb. But the engraving on the back is incomplete, without any legends and with almost all the scales unnumbered.

Components

Main body (d. 148, h. 180, t. 10) with crown, shackle and ring, rete, 4 plates, wooden case; alidade, pin and wedge appear to be missing.

Front

The crown is high and solid with a broad base; profiles are formed lobes and ogees, two decorative holes at the left and right; there is a finial, but its shape is not clearly visible, simple shackle and ring. The limb is graduated in 1° and 6°; groups of 6° numbered separately in each quadrant (6—90; 90—6; 6—90; 90—6).

Rete

The rete consists of a very narrow ring of the Tropic of Capricorn, a narrow ring of the lower half of the equator and a very broad ring of the ecliptic, the three held together by the equinoctial bar which has one counter change at the vernal equinox. The ecliptic ring is divided into the 12 zodiac signs and labelled with their names; each sign is subdivided in groups of 6°, but not numbered. There is a sturdy knob at the north point. The rete displays the 'bird in the cage' pattern.[758] Because of the heavy patina, star names cannot be read completely, but it is not difficult to identify them.

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[758] Cf. Sarma 2011a, pp. 108-110, figure 8.

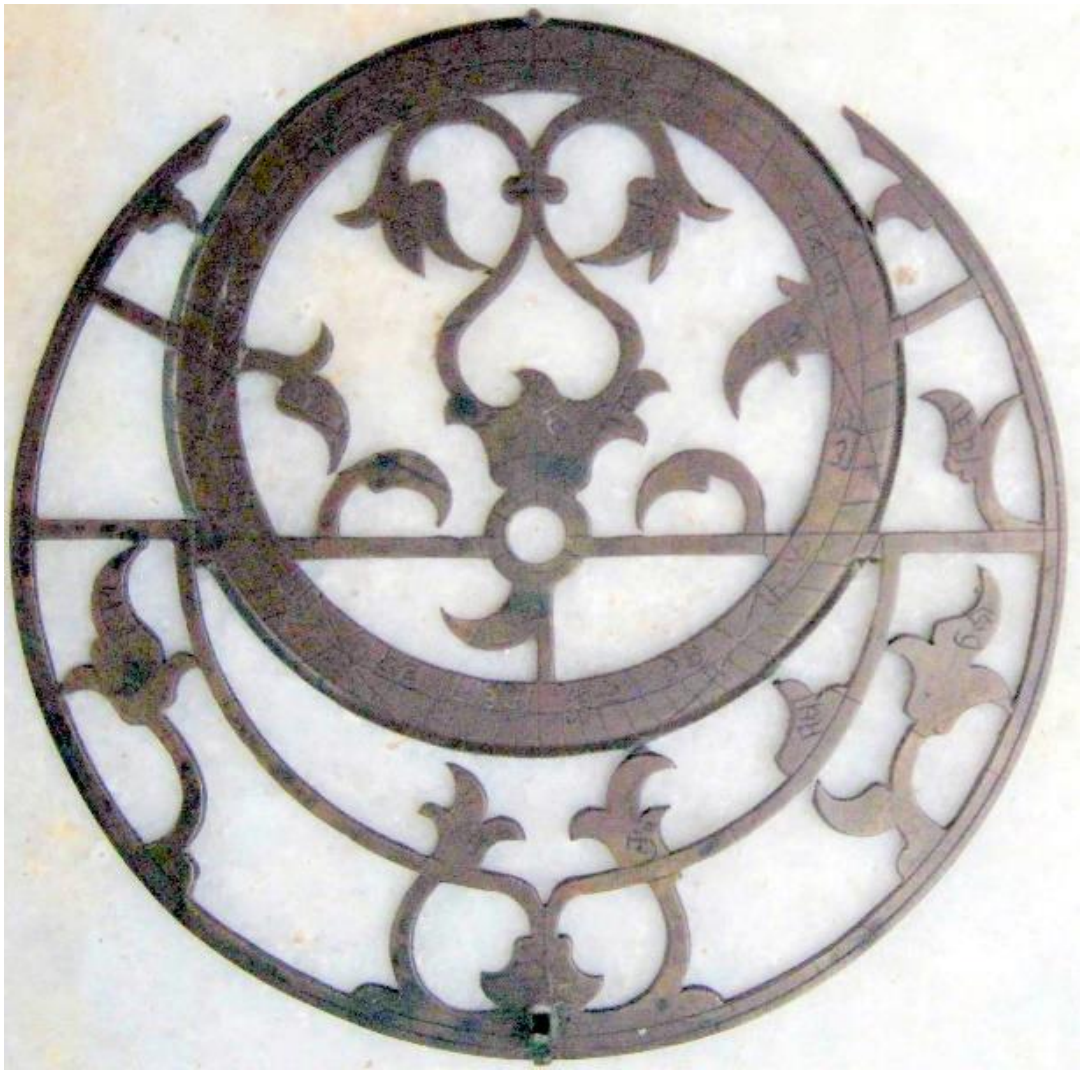


Figure C020.2 – Rete of the Astrolabe (photo by Dr Jean-Michel Delire)

Table C020-1 Stars on the Rete

	Star Name	Identification
1	*Samudra-pakṣī*	β Ceti
2	*Manuṣya-śīrṣa*	β Persei
3	*Rohiṇī*	α Tauri
4	*Ārdrā-lubdhaka*	α Canis Majoris
5	*Lubdhaka-bandhu*	α Canis Minoris
6	*Maghā*	α Leonis
7	*Hasta*	δ Corvi
8	*Cītrā*	α Virginis

	Star Name	Identification
9	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
10	*Svāti*	α Bootis
11	*Dhanuṣkoṭi*	α Ophiuchi
12	*Abhijit*	α Lyrae
13	*Śravaṇa*	α Aquilae
14	*Kukkuṭapuccha*	α Cygni
15	*Pūrvā-bhādrapadā*	β Pegasi

PLATES

There are four plates serving 8 different latitudes. On all the plates altitude circles are drawn for every 6° and labelled in the east and west, but there are no azimuth arcs. Lines for unequal hours are drawn from the western horizon and those for equal hours from both the western and eastern horizons. On each plate face, the name of the locality (in locative case) and the corresponding latitude are inscribed. The latitude value is preceded by an *S*-like symbol used commonly for *avagraha*.[759]

It is not possible to decide from the photos which two faces belong to a particular plate. Therefore, the legends on the plate faces are reproduced below in the order of increasing latitudes.

Table C020-2 Plates

	Place Name as engraved	φ	Modern Name
1	*Vījāpure*	*S 18*	Bijapur
2	*Vurāhanapure*	*S 21*	Burhanpur

[759] This symbol occurs also on the astrolabe dated 1651 by Jīvatāpa (C007) and on the astrolabe made for Rāghavajit in 1669 (C008).

	Place Name as engraved	φ	Modern Name
3	*Aṇahillapure*	*S 24*	Anahilwad Patan
4	*Jodhapure*	*S 26*	Jodhpur
5	*Yoginīpure*	*S 28;30*[760]	Delhi
6	*Thān[e]śvara*	*S 30*	Thanesar
7	*Lābhapure*	*S 32*	Lahore
8	*Kāśmīre*	*S 35*	Kashmir (Srinagar)

No geographical gazetteer is inscribed on the inner surface of the mater.

[760] The traditional value of the latitude of Delhi is 28;39.



Figure C020.3 – Back of the astrolabe (photo by Dr Jean-Michel Delire)

BACK

The back of the Astrolabe is not completed. There are no labels; except for one scale, the other scales are not numbered. The rim on the upper half carries the altitude

scales, divided in 1° and 6°. Groups of 6° are numbered only in the rim of the left quadrant, from the east point to the south point from 6 to 90. In fact, this is the only numbering on the back. All other scales are unnumbered. The rim of the lower half bears a cotangent scale, but is not numbered.

The upper left quadrant carries a sine-cosine grid with 60 horizontal and 60 vertical parallel lines. The lines are not evenly spaced. On the upper right is the solar quadrant which is divided by 15 declination. Here two curves of the sun's altitude at noon are drawn, but there are no labels. The curves may be for the latitudes of Delhi and Lahore (at 29° and 32°) but they are not correctly drawn.

In the lower half there are shadow squares, on the left for a gnomon of 12 digits and on the right for a gnomon of 7 digits. The scales are divided in 12 and 7 units respectively, but not numbered.

Between the cotangent scale on the rim and the shadow squares, a table of two rows is drawn; one row is divided in 12 parts to accommodate the names of the twelve signs and another row into 28 units to accommodate the names of the corresponding lunar mansions, but the names are not engraved.



Figure C020.4 – Wooden Case of the Astrolabe (photo by Dr Jean-Michel Delire)

The astrolabe is housed in a wooden case which has depression corresponding to the outline of the astrolabe.

C021 SANSKRIT ASTROLABE (LARGE WHEEL ASTROLABE) MADE FOR SAWAI JAI SINGH

Ca 1720 Amber, Rajasthan

Diameter 351 mm

Jaipur, Jai Singh's Observatory

CCA 93



Figure C021.1 – Large Wheel Astrolabe (photo by S. R. Sarma)

On the back of this large astrolabe, there are three curves for the sun's meridian altitude at Lahore, Delhi and Amber. The first two are the Mughal Imperial capitals. Amber was the capital of Sawai Jai Singh before he built and moved to Jaipur in 1728. Therefore, this astrolabe must have been made for Jai Singh about 1720 at Amber. In this astrolabe can be seen some influences of the Lahore astrolabes, the best specimens of which he had collected. Jai Singh's instrument makers, however, did not imitate the floral patterns of the retes of the Lahore astrolabes; instead they created their own designs. This and the next astrolabe have retes formed like wheels with twelve spokes each.

Components

Mater (d. 351, h. 432, t. 16) with crown, shackle and ring, rete (d. 318) for 44 stars, 7 plates, alidade and pin; the wedge is lost. To the ring is attached a small copper plaque.



Figure C021.2 – The shackle and ring (photo by S. R. Sarma)

Front

The crown is plain, high and lobed. The crown and rim are made together and joined to the main body. On the back, all around the circumference can be seen the marks of some 20 nails with which these were joined. A very heavy and ornate shackle and a slightly thinner ring, both with octagonal cross-sections, are attached to the crown. On the front of the crown is engraved *śrī* (auspiciousness, glory). The limb is divided in 1° and 6° and numbered by 6s from 6 to 360.

RETE

The rete is in the form of a wheel with 12 spokes. There is a counter change at the centre between each two opposite spokes. There are turning knobs at the ends of the two horizontal spokes. The ecliptic circle is divided into twelve signs. Each sign is further subdivided into 5 parts. The first part carries the name of the sign and the other parts are empty. Parallel to this, there is another circular scale, also divided into 12 x 5 = 60 parts. This should have contained the scale of single degrees, but is empty. From the spokes of the wheel arise a series of projections shaped like tiger's claws. Some 44 of these are star pointers with the names of stars inscribed on them. These stars include several junction stars of the lunar mansions, a feature which can be noticed also in D001.



Figure C021.3 – Rete of the Astrolabe (photo by S. R. Sarma)

Table C021-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Matsyoda*	*Matsyodara*	β Andromedae
3	*Aśvinī*		β Arietis
4	*Matsyodapāda*	*Matsyodara-pāda*	γ Andromedae
5	*Bharaṇī*		41 Arietis
6	*Manuṣyapārśva*		α Persei
7	*Kṛttikā*		η Tauri
8	*Agri*	*Agni*	β Tauri
9	*Rohiṇī*		α Tauri
10	*Brahmadaya*	*Brahma-hṛdaya*	α Aurigae
11	*Prajāpati*		δ Aurigae
12	*Mithuna vāma pāda*		β Orionis
13	*Mithuna vā hasta*	*Mithuna-vāma-hasta*	γ Orionis
14	*Magaśira*	*Mṛgaśirā*	λ Orionis
15	*Mithuna da hasta*	*Mithuna-dakṣiṇa-hasta*	α Orionis
16	*Mithuna da pāda*	*Mithna-dakṣiṇa-pāda*	κ Orionis
17	*Lubdhaka*		α Canis Majoris
18	*Punarvasu*		β Geminorum
19	*Dvi punarvasu*	*Dvitīya-punarvasu*	α Geminorum
20	*Āśleṣā*		ζ Cancri
21	*Lubdhakabaṃdhu*	*Lubdhaka-bandhu*	α Canis Minoris

	Star Name as engraved	Full/Correct Form	Identification
22	*Pharaduśujā*[761]		α Hydrae
23	*Maghā*		α Leonis
24	*Pūrvā Phālgunī*		δ Leonis
25	*Utarā Phā*	*Uttarā Phālgunī*	β Leonis
26	*Kākaskada*	*Kākaskandha*	γ Corvi
27	*Hasta*		δ Corvi
28	*Citrā*		α Virginis
29	*Apāṃvatsa*		θ Virginis
30	*Svāti*		α Bootis
31	*Viśāmātṛla*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
32	*Viśākhā*		α Librae
33	*Sarpadhāriśira*		α Ophiuchi
34	*Abhijit*		α Lyrae
35	*Śravaṇa*		α Aquilae
36	*Dhaniṣṭhā*		α Delphini
37	*Kukkupaṃcu*	*Kukkuṭacañcu*	β Cygni
38	*Kukupu*	*Kukkuṭa-puccha*	α Cygni
39	*Śatabhiṣā*		λ Aquarii
40	*Arpaśāvā*	*Aśvapārśva*	α Pegasi
41	*Aśvaskaṃdha*		β Pegasi
42	*Aśvapakṣa*		γ Pegasi

761 Here the Arabic word *Fard al-Shujāᶜ* is merely transliterated. The Sanskrit name is *Mahāpuruṣa.*

	Star Name as engraved	Full/Correct Form	Identification
43	*Aśvanābhi*		δ Pegasii
44	*Raṃjitakara*	*Rañjita-kara*	β Casssiopeiae

PLATES

There are seven plates. Six of these serve the latitudes of 18°— 20°, 22°— 23°, 27°— 27;40°, 28;39°—32°, 34°— 48°, 72— 0°+90°. The seventh plate is designed for the ecliptic coordinates on one side and for the multiple horizons on the reverse. On the latitude plates, altitude circles are drawn for each 2° and labelled on both sides of the meridian; every third is dotted. Azimuths are drawn for 2° above the horizon and for 6° below the horizon. These are numbered in a straight line in the lower half of the plate. Lines for unequal hours are drawn and numbered as 1, 2, 3, 4, 5, 6, 5, 4, 3, 2, 1. Below the horizon is marked just the latitude without any legend.

Even though the circles and arcs are drawn with great care on all the plates, uniformity is lacking in some plates. On some there are no dotted lines. On some there are no labels at all. On the plate serving the latitudes 34° and 48°, there are no dotted curves among the altitude circles, nor are they numbered; azimuths are drawn for every 5° above the horizon and for every 15° below the horizon; there are equal hour lines counted from the western horizon. On the plate of horizons, the label *sarvadeśī* (for all latitudes) is inscribed, but there is no other label; on the reverse side is the projection for the latitude of 66°, but there are no numbers or labels.

The inner side of the mater is empty. There is no gazetteer.

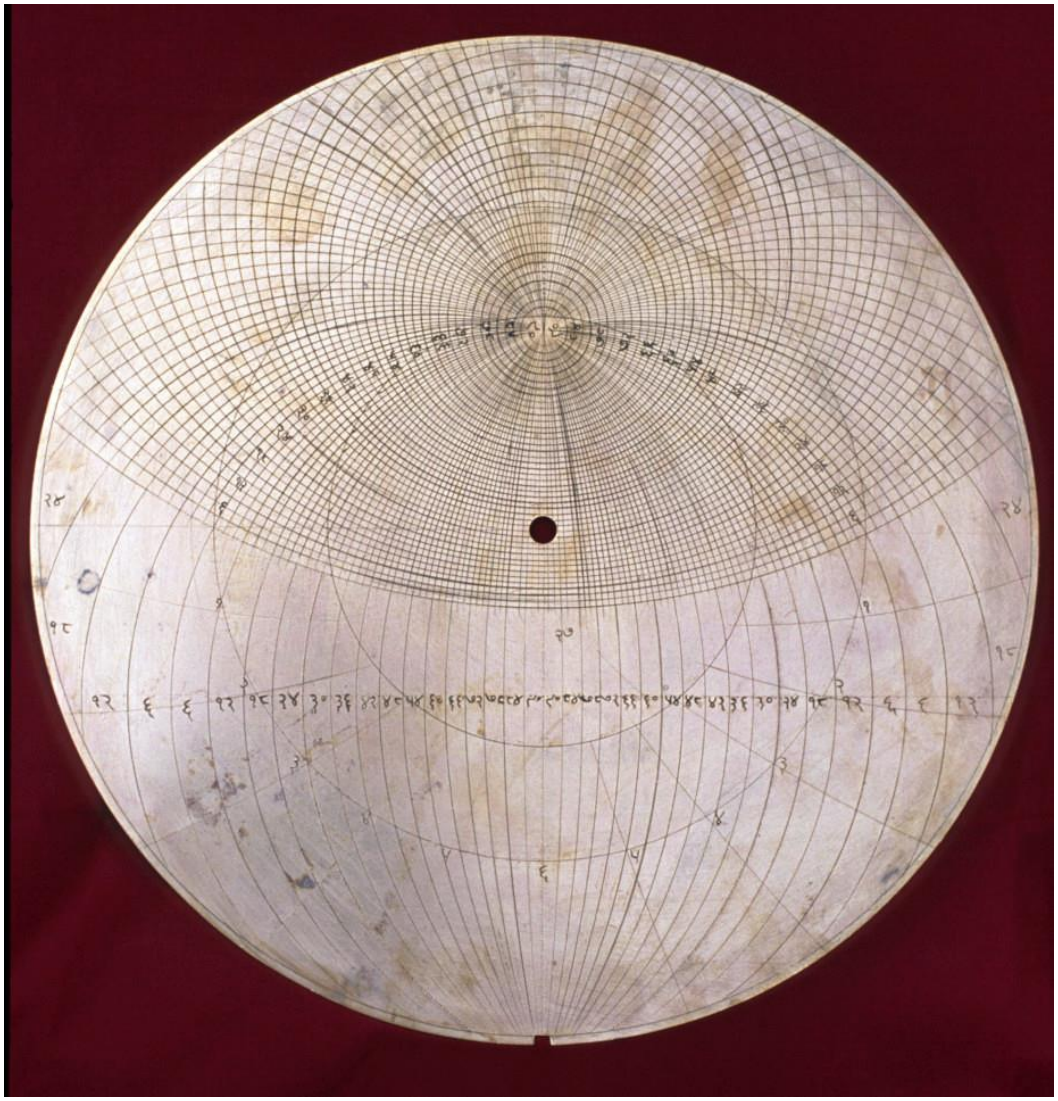


Figure C021.4 – Plate for the latitude of 27° (photo by S. R. Sarma)

BACK

The rim of the upper half carries altitude scales divided in 1° and 6°. The upper left quadrant has a sexagesimal sine-cosine grid with 60 vertical and 60 horizontal lines, with each sixth line dotted. The upper right quadrant has 18 declination arcs, which are labelled in signs and degrees along the vertical and horizontal radii. On this grid are three sigmoid graphs, showing the solar meridian altitude at Lahore, Delhi and Amber.[762]

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762 Garrett & Guleri 1902, p. 60: 'There are several ingenious contrivances on the back sides of some of the Yantra Rajs. Some are provided with sundials, and there is an arrangement shewing graphically, by means of a curve, the relation between the sun's longitude and its declination. A different curve is required for each latitude, and there are therefore three curves, one for use at Delhi, one for Amber and the third for Lahore.'



Figure C021.5 – Back of the astrolabe (photo by S. R. Sarma)

These are labelled as follows (reading from below): *madhyāhne unnatāṃśa rekhā Lāhore akṣāṃśāḥ 31;30* (The line of meridian altitude at Lahore, φ 31;30);
Iṃdraprasthe 28;39 (at Indraprastha = Delhi, [φ] 28;30)
Ambāvatyāṃ 27;0 (at Ambāvatī = Amber, [φ] 27;0).
In the lower half are engraved the shadow squares, on the left for a gnomon of 7 digits and the right for a gnomon of 12 digits, with the following labels:
Vertical scale on the left: *saptāṃgulaśaṃkor vilomacchāyā* (umbra versa of a gnomon of 7 digits).

Horizontal scale on the left: *saptāṃgulaśaṃkoḥ samacchāyā* (umbra recta of a gnomon of 7 digits).
Vertical scale on the right: *dvādaśāṃgulaśaṃkor vilomacchāyā* (umbra versa of a gnomon of 12 digits).
Horizontal scale on the right: *dvādaśāṃgulaśaṃkoḥ samacchāyā* (umbra recta of a gnomon of 12 digits).

The scales are first divided in 7 or 12 parts and each part is subdivided into 6 units. The cotangent scale is extended to the circumference.

The rim of the lower half carries the cotangent scale and inside this a degree scale which is extended from the upper half.

The graduated alidade has ornate ends and sights are equipped with 2 pinholes each.

PROVENANCE

This astrolabe was in Jai Singh's personal collection of portable astronomical instruments. When G. R. Kaye studied Jai Singh's masonry instruments around 1918, the collection of portable instruments was with the Jaipur Museum. Later this collection was shifted to the Astronomical Observatory and was kept in a small room under the masonry construction of the *Nāḍīvalaya-yantra.* Around 2000, a gallery was constructed in the premises of the observatory to house these portable instruments.

Perhaps during the reign of Madho Singh (r. 1750-1767) copper plaques were prepared for each instrument with the name of the instrument and sometimes also with the functions of the instrument. In the course of shifting the instrument collection from one place to another, some of these plaques got detached from the instruments and then attached to other instruments by mistake or just kept loose. To the ring of the present astrolabe is attached a small plaque on which is engraved in three lines *yaṃtrarāja baḍā | patra 7 sāt ko chai | bhapatra sivāy*, (astrolabe large | plates 7 seven plates [i.e.] six without the rete). Actually there are seven plates and the rete.

In his description of the portable instruments at Jaipur, Kaye (Kaye 1918, p. 31, figs 26-27), assigns to this astrolabe the code 'G' (p. 16) and illustrates the front and back of the instruments as figs. 26 and 27 on plate IX. But his description on p. 31 is partly wide off the mark: 'Hindu astrolabes are mostly of modern workmanship and of

modern pattern; but at Jaipur there is a Hindu copy of a Persian astrolabe that is of interest. It is of inferior workmanship, and was, apparently never properly completed. It is *thulthi* or tripartite instrument, and has two tablets, for latitudes of 27° and 72° N., and a tablet of celestial latitudes and longitudes. On the ‘ankabūt the ecliptic is graduated at intervals of 6 degrees (figure 26), and on most of the points no names are engraved. On the back of the instrument (figure 27) is the usual table of sines, and declination graphs for 27°and 28°39’. On the lower half are the usual shadow scales but nothing else.’

Kaye must have mixed up his notes. It is not a tripartite instrument but bipartite. Kaye thinks that because ‘on most of the points no names are engraved’, it was ‘apparently never completed.’ The nearly hundred tiger’s claw like projection are not all meant as star pointers but for the balance in the rete which should have equal balance between the two sides around the meridian. The 44 named star pointers constitute the largest number to be found on Sanskrit astrolabes. There are not two plates but seven. On the back there are not two declination graphs, but three. Even the diameter of the astrolabe (p. 16) is not accurate; it is not 16 inches, but 13.8 inches. Gunther 1932, vol. I, no. 93, p. 222 took over Kaye’s information, and added that it was made about 1670! This is repeated in CCA 93.

BIBLIOGRAPHY

Garrett & Guleri 1902, p. 60.
Kaye 1918, pp. 16, 31, figs 26-27.
Gunther 1932, vol. I, no. 93, p. 222.

C022 SANSKRIT ASTROLABE (SMALL WHEEL ASTROLABE) MADE FOR SAWAI JAI SINGH

Ca 1730, Jaipur, Rajasthan

Diameter 198 mm

Jaipur, Jai Singh's Observatory

CCA 94



Figure C022.1 – Small Wheel Astrolabe (photo by Alain Brieux)

This astrolabe also appears to have been produced for Sawai Jai Singh by the same instrument maker who made the large wheel astrolabe. But, since Sawai Jaipura, with its latitude and longitude, is mentioned in the gazetteer, it can be presumed that the astrolabe may have been made at Jaipur after the completion of the new city in 1728.

Components

Mater with crown (d. 198, h. 243, t. 8), rete (d. 176) for 20 stars, 3 plates (d. 176), alidade (slightly damaged; only one sighting plate with three apertures), pin, modern wedge, but no shackle or ring.

Front

High crown with three lobes on each side, terminating into a diamond-shaped finial; the shackle and ring are missing. The limb is divided in 1° and 6° and numbered by 6s, separately for each quadrant, starting at the east and west points and reaching the south and north points (6—90; 90—6; 6—90; 90—6). There is a tooth at the north point to hold the plates in position.

Rete

As in the larger wheel astrolabe, the rete here also is formed like a wheel with twelve spokes which have a counter change at the centre. This is more elegant than the rete in the large wheel astrolabe. Here decorative scrolls are added to the two ends of the Capricorn ring. There is a turning knob near the star pointer for *Maghā* (α Leonis). The ecliptic is divided into 12 signs and labelled. Each sign is subdivided into groups of 6° and these are numbered in an anti-clockwise direction. There are 20 named star pointers which are shaped like leaves.

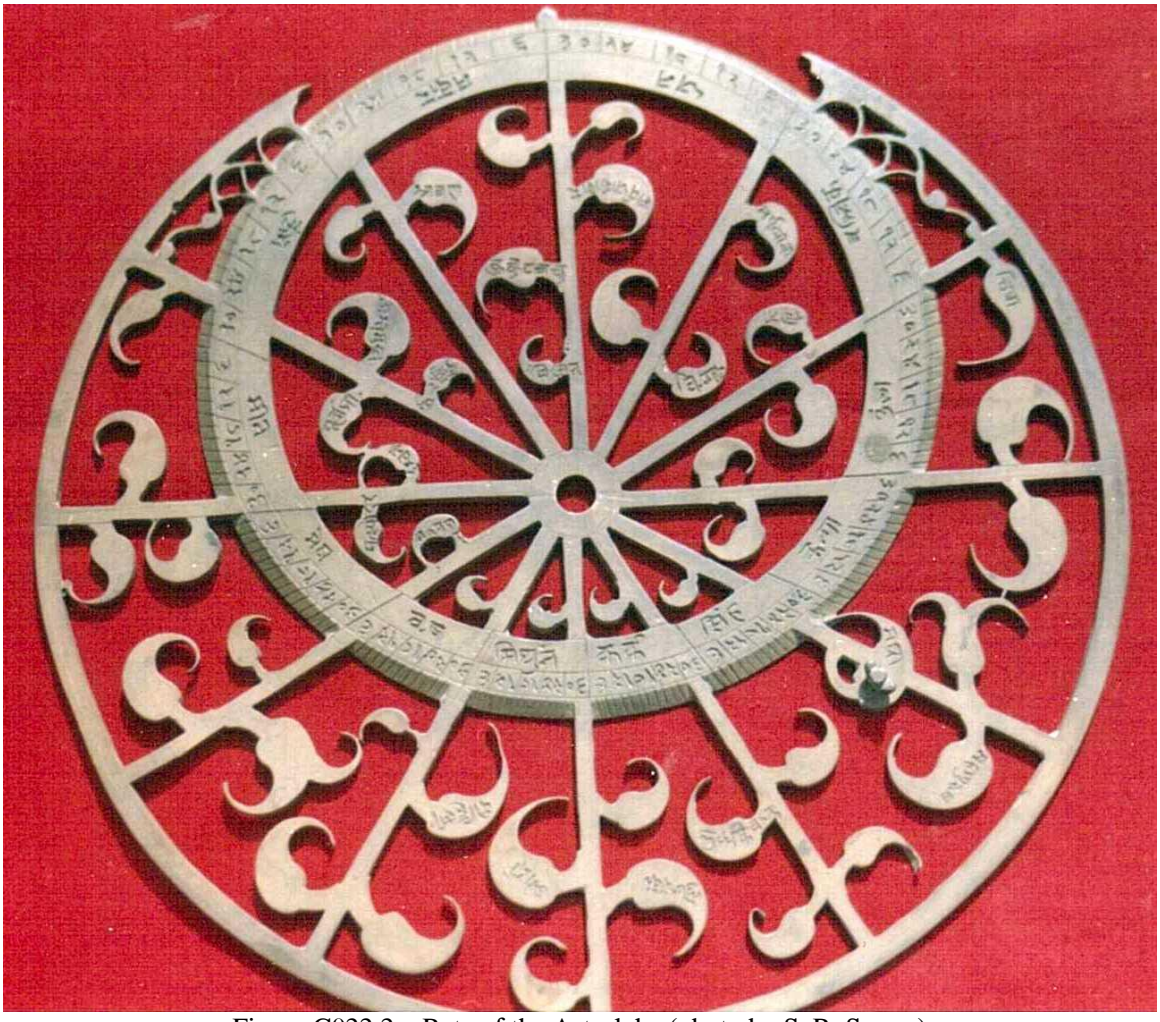


Figure C022.2 – Rete of the Astrolabe (photo by S. R. Sarma)

Table C022-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Matsyodara*		β Andromedae
2	*Gatapadā*	*Matsyodara-pāda*	γ Andromedae
3	*Rohiṇī*		α Tauri
4	*Ārdrā*		α Orionis
5	*Lubdhaka*		α Canis Majoris
6	*Lubdhakavadhu*	*Lubdhaka-bandhu*	α Canis Minoris
7	*Mahāpuruṣa*		α Hydrae
8	*Maghā*		α Leonis

	Star Name as engraved	Full/Correct Form	Identification
9	*Citrā*		α Virginis
10	*Svātī*	*Svāti*	α Bootis
11	*Vimā*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
12	*Sarpagrīvā*		α Serpentis
13	*Sarpadhārīśra*	*Sarpadhārīśira*	α Ophiuchi
14	*Abhijit*		α Lyrae
15	*Śravaṇa*		α Aquilae
16	*Kukkuṭacañcu*		β Cygni
17	*Kukkuṭapuṃ*	*Kukkuṭapuccha*	α Cygni
18	*Aśvamukha*		ε Pegasi
19	*Aśvinī* !		β Arietis
20	*Pūrvabhādrapadā*		β Pegasi

Plates

There are three plates, serving 21°—horizons; 23°—29°; 25°—27°. The latitudes are inscribed on the plates with the prefix *akṣāṃśa* (degrees of latitude). On the plate for 27°, there is the additional information *horā paramadina 13;44*, 'hours [in the] longest day 13;44'. This value is not recorded on other plates. Altitude circles are drawn for 6°, azimuth arcs for 6° below the horizon, equal hour lines, counted from the western and eastern horizons, labelled from 1 to 6 and 6 to 1.

Geographical Gazetteer

On the inner side of the mater, there is a gazetteer of 58 localities in two concentric circles, preceded in each circle by the argument: *sahara-nāmāni* (names of the towns), *akṣāṃśa* (latitude) and *tūlāṃśa* (longitude). Some names appear to have been taken from the gazetteers of Indo-Persian astrolabes and are poorly transliterated.



Figure C022.3 – Geographical Gazetteer (photo by S. R. Sarma)

Table C022-2 Geographical Gazetteer

	Place Name (*sahara-nāmāni*)	φ (*akṣāṃśa*)	L (*tūlāṃśa*)	Modern Name
	Outer Circle			
1	Gaṅgāsāgara	19;20	109;30	Gangasagar
2	Satagāma	27;00	123;30	?
3	Baṃdu	26;55	120;30	?
4	Uḍīsā	23;50	126;30	Orissa (Jajnagar)
5	Maṃnakapura	26;29	139;40	Manikpur
6	Kanoja	26;34	115;50	Kannauj

	Place Name (*sahara-nāmāni*)	**φ (*akṣāṃśa*)**	**L (*tūlāṃśa*)**	**Modern Name**
7	Avadha	26;22	116;30	Faizabad
8	Vaṇārasa	26;14	116;20	Varanasi
9	Ahmadābāda	25;1	111;20	Ahmedabad
10	Bharoca	21;0	110;30	Bharuch
11	Khambhāica	22;0	109;30	Khambhat
12	Somanātha	17;0	106;0	Somnath
13	Nahalavārā	22;0	102;30	Anahilwad Patan
14	Dolatābāda	20;30	111;0	Daulatabad
15	Golakuṃḍā	17;30	111;6	Golconda = Hyderabad
16	Kalavarago	17;0	109;30	Gulbarga
17	Vurahānapura	20;30	103;0	Burhanpur
18	Vījāpura	16;0	125;0!	Bijapur
19	Mahamadānagara	19;21	104;15	Ahmednagar
20	Buṃdī	25	112;20	Bundi
21	Bhorakhā	25;0	112;20	?
22	Ujjeṇa	23;10	115;30	Ujjain
23	Hāsī Hisāra	29;0	112;25	Hansi Hissar
24	Vadāṃu	26;30	114;39	Badaun
25	Gvāler	26;29	114;0	Gwalior
26	Thāṃnesara	30;10	112;23	Thanesar
27	Pānīpatha	29;36	113;20	Panipat
28	Āgarā	27;0	115;0	Agra
29	Dillī	28;39	113;35	Delhi
	Inner Circle			

	Place Name (*sahara-nāmāni*)	φ (*akṣāṃśa*)	L (*tūlāṃśa*)	Modern Name
30	Kaśmīra	35;0	113;0	Srinagar
31	Suṃnāma	30;30	109;30	Sunam
32	Śyālakoṭa	33;0	109;30	Sialkot
33	Lāhora	31;50	109;20	Lahore
34	Mulatāna	29;40	107;35	Multan
35	Śīghasthāṃ	32;0	113;30	Sijistan = Sistan
36	Kha[ṃ]dhāra	33;0	107;40	Qandahar
37	Thatā	25;10	102;30	Thatta
38	Sāhila vahara u Kāvānus[763]	0;0	11;0	Ocean Coast Oceanus
39	Jajīra Kaṃvalā[764]	3;0	21;00	Madagascar Island
40	Yamakoṭ	5;0	177;0	Yamakoṭi
41	Salā[765]	5;0	190;0	Sala (China)
42	Khuramīdo (?) vulamula kahavāra[766]	9;30	65;0	Jarmi
43	Misara	30;20	63;0	Egypt
44	Sakaṃdarātha	30;18	61;54	Alexandria (*Iskandariya*)
45	Tijavāna	35;0	85;0	?
46	Rasphīhā	32;25	86;40	Isfahan

763 Arabic *Sāḥil bahr awqayānus,* ‘Ocean Coast Oceanus’. Oceanus, or Greek *Okeanos,* is said to be the divine personification of the sea which encircles world. Cf. Kennedy 1987a, s. v. Ocean Coast.

764 *Jazīrah Qanbalah.* Cf. Kennedy 1987a, s. v. Qanbala.

765 Cf. Kennedy 1987a, s.v. Sala China.

766 Jarmi, capital of Abyssina, referred to as in Arabic *Khurmus dār al-mulk ḥabashiah*; Kennedy 1987a, s.v. Jarmi.

	Place Name (*sahara-nāmāni*)	**φ (*akṣāṃśa*)**	**L (*tūlāṃśa*)**	**Modern Name**
47	Kasāṃna	34;0	96;42	?
48	Kuṃm	34;45	95;4	Qom
49	Raiya	35;0	86;20	Rayy
50	Mānakāṃna	36;10	95;45	?
51	Adārāvāda	36;50	19;35	Astarabad
52	Jarajāna	36;49	90;0	Jurzān
53	Varādāha	33;25	90;0	Baghdad
54	Kīramān	3[0];5	61;40	Kerman
55	Haramuj	25;40	92;0	Hurmuz
56	Ajamera	26;0	111;5	Ajmer
57	Savāī Jayapura	26;15,6	112;19	Jaipur
58	Halav	35;50	72;10	Halab=Aleppo

BACK

The rim of the upper half carries an altitude scale in 1° and 6° (6—90; 90—6). The upper left quadrant carries a sine-cosine grid with 30 horizontal and 30 vertical parallels. On the upper right is the solar quadrant, with seven concentric quarter circles. The seven zones so produced are named from Cancer to Capricorn upwards along the vertical axis (*Karka, Siṃha, Kanyā, Tulā, Vṛści[ka] Dhana !, Makara*) and from Capricorn to Cancer leftwards along the horizontal axis. Actually there should have been only six spaces and these should have been labelled along the vertical axis as *Karka, Siṃha, Kanyā, Tulā, Vṛścika, Dhanuḥ* (i.e. from summer solstice to winter solstice) and along the horizontal axis towards the centre as *Makara, Kumbha, Mīna, Meṣa, Vṛṣa, Mithuna* (i.e. from winter solstice to summer solstice).

In the lower half, there are shadow squares, on the left for a gnomon of 12 digits and on the right for a gnomon of 7 digits. The divisions are numbered on the left, but on the right only the last division is numbered as 7. There are no labels for the scales.

On the rim of the lower half, cotangent scales are drawn but not completely. On the left is a label *chāyā 12* (shadow 12), on the right *chāyā 7* (shadow 7).



Figure C022.4 – Back of the astrolabe (photo by S. R. Sarma)

In the space between the shadow squares and the rim is inscribed a table which is often engraved on the back of the Lahore astrolabes with the title *jadwal faḍl al-dawr* (table of the excess of revolution). It shows multiples of differences, in minutes and seconds, between the approximately correct length of the tropical year and 365 days.[767] Here it has the label *prativarṣe lagna-bhrama-sāraṇī* (table of the rotation of the ascendant in every year):

Table C022-3 Excess of Revolution

1	**2**	**3**	**4**	**5**	**6**
87;33	115;6	162;38	350;12	77;45	165;18
7	**8**	**9**	**10**	**20**	**30**
252;51	340;24	67;57	155;30	311;3	106;33
40	**50**	**60**	**70**	**80**	**90**
262;3	51;33	213;3	8;3	164;3	319;33

The alidade is slightly damaged; it has only one sighting plate with three apertures.

PROVENANCE

The same as that of no. 20. At the Jai Singh's Astronomical Observatory, aside from the wheel-shaped rete, the rete of another single plate astrolabe is wrongly attached to this astrolabe along with a small plaque with the inscription *yantrarāja do ṭo patra ek ko,* 'astrolabe with two plates in one [ensemble]'.

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767 Kaye 1918, p. 24; see the Table A062-3.



Figure C022.5 – In Jai Singh's Observatory at Jaipur, a second rete was wrongly attached to this astrolabe (photo by S. R. Sarma)

BIBLIOGRAPHY

Gunther 1932, I, no. 94, pp. 223-224, plate L.

C023 SANSKRIT ASTROLABE, NOT SIGNED, NOT DATED[768]

Late 18th or early 19th century, Uttar Pradesh (?)

Diameter 167 mm

PLU; ex-London, Sotheby's



Figure C023.1 – Front of the astrolabe (courtesy Sotheby's, London)

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768 Entry based on photos kindly provided by Sotheby's, London.

This is one of the few Sanskrit astrolabes which follow the style of the Lahore astrolabes in respect of its open work crown, floral traceries on the rete, curves for the meridian altitudes of the sun on the back and the ornate alidade. It is attractively made, and the geometrical lines are drawn quite accurately. But the engraving of the Devanagari legends and numerals is rather crude and not always complete. Particularly on the back, the letters in the two semi-circular scales in the lower half are incised with such force that the impressions can be seen on the inner side; likewise the geographical table incised on the inner side left impressions on the back.

The astrolabe bears no signature of the maker, nor the date of its manufacture. Jaipur is mentioned in the geographical gazetteer. Since this city was founded in 1728, the astrolabe must have been produced thereafter, either in the late eighteenth or in early nineteenth century. The gazetteer also contains the names of a large number of towns from the area constituting the modern federal state of Uttar Pradesh (Agra, Ajamgarh, Anup Shahar, Badaun, Gorakhpur, Jaunpur, Kannauj, Kanpur, Lucknow, Meerut, Varanasi). Several of these towns (Ajamgarh, Anup Shahar, Gorakpur, Kanpur) are not mentioned in any other astrolabe. It is therefore likely that the astrolabe was produced somewhere in Uttar Pradesh.

Components

Mater (d. 167, h. 197) with crown, shackle and ring, rete with 10 named stars, 3 plates, alidade, pin, wedge.

Front

The open work crown with its simple elegance is reminiscent of the crown in an astrolabe crafted by Ḍiyā' al-Dīn of the Lahore family in 1072/1663 A080). The crown, the back plate of the mater, and the circular limb are first made separately and then riveted together. The limb is divided in 1° and 6° and numbered in 6s from 6 to 360.

Rete

The rete is graceful with floral motifs and is almost symmetric. The circles of Capricorn and the ecliptic are held together by the equinoctial bar with two counter changes and by the floral tracery. The equator is not represented at all. The ecliptic circle is divided into the 12 zodiac signs and labelled with their names. The signs are not subdivided. The bevelled edge is divided very irregularly into units of 2°. The floral

tracery has many projecting tips to represent the star positions, but only ten in the upper half are named; the engraver failed to name the star pointers in the lower half. The named stars are as follows, in the order of increasing longitude from the vernal equinox:

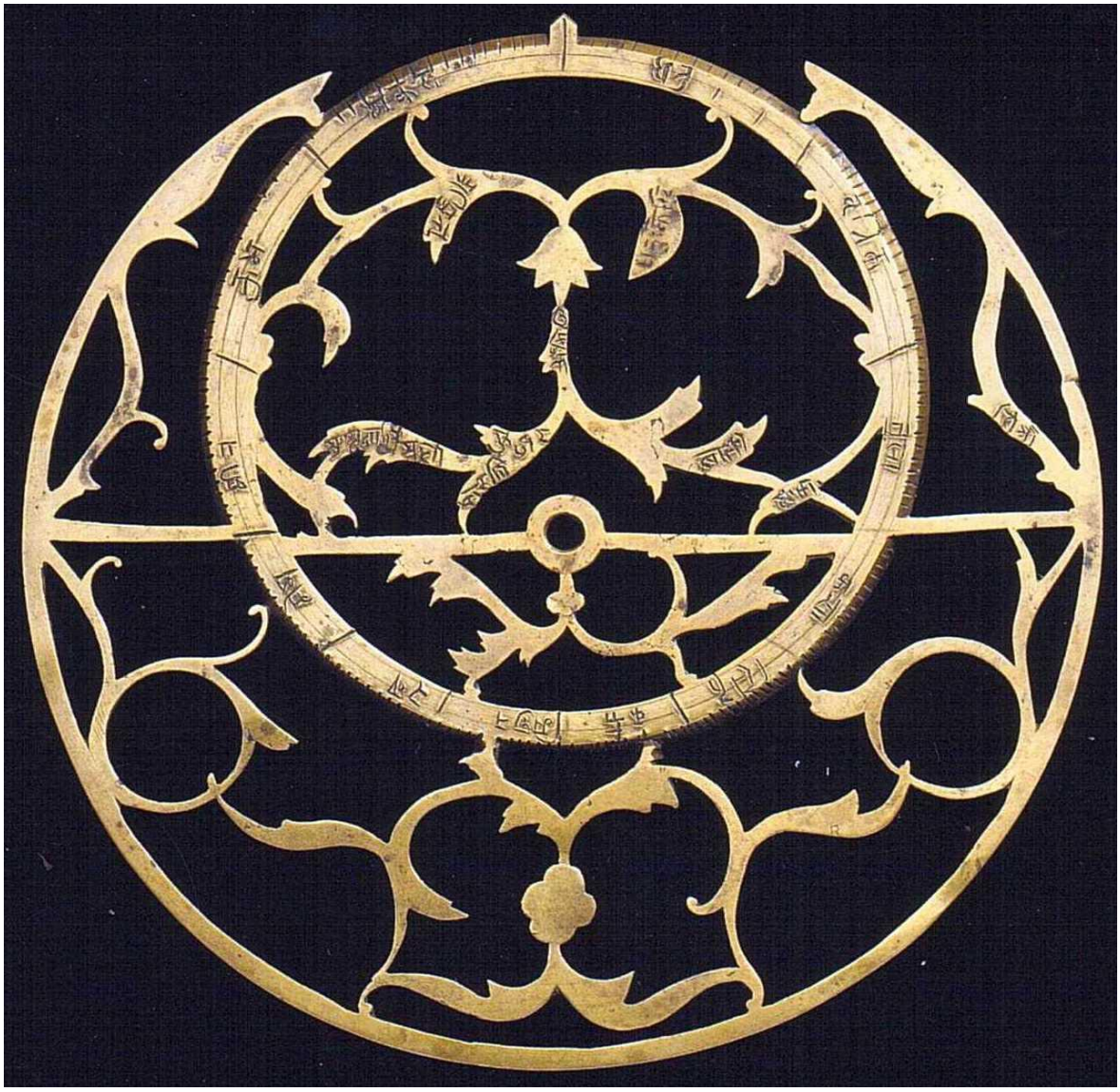


Figure C023.2 – Rete of the Astrolabe (courtesy Sotheby's, London)

Table C023-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Pū.phā.*	*Pūrva-phālgunī*	δ Leonis.
2	*Citrā*		α Virginis
3	*Svāti*		α Bootis
4	*Dhanuḥkoṭi*	*Dhanuṣkoṭi*	α Ophiuchi

	Star Name as engraved	Full/Correct Form	Identification
5	*Abhijit*		α Lyrae
6	*Śravaṇa*		α Aquilae
7	*Kukura*	*Kukkuṭapuccha*	α Cygni
8	*Aśvamukha*		ε Pegasi
	Two star names are undecipherable		



Figure C023.3 – Plate for the latitude of 29° (courtesy Sotheby's, London)

Plates

There are three plates serving the latitudes 24°—26°; 29°—32°; 34°—36°, the last one wrongly labelled as 25. Probably there were more plates originally. The plates have a small slit at the north point which fits into the tooth on the limb. At the centre of the plate the latitude for which the plate is calibrated is mentioned in numbers. In two cases (29, 34) the number is preceded by the term *akṣāṃśa,* 'degrees of latitude'.

The projections and labels are not done uniformly on all plates. Altitude circles are drawn for each 2° of argument, but on the plate for 34°, these are traced for every 1°. On some plates each fifth circle is highlighted with dots. Generally each alternate circle is numbered both on the left and right. Azimuth circles are drawn below the horizon for each 6° and labelled; on some plates each fifth of these is highlighted. Lines are drawn for seasonal hours and for equal hours counted from the western horizon. Sometimes the latter are distinguished by dotted lines. Just below the horizon is engraved *pūrva* 'east' in the east and *pa[ścima]* 'west' in the west.

Geographical Gazetteer

On the inner surface of the mater, a grid is drawn with concentric circles and radial lines, for a geographical gazetteer, but it is filled partially with place names and the corresponding latitudes. In the outer circle, the gazetteer does not start at the zero point, but under 284° where the first cell contains the argument: *deśa* (country or region) instead of *nagara* (town). In the second circle, however, the place names begin from the zero point and proceed clockwise. In both the rings, an attempt was made to arrange the places with increasing latitudes, but not consistently. Sometimes, a place name occupies two or even three cells. Total places mentioned are 58. Some of these names could not be deciphered because of the poor quality of engraving and also because of the impressions left by the engraving on the other side.



Figure C023.4 – Geographical Gazetteer (courtesy Sotheby's, London)

Table C023-2 Geographical Gazetteer

	Place name	φ	Modern name
1	Laṃkā	0	equator
2	Arama	0	?
3	Varavā	4;30	?
4	Tapakora	5	?
5	Rameśvara	7	Rameswaram
6	Sara[na]dīpa	10	Sri Lanka
7	Vījāpur	17	Bijapur
8	Sopatāgha	17	?
9	Bidar	19	Bidar
10	Ahmadanagara	19	Ahmednagar
11	Sarama	20	?
12	Aurangābāda	20	Aurangabad
13	Sūrata	21	Surat
14	Karaka	21	?
15	?	20	?
16	Tilara	31	?
17	Lahora	31	Lahore
18	Śrīnagara	31	Srinagar
19	Śyālakoṭa	33	Sialkot
20	Rāyagaḍha Kile	33	Qila Raigarh
21	Hābula	35	Kābul?
22	Kismīra	35	Kashmir
23	Mewat	29	Mewat
24	Vālesara	30	?

	Place name	φ	Modern name
25	?	32	?
26	Burahānapura	21	Burhanpur
27	Daulatābāda	21	Daulatabad
28	Ahamadābāda	23	Ahmedabad
29	Sironja	24	Sironj
30	Golakuṃḍa	18	Hyderabad
31	Badāū	28	Badaun
	Inner Circle		
32	Ajamara	26	Ajmer
33	Gvaliyar	26	Gwalior
34	?	26	?
36	?	26	?
37	Meraṭa	26	Meerut
38	Kānapura	26	Kanpur
39	Jaunapura	26	Jaunpur
40	Ājamagaḍha	26	Ajamgarh
41	Gorakhapura	27	Gorakhpur
42	Jaipura	27	Jaipur
43	Phatahapura Halaā	20 ?	Fatehpur ?
44	Kanauja	27	Kannauj
45	?	27	?
46	Mathura	27	Mathura
47	Anūpasahara	28	Anup Shahar
48	Lakhanaū	26	Lucknow

	Place name	φ	Modern name
49	Sūrajabura	28	?
50	Hāṃsī	30	Hansi
51	Mulatāna	30	Multan
52	Pānīpata	29	Panipat
53	Dvārakā	20	Dwaraka
54	Paṭanā	26	Patna
55	Āgarā	27	Agra
56	Gaṃgāsāgara?	--	Gangasagar
57	Dillī	29	Delhi
58	Kaśī	26	Varanasi



Figure C023.5 – Back of the astrolabe (courtesy Sotheby's, London)

Back

While the degree scale on the front is divided in 1° and 6° and numbered in 6s, the altitude scale on the rim on the upper half of the back is divided in 1° and 5° and numbered in 5s (5—90; 90—5). In the upper left there is a sine graph constituted by 60 equidistant horizontal parallel lines. The upper right is occupied by a solar quadrant with axial scales and quarter circles for each sign of the solar longitude. Upon these are drawn six unequal hour lines and three curves of solar meridian altitudes, which are not labelled but are certainly for the latitudes 27°, 29°, and 32°, on which lie respectively the three Mughal imperial cities of Agra, Delhi and Lahore.

In the lower half, there are two shadow squares and the circumferential scales for determining shadows to bases 12 (left) and 7 (right). These are not labelled. The divisions in the square of 7 are numbered, but not those in the other square. Within the squares, a grid was drawn for some astrological table, but it was not filled either.

Around the squares, there are two concentric semi-circular scales, the outer one of the 12 zodiacal signs and the inner one of the 28 corresponding lunar mansions. The names of the signs are occasionally abbreviated and are preceded by serial numbers. The names of the lunar mansions are also abbreviated, generally with the initial syllables.

The alidade has ornate terminals and an ornate middle as in the Lahore astrolabes; its upper surface is divided into two longitudinal sections; the edge of one half is divided into 12 units, the other half is plain. A pin and a wedge complete the ensemble.

Bibliography

Christie’s, London, auction catalogue of 1992, lot 117, p. 45.

Christie’s, London, auction catalogue of 30 March 1989, lot 251, pp. 58-59.

Sotheby’s, London, auction catalogue of 24 October 2007, lot 202, pp. 196-199.

C024 SANSKRIT ASTROLABE MADE BY VĪRABHA[DRA][769]

1805, Jodhpur

Diameter 141 mm

Washington DC, National Museum of American History

CCA 4000.



Figure C024.1 – Front of the astrolabe (© National Museum of American History, Washington, D.C.)

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769 This astrolabe was read by Professor David Pingree in September 1979; his notes were kindly made available to me by Dr Sharon Gibbs Thibodeau. This entry is based on Pingree's notes and Gibbs & Saliba 1984, pp. 181-184 and Figs. 121-123.

On the inner surface of the mater is engraved *karanyaṃ suyāramayā rāmaputra vīrabheṇa mukalāmītī māhā vada 5 saṃ 1861.* Pingree understood the last part as the date of manufacture *māgha kṛṣṇa 5 in Vikrama Saṃvat 1861* which corresponds to 20 January 1805. The first part of the inscription is problematic as the Sanskrit is mixed with old Gujarati and Persian. The third and fourth words (*rāmaputra-vīrabheṇa*) are in Sanskrit and mean 'by Rāma's son Vīrabha.' It is possible that the astrolabe was made by a certain Vīrabha son of Rāma and that Vīrabha is miswriting or shortening for Vīrabhadra.

On the front of the crown is an inscription in Persian script which reads *satardār miyān rām shāsan qaṣbā jod[h]pūr 1235,* which translates roughly to 'Mr Ram, the store keeper, Government of the City of Jodhpur'.[770] The Hijrī year 1235 corresponds to AD 1819-20. Therefore this inscription cannot refer to the original owner for whom the astrolabe was made in 1805. It is possible that the astrolabe changed hands in 1819-20 and the new owner caused this inscription engraved in Persian script. But it is still likely that the astrolabe was made at Jodhpur which was also a centre for the manufacture of astrolabes.[771]

Below the Persian inscription, there are some Devanagari writings. On the left is inscribed *12 chaṃ* above and below that *sa 7 bhā 12 se 5 chaṃ 7*; on the right *7 chaṃ* above and below that *bā 12 bhā 7 se 8 ½* . These appear to refer to the shadow squares at the back, but the exact meaning eludes us.

COMPONENTS

Mater (d. 141) with crown, shackle and ring, rete for 15 stars, 8 plates, alidade with a sighting tube, pin and wedge.

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770 In Gibbs & Saliba 1984, pp. 181-184, the information about the two inscriptions got mixed up; this catalogue states that this inscription is 'in Sanskrit: "The headman Sri Rama, government of the town of Jodhpur, 1235 [1819]."' In a personal communication dated 3 February 1993, Dr Sharon Gibbs Thibodeau admitted the mix-up in the catalogue and sent me a copy of Pingree's original notes. His interpretation of the second expression was tentative; my friend S. M. Razaullah Ansari advises me that the term *satardār* at the beginning of the inscription would mean 'storekeeper'.

771 The astrolabe of 1625 (C003), that of 1809 (C025) and the two astrolabes of 1810 by Māyārāma (C026 and C027) were produced at Jodhpur. There survive also two single plate astrolabes manufactured in Jodhpur (D049 and D050), and these two have the same type of high crown as the present one.

FRONT

The crown is unusually high with a very wide base and large scallops in profile; the small ring has a circular cross-section and the shackle a diamond-shaped cross-section; the limb is divided in 1° and 6° and numbered serially from 1 to 60.

RETE

The rete follows the characteristic 'bird in the cage' pattern.[772] The ecliptic circle is divided into the 12 signs of zodiac and labelled with the initial syllables of their names. Each sign is divided into units of 6° which are numbered and further subdivided into divisions of 2°. There are 15 named star pointers.

Table C024-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudra*	*Samudrapakṣī*	β Ceti
2	*Masī*	*Manuṣyaṣīrṣa*	β Persei
3	*Rohiṇī*		α Tauri
4	*Ārdrā*		α Orionis
5	*Lubdhaka*		α Canis Majoris
6	*Maghā*		α Leonis
7	*U. lgunī*	*Uttara-phālgunī*	β Leonis
8	*Hasta*		δ Corvi
9	*Citrā*		α Virginis
10	*Viśā*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
11	*Dhanuko*	*Dhanuḥkoṭi*	α Ophiuchi
12	*Ābhī*	*Abhijit*	α Lyrae

772 Cf. Sarma 2011a.

	Star Name as engraved	Full/Correct Form	Identification
13	*Śrava*	*Śravaṇa*	α Aquilae
14	*Śata[bhiṣā]*	*Kukkuṭa-puccha*	α Cygni[773]
15	*Pūrba*	*Pūrva-bhādrapada*	β Pegasi

PLATES

There are 8 plates, each notched at 90°. Plate 1a carries multiple horizons for every degree of latitude from 10° to 67°. Plate 2a contains projections for four different latitudes, one in each quadrant. According to the inscription, 6a seems to carry a double projection for Agra at 27° and Māgava (Mecca ?) at 22°. The remaining plates contain altitude circles for every 6°, azimuth arcs at various intervals, lines for unequal hours and for equal hours counted from the western horizon. The inscriptions engraved at the centre mention, in not very correct Sanskrit, the name of a town, its latitude (*akṣe*!, or *akṣe aṃśa*!), the midday equinoctial shadow (indicated by *chaṃ* for *chāyā*), and in some cases the duration of the longest day in *ghaṭīs* and *palas*.

1a *sarbadesāpatra* [! *sarvadeśī-patra*] (universal plate, i.e. plate of horizons)

1b *akṣe 26 ajamera chaṃ 5/55* (Ajmer, latitude 26°, shadow 5;55)

2a upper left quadrant: *akṣe 48 chaṃ 13/50* (latitude 48°, shadow 13;50)
upper right quadrant: *akṣa 60 chaṃ 20/3* (latitude 60°, shadow 20;3)
lower left quadrant: *ak 42 chaṃ 11/10* (latitude 42°, shadow 11;10)
lower right quadrant: *akṣe 52 chaṃ 15/50* (latitude 52°, shadow 15;50)

2b *Kurukṣetra [30°] chaṃ 6/55* (Kurukṣetra [30°], shadow 6;55)

3a *Tīlaṃge akṣe aṃśa 18 [chaṃ] 3/55 paramadina 32* (Tilanga latitude 18°, [shadow] 3;55, longest day 32)

3b *Devagiri akṣe 20 chaṃ 4/20* (Daulatabad, latitude 20°, shadow 4;20)

4a *akṣe aṃśa 19 amhadāvā[da] chaṃ 4/18* (latitude 19°, Ahmedabad, shadow 4;18)

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[773] The names *Śatabhiṣā* (λ Aquarii) and *Kukkuṭa-puccha* (α Cygni) are wrongly interchanged here; also in C002, C004 and D071; cf. Sarma 2011a, p. 101.

4b *akṣe aṃśa 29 dīlī chaṃ 6/40 paramadī 34/34* (latitude 29°, Delhi, shadow 6;40, longest day 34;34)

5a *akṣasā 21 vārānapura chaṃ 4/30* (latitude 21°, Burhanpur, shadow 4;30)

5b *akṣa 2[6] gvālera chaṃ 5/35* (latitude 26°, Gwalior, shadow 5;35)

6a *āgaro akṣa 27 māgava akṣa 22*
chaṃ 6/6, chaṃ 4/4 (Agra, latitude 27°, shadow 6;6. Māgava, lat. 22°, shadow 4;4)

6b *āgaro akṣa 27 chaṃ 6/6* (Agra, latitude 27°, shadow 6;6)

7a *depālapura [read! Nepālapura] akṣe 31 chaṃ 6/20* (Kathmandu, latitude 31°, shadow 6;20)

7b *Yamaskandha akṣa 40 chaṃ 11/23* (Samarqand, latitude 40°, shadow 11;23)

8a *lāhora akṣe 32 chaṃ 7/31* (Lahore, latitude 32°, shadow 7;31)

8b *Kaśamera akṣa 35 chaṃ 8/3* (Kashmir, latitude 35°, shadow 8;3)

This data is rearranged in the following table.

Table C024-2 Plates

	Place Name	φ	Equinoctial Shadow	Longest Day	Modern Name
1	Ajmer	26°	5;55		Ajmer
2	Kurukshetra	30°	6;55		Kurukshetra
3	Tilanga	18°	3;55	32	Hyderabad
4	Devagiri	20°	4;20		Daulatabad
5	Amhadāvā[da]	19°!	4;18		Ahmedabad
6	Dilī	29°	6;40	34;34	Delhi
7	Vārānapura	21°	4;30		Burhanpur
8	Gvālera	2[6]°	5;35		Gwalior
9	Āgaro	27°	6:6		Agra
10	Depālapura	31°	6;20		Nepālapura=Kathmandu
11	Yamaskandha	40°	11;23		Samarqand
12	Lahora	32°	7;31		Lahore

13	Kaśamera	35°	8;3	Srinagar
14	Māgava	22°	4;4	Mecca ?
15	?	42°	11;30	
16	?	48°	13;50	
17	?	52°	15;50	
18	?	60°	20;3	

BACK

On the back, the rim of the upper half carries the altitude scales, divided in 1° and 6° and numbered in 6s (6—90; 90—6). The upper left quadrant contains a sine-cosine grid with 30 vertical and 30 horizontal parallels, upon which are drawn the circle of the obliquity of the ecliptic and two semicircles along the two radii. The upper right quadrant has equally spaced declination arcs, one for each 10° of solar longitude, on which are superimposed unequal hours and two prayer lines; along the radii are engraved the names of the corresponding signs and their degrees. In the lower half there are shadow squares, on the left for a gnomon of 7 digits and on the right for the gnomon of 12 digits. The scales are not labelled, nor are the divisions on these scales numbered.

Outside these squares are six semicircular tables with the label *krāṃtī* (read *krānti,* declination). In the first scale can be seen the argument: solar longitude in degrees 1° to 45°, written from the left to the right; in the second scale are the corresponding declinations. The next two scales must contain the remaining table from 46° to 90°, but it is difficult to decipher the digits. Likewise it is difficult to identify the table in the last two scales, so also the tables engraved on the edge of the mater.

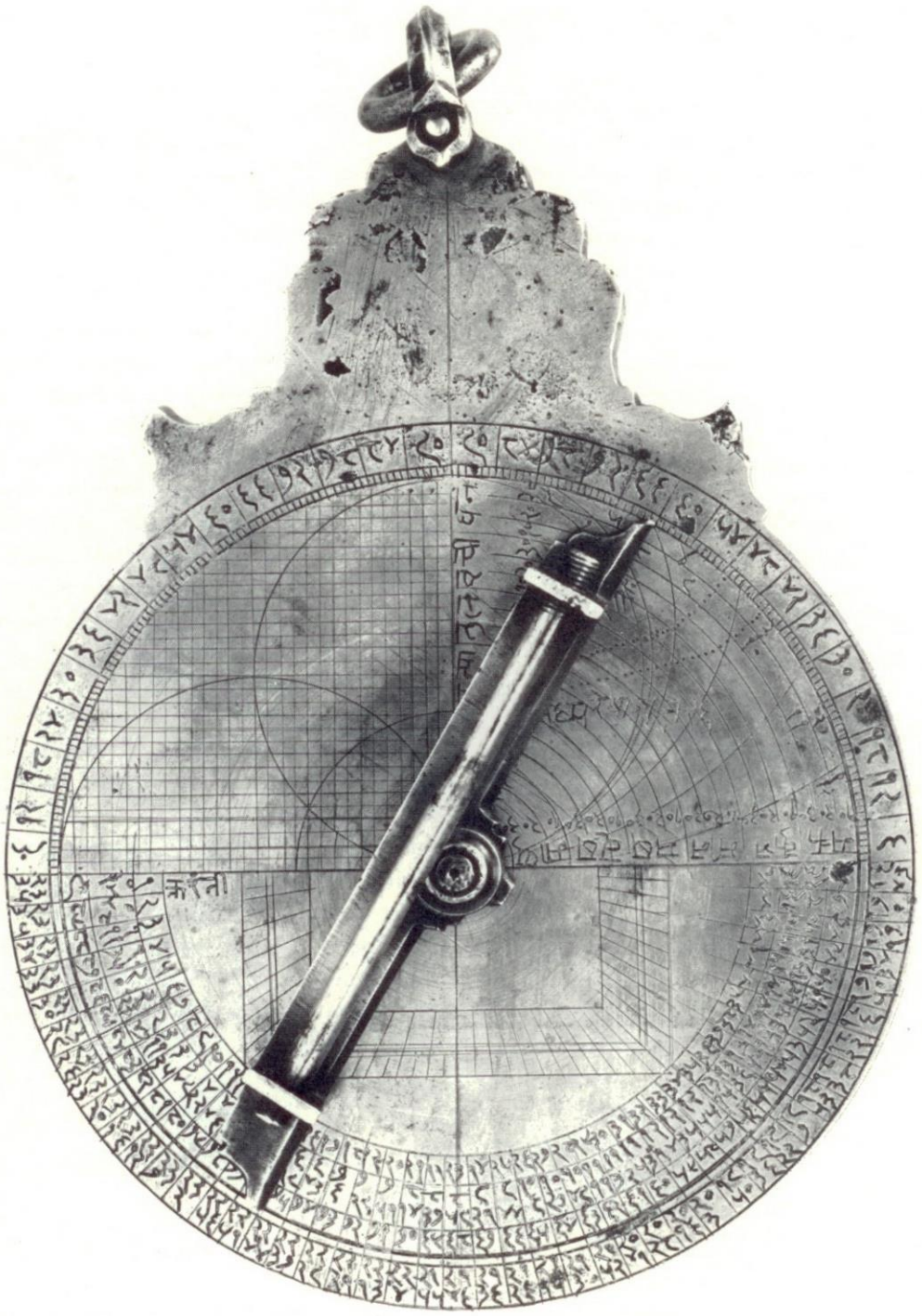


Figure C024.2 – Back of the astrolabe (© National Museum of American History, Washington, D.C.)

ALIDADE

The alidade is equipped with a sighting tube.

BIBLIOGRAPHY

Gibbs & Saliba 1984, pp. 181-184 and Figs. 121-123.

C025 SANSKRIT ASTROLABE ATTRIBUTABLE TO VĪRABHADRA[774]

1809, Jodhpur, Rajasthan

Diameter 153 mm

PLU, Ex-Rockford, Time Museum

CCA 2712

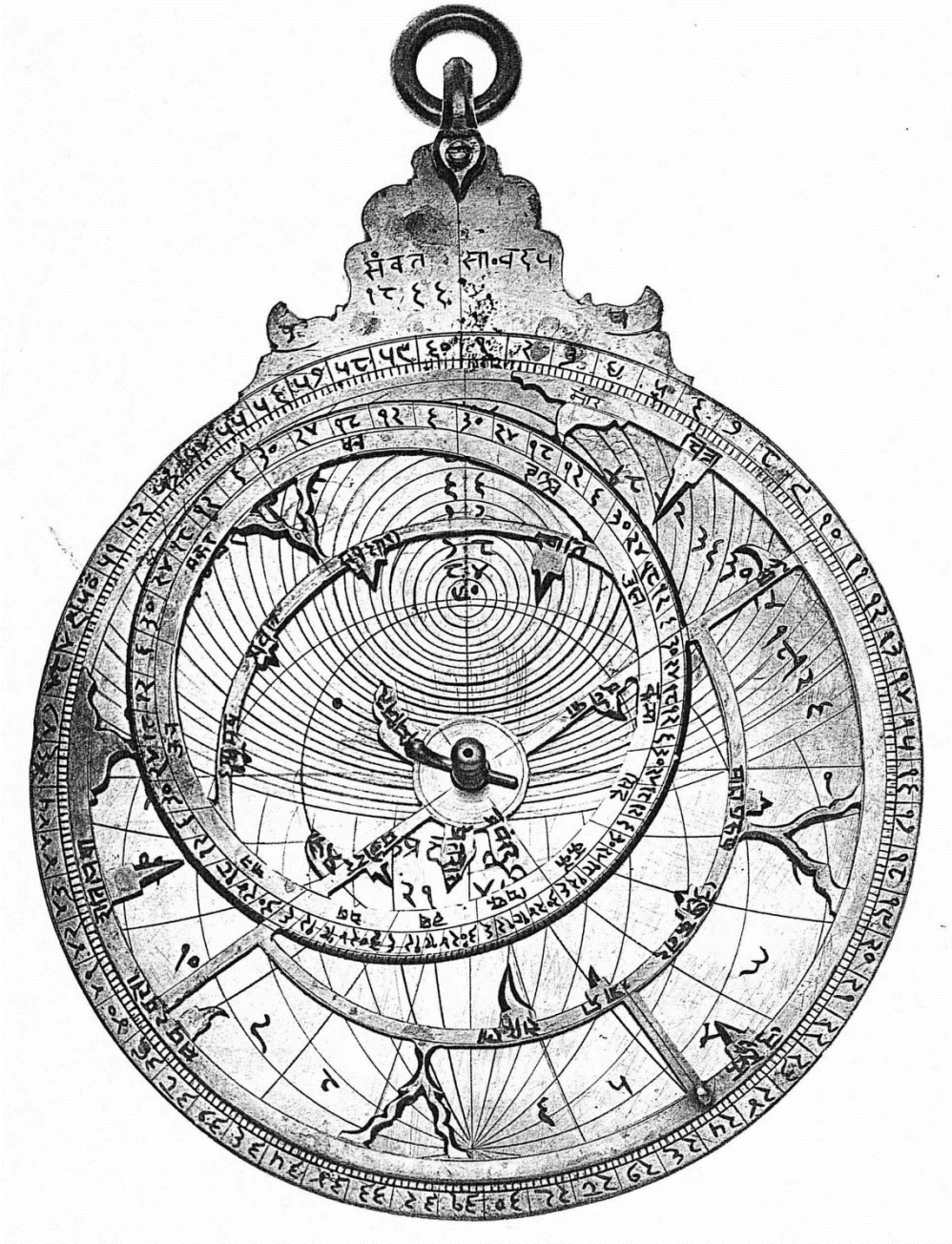


Figure C025.1 – Front of the astrolabe (from Turner 1985)

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774 The entry is based on the description and photos in Turner 1985, no. 13, pp. 114-117; Christie's, auction catalogue of 14 April 1988, lot 161, pp. 106-107.

There are several similarities between this astrolabe and the previous astrolabe (C024) made by Vīrabha[dra] four years earlier in 1805: the strikingly high crown with deep scallops, the script and the numerals, the alidade with the sighting tube, the table on the rim of the lower half at the back, and the quadruple projection on one plate. But the retes are quite different. It is nevertheless possible that the same Vīrabha[dra], the son of Rāma, may have fabricated these two astrolabes.

Components

Mater (d. 153) with crown, shackle and ring, rete for 19 stars, 5 plates, alidade with a sighting tube, pin and wedge.

Front

A rather high suspension bracket with lobes and very deeply cut scallops, otherwise with plain surfaces. On the front is engraved *Saṃvat sā. va da 5,* ‘the 5th day of the dark half of the month Śrāvaṇa in the Saṃvat year 1866’. The date corresponds to 30 August 1809. The limb is graduated in 1° and 6° and numbered from 1 to 60.

Rete

The rete consists of a narrow ring of the Tropic of Capricorn, a narrow ring of the complete celestial equator and a broad ring of the ecliptic, the three held together by the equinoctial bar without counter changes. In the upper half the equatorial ring and the ecliptic ring are joined together by a V-shaped strut, in the lower half the equatorial ring and Capricorn ring are held together by two reverse V-shaped struts and a part of the solstitial bar. The ecliptic is divided into 12 zodiac signs and labelled with their names; each sign is subdivided into groups of 6° and numbered. There are 19 named dagger-shaped star pointers.

Table C025-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Matsyodara*		β Andromedae
3	*Pretaśara*		β Persei

	Star Name as engraved	Full/Correct Form	Identification
4	*Rohiṇī*		α Tauri
5	*Bramaṃrada*	*Brahma-hṛdaya*	α Aurigae
6	*Ārdrā*		α Orionis
7	*Lubdhaka*		α Canis Majoris
8	*Lubdhakavada*	*Lubdhaka-bandhu*	α Canis Minoris
9	*Mahāpuruṣa*		α Hydrae
10	*pūrvaphā*	*Pūrva-phālgunī*	δ Leonis
11	*Hasta*		δ Corvi
12	*Citrā*		α Virginis
13	*Svāti*		α Bootis
14	*Māṃra*[775]	*Jyeṣṭhā*	α Scorpii
15	*Sarpadhārī*	*Sarpadhārī-śira*	α Ophiuchi
16	*Abhijit*		α Lyrae
17	*Śravaṇa*		α Aquilae
18	*Aśvamuṣa*	*Aśvamukha*	ε Pegasi
19	*Śatabhiṣā*		λ Aquarii
20	*Pūbhā*	*pūrva-bhādrapadā*	β Pegasi

PLATES

There are five plates, serving different latitudes, ecliptic coordinates, and multiple horizons, with altitude circles drawn for 3° and labelled in 6s, azimuth arcs for 15° below the horizon (except on 3a and 5a where they are drawn both above and below and

[775] Engraved faintly by a later hand ?

numbered) but not numbered, and unequal hour lines, numbered from 1 to 12 from the western horizon. Each plate face is inscribed with the latitude and the length of the noon equinoctial shadow, as shown below.

1a *akṣā[ṃśa] 21 chā[yā] 4/37* (latitude 21°, shadow 4;37)

1b quadruple projection for latitudes 0°, 18°, 42° and 48°

2a *akṣa 24 chā 5/10* (latitude 24°, shadow 5;10)

2b *akṣāṃśa 30 chā 6/55* (latitude 30°, shadow 6;55)

3a *akṣa* 26 *chāyā 5/56* (latitude 26°, shadow 5;56)

3b *akṣa* 66 *chā 27* (latitude 66°, shadow 27)

4a *akṣāṃśā 28 chāyā 6/20* (latitude 28°, shadow 6;20)

4b *akṣāṃśā 36 chā 8/48* (latitude 36°, shadow 8;48)

5a *[a]kṣāṃśā 27 chāyā 6;16* (latitude 27°, shadow 6;16)

5b Multiple horizons

Strangely, on 2a, 2b, 3a, 3b, 5a, 5b, four concentric circles are drawn with the centre of the plate as the centre, that is to say, two more in addition to the Tropic of Cancer and the Celestial Equator, one between the two and one outside the equator!

Plate of Horizons: There are four sets of horizons, 7 in each quadrant, labelled twice along the vertical/horizontal radius and the arc of the quadrant for the following latitudes:

14	24	34	44	54	64	74
15	25	35	45	55	65	75
16	26	36	46	56	66	76
17	27	37	47	57	67	77

There are no scales of declination and there is no legend.

On the inner surface of the mater are drawn concentric circles and radial lines, for a geographical gazetteer, but the cells are not filled in.

BACK

The upper half of the rim carries altitude scales divided in 1° and 6° and numbered 6—90; 90—6. On the rim of the lower half is an unidentifiable table in three semicircles. The upper left quadrant is blank. The upper right quadrant has a sine-cosine graph with 30 horizontal and 30 vertical parallels. The vertical parallels are numbered twice in two separate rows.

In the lower half are shadow squares, on the left with 7 divisions, numbered and halved, on the right 12 divisions, also numbered and halved. The four scales carry the following legends. Above the horizontal scale with 7 divisions is written *chāyā 7* (shadow 7) and below *kramachāṃyā* (sic! °*chāyā*) (umbra recta). Above the horizontal scale with 12 divisions is written *chāyā 12* (shadow 12) and below *kramachāṃyā* (sic! *chāyā*) (umbra recta). Parallel to the vertical scale with 7 divisions is written outside *utapāchāṃyā* and parallel to the vertical scale with 7 divisions is written outside *utapāchāṃyā.* The words have no meaning and are corruptions for *utkrama-chāyā* (umbra versa). It is strange that *chāyā* is often engraved as *chāṃyā* with a nasalization. This explains why in the astrolabe at Washington (C024), *chāyā* is abbreviated as *chāṃ.*

BIBLIOGRAPHY

Turner 1985, no. 13, pp. 114-117.

Christie's, London, auction catalogue of 14 April 1988, lot 161, pp. 106-107.

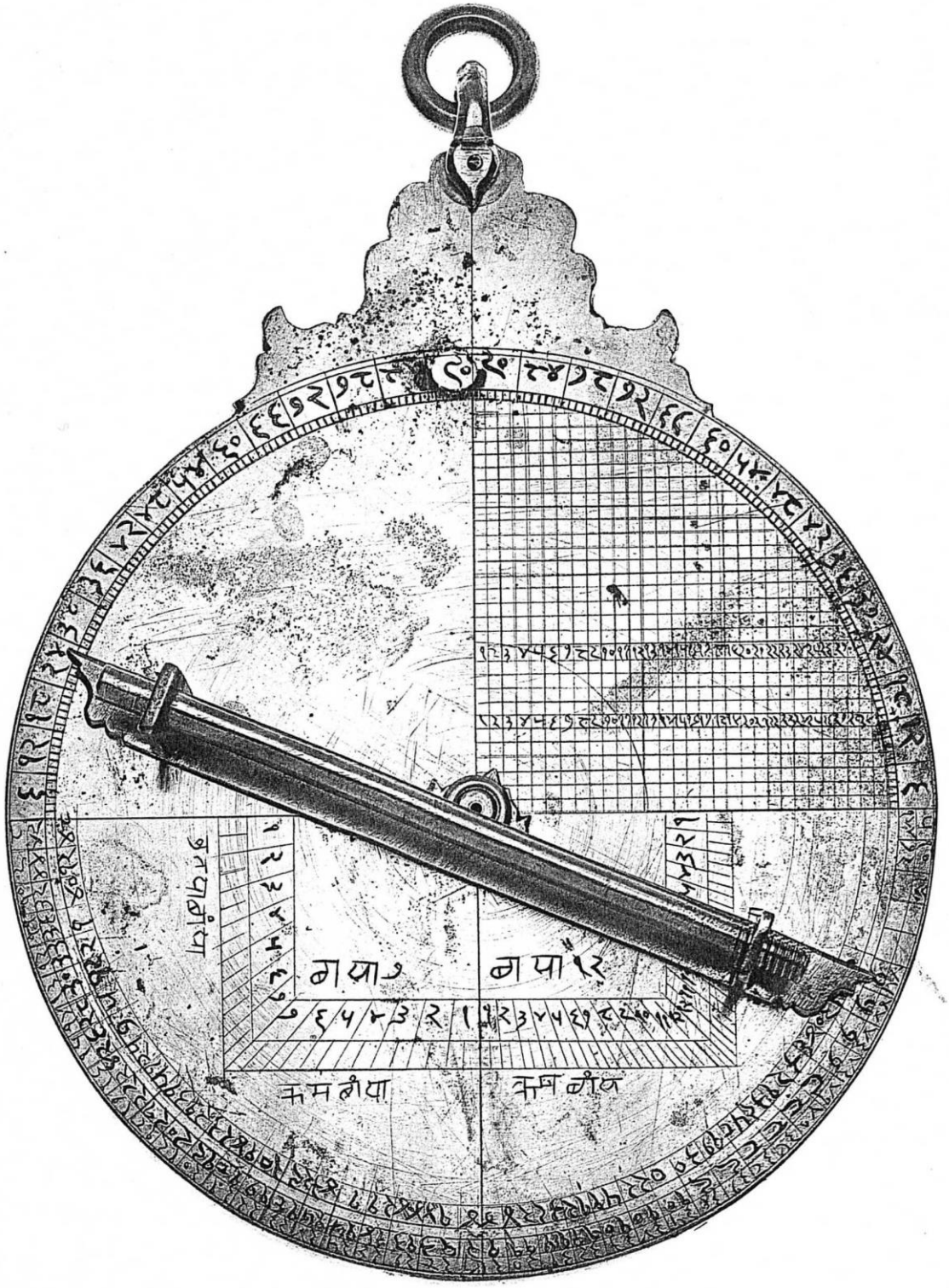


Figure C025.2 – Back of the astrolabe (from Turner 1985)

C026 SANSKRIT ASTROLABE BY SŪTRADHĀRA MĀYĀRĀMA[776]

1810, Jodhpur, Rajasthan

Diameter ca 180 mm

PLU; ex-Paris, Alain Brieux

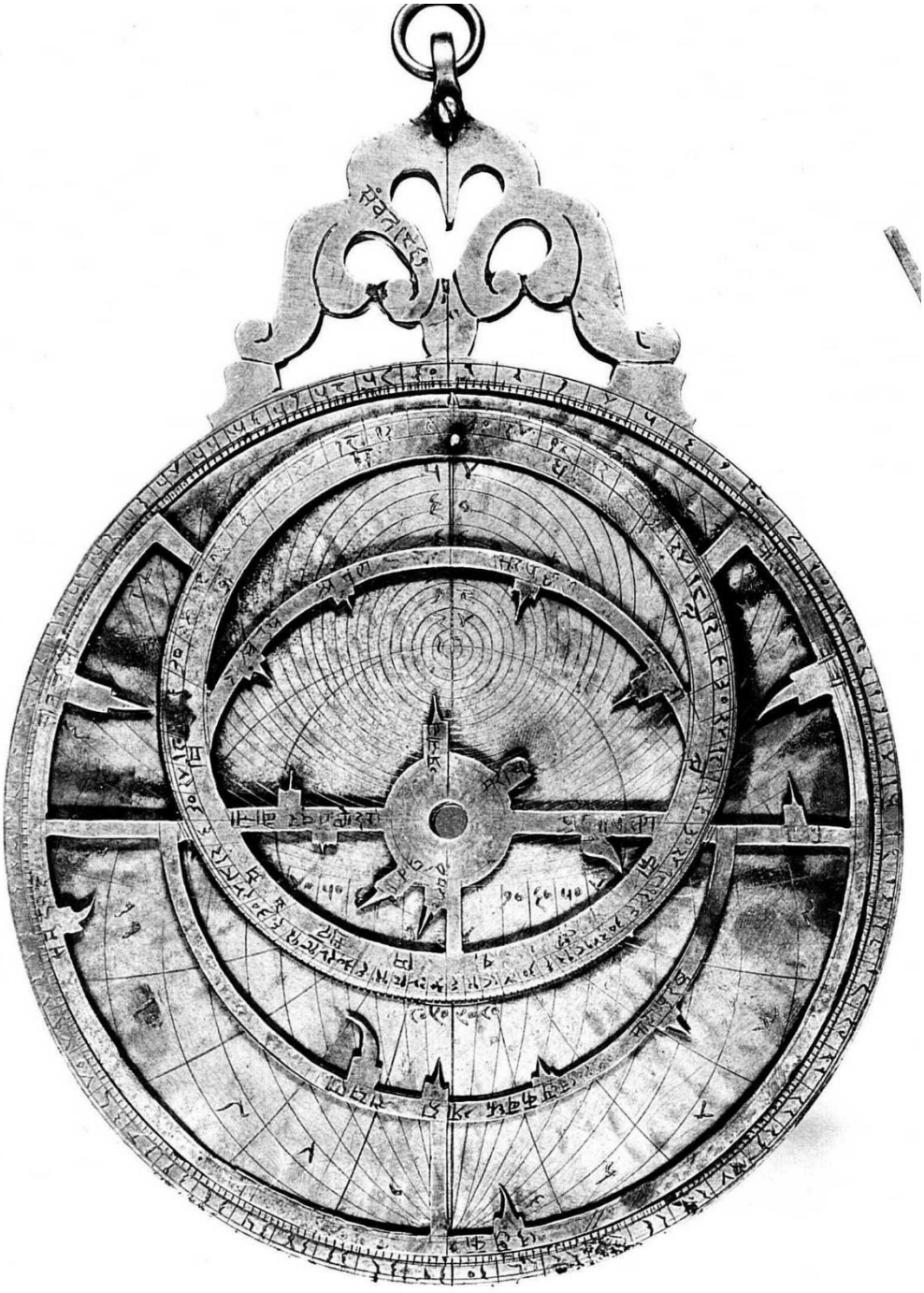


Figure C026.1 – Front of the astrolabe (photo by Alain Brieux)

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[776] Entry based on photos made by Alain Brieux, kindly made available to me by Anthony J. Turner.

On the crown is engraved *Saṃvat* 1867. On the inner recess of the mater, a little above the north point is an inscription in two lines, in Sanskrit and local vernacular, which is difficult to decipher in the available photograph.

saṃvata 1867 ro kīyo chai jodapura madhyai
sutradhāra mayārāṃma karīyata kā tī ha(?) 21

The purport is that an artisan (the word should read *sūtradhāra* and not *sutradhāra*) named *Māyārāma* (not *mayārāṃma* as wrongly engraved) made this astrolabe in *Saṃvat* 1869 (= AD 1810-1811) at Jodhpur (also wrongly spelt as *Jodapura*).

COMPONENTS

Mater (d. ca. 180) with crown, shackle and ring, rete for 20 stars, plates, alidade with a sighting tube, pin and wedge.

FRONT

A high crown cut *à jour*, with a large heart-shaped hole at the top and two symmetrical holes in the left and right. The limb is divided in 1° and 6°; the latter are numbered serially from 1 to 60.

RETE

The rete consists of the three rings of Capricorn, celestial equator and ecliptic. The equatorial ring is complete and the ecliptic ring is much broader than the other two. These three are held together by the equinoctial bar with two counter changes at the equinoxes and partly by the solstitial bar. At the head of Capricorn, a small triangular piece represents the Capricorn index. Just below it, on the ecliptic bar, is a turning knob. The ecliptic is divided into 12 signs and labelled with the initial syllables of their names. Each sign is subdivided into groups of 6° and numbered. There are 20 star pointers which are shaped like daggers or tiger's claws.

Table C026-1 Stars on the Rete

	Star name as engraved	Full/Correct Form	Identification
1	*Samudrapa*	*Samudra-pakṣī*	β Ceti
2	*Matsyodara*		β Andromedae

	Star name as engraved	Full/Correct Form	Identification
3	*Preta*	*Pretaśira*	β Persei
4	*Rohiṇī*		α Tauri
5		[*Brahmahṛdaya*]	α Aurigae
6	*Ārdrā*		α Orionis
7	*Luvdhaka*	*Lubdhaka*	α Canis Majoris
8	*Luvdhakabadhu*	*Lubdhaka-bandhu*	α Canis Minoris
9	*Mahāpuraṣa*	*Mahāpuruṣa*	α Hydrae
10	*Pūrvaphā*	*Pūrva-phālgunī*	δ Leonis
11	*Hasta*		δ Corvi
12	*Citrā*		α Virginis
13	*Marīci*		η Ursae Majoris
14	*Svāti*		α Bootis
15	*Sarapa*	*Sarpagrīvā*	α Serpentis
16	*Abhīca*	*Abhijit*	α Lyrae
17	*Śravaṇa*		α Aquilae
18	*Aśvamuṣa*	*Aśvamukha*	ε Pegasi
19	*Satabhiṣā*	*Śatabhiṣā*	λ Aquarii
20	*Pūrabā bhā*	*Pūrva-bhādrapadā*	β Pegasi

PLATES

It is not known how many plates there are. On the plate which is visible below the rete in the photo, almucantars are drawn for 3° each, but not numbered, azimuths are drawn below the horizon for 10° and numbered, unequal hour lines are drawn which are numbered from the western horizon. The plate is probably calibrated for the latitude of 21°.

Geographical Gazetteer

On the inner recess of the mater, an attempt was made to draw the projections for the latitude of 66°. After drawing east-west and north-south lines, and a whole series of altitude circles at intervals of 6°, the artisan may have realized that the projections for the latitude of 66° were to be traced on a separate plate and not here. Just above the north point, the inscription mentioned above is engraved.

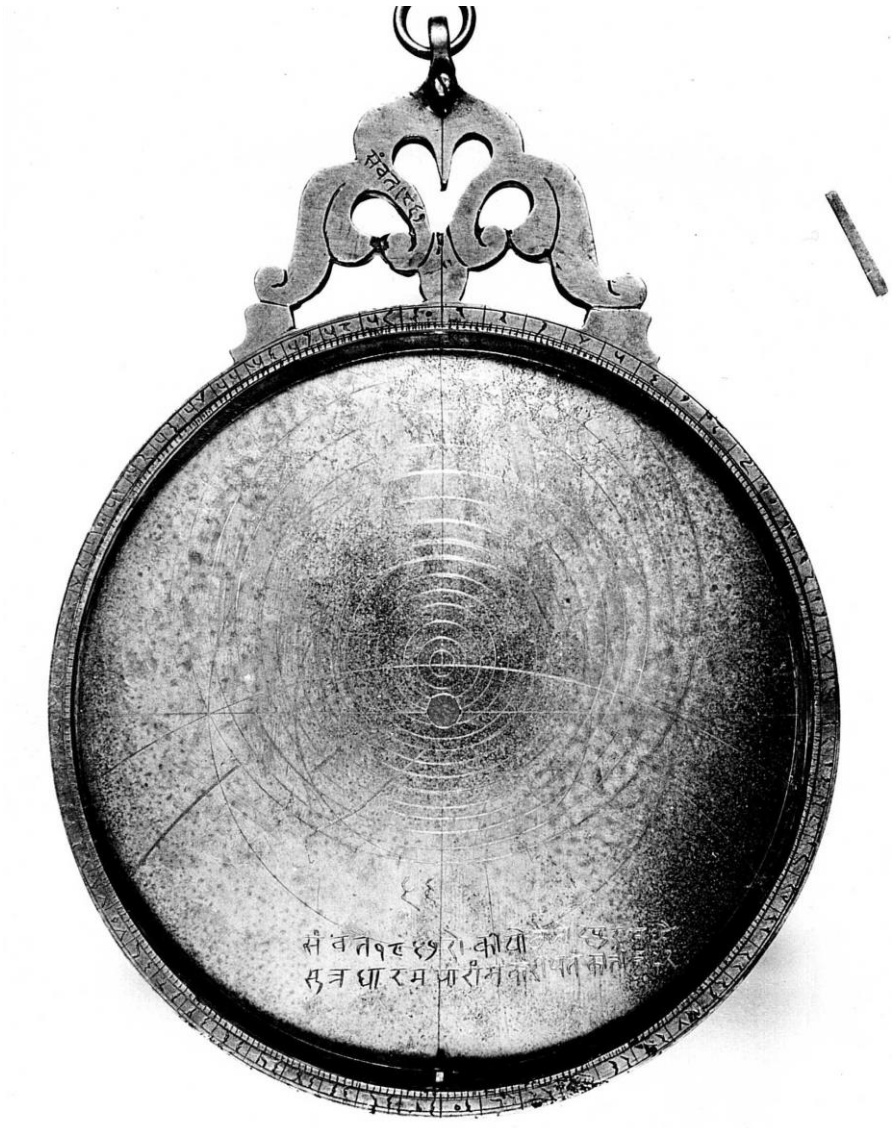


Figure C026.2 – Inner side of the mater (photo by Alain Brieux)

Back

The rim of the upper half carries the altitude scale in 1° and 6° and numbered in 6s. In the upper left quadrant, the two quarter circles are drawn below the altitude scale and resulting spaces are divided in about 15 cells. These cells are filled with syllables which are difficult to decipher. In the upper right quadrant is a sine-cosine graph with

30 horizontal and 30 vertical parallels. In the lower half are two very crudely drawn shadow squares: on the left for 12 and on the right for 7. Inside the squares is written *chāyā 12* (shadow 12) on the left, and *chāyā 7* (shadow 7) on the right. The rim of the lower half is blank.

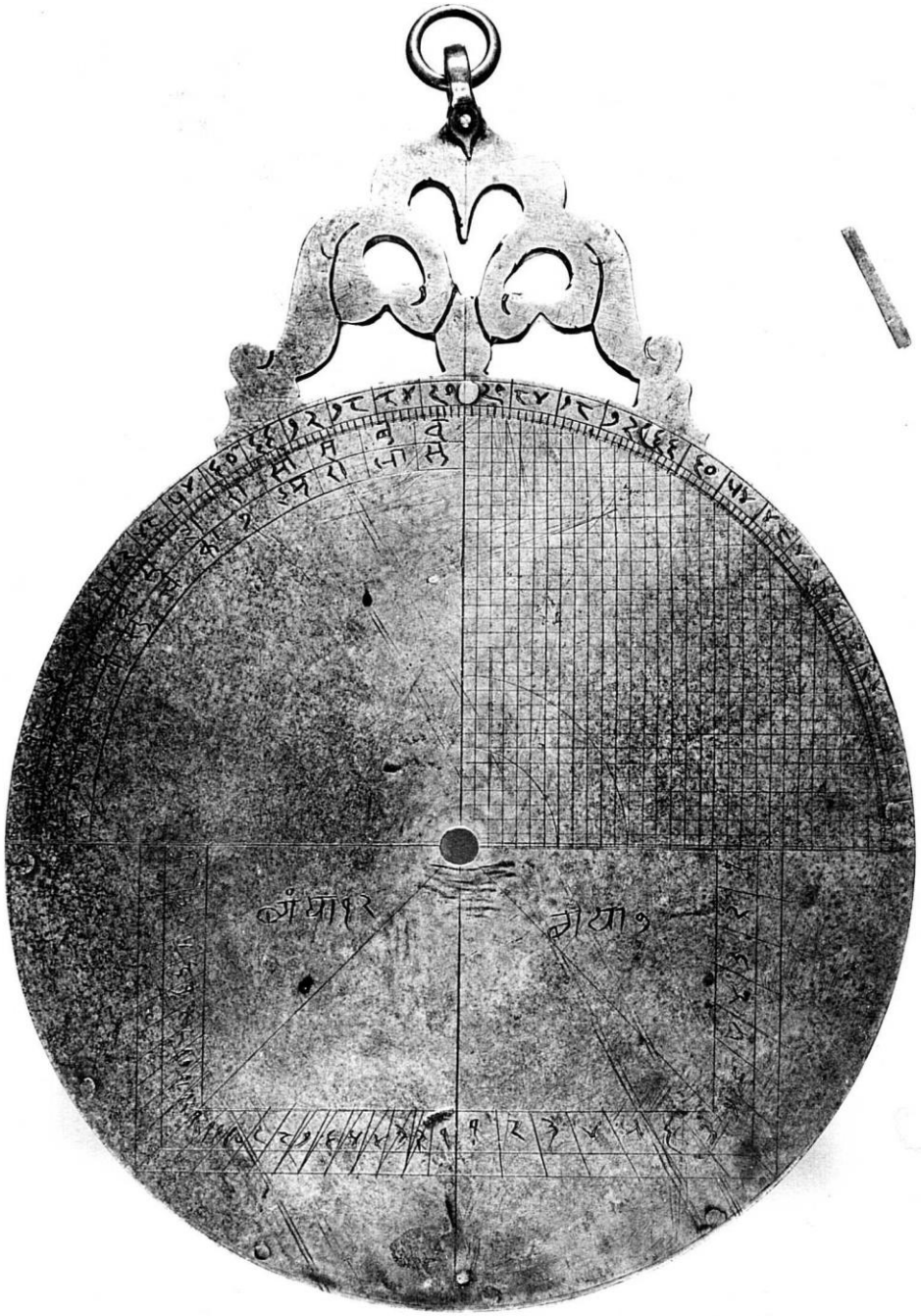


Figure C026.3 – Back of the astrolabe (photo by Alain Brieux)

ALIDADE

The straight bar alidade is equipped with a sighting tube which is much longer than the diameter of the astrolabe. One end looks like a screw with spiral grooves; this part is now slightly bent. There is a pin; the wedge is just a long flat piece of metal.

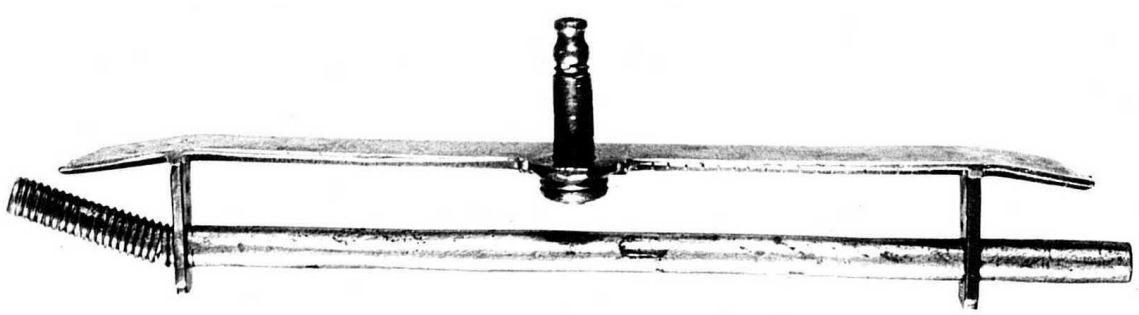


Figure C026.4 – Alidade with a sighting tube (photo by Alain Brieux)

PROVENANCE

The astrolabe was in the collection of Alain Brieux, Paris, at one time and was photographed by him.

C027 SANSKRIT ASTROLABE BY SŪTRADHĀRA MĀYĀRĀMA[777]

1810, Jodhpur, Rajasthan

Diameter 179 mm

PLU; ex-Paris, Alain Brieux

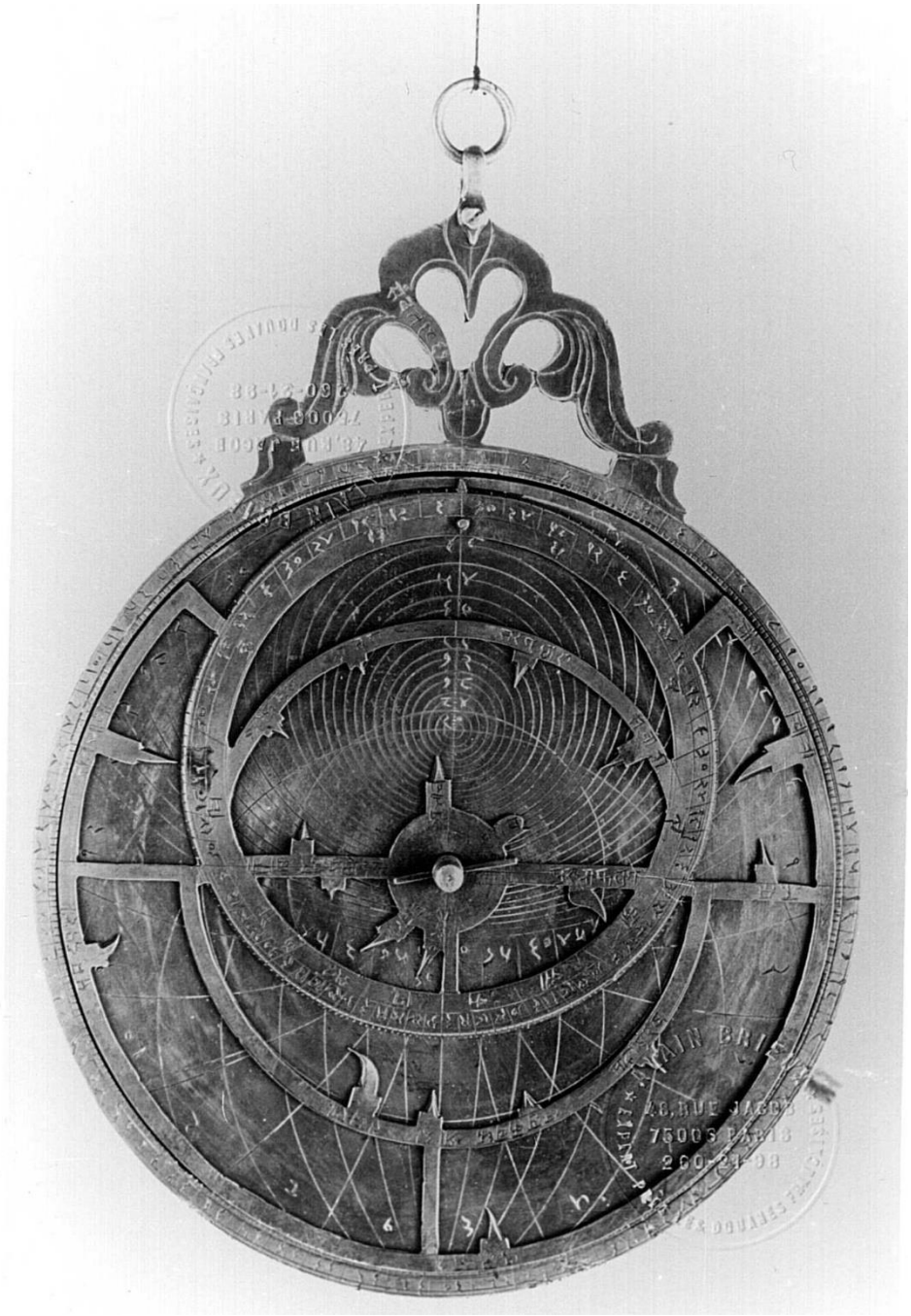


Figure C027.1 – Front of the astrolabe (photo by Alain Brieux)

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[777] Entry based on photos made by Alain Brieux, kindly made available to me by Anthony J. Turner.

In the available photos, the front and back of this astrolabe look exactly the same as the previous specimen C026, including the irregularities in spelling. The only difference is that the artisan drew decorative lines on the front and the back of the crown of this astrolabe. Therefore the crown here looks quite elegant. On the crown is written the year of manufacture as *Saṃvat 1867* as in the previous one. No photo is available of the inner side of the mater; therefore it is not known whether any inscription is engraved there. But it is certain that Māyārāma prepared two almost exactly alike astrolabes in 1810.

With the photo is a note by Alain Brieux stating that the diameter is 179 mm and that there are two plates.

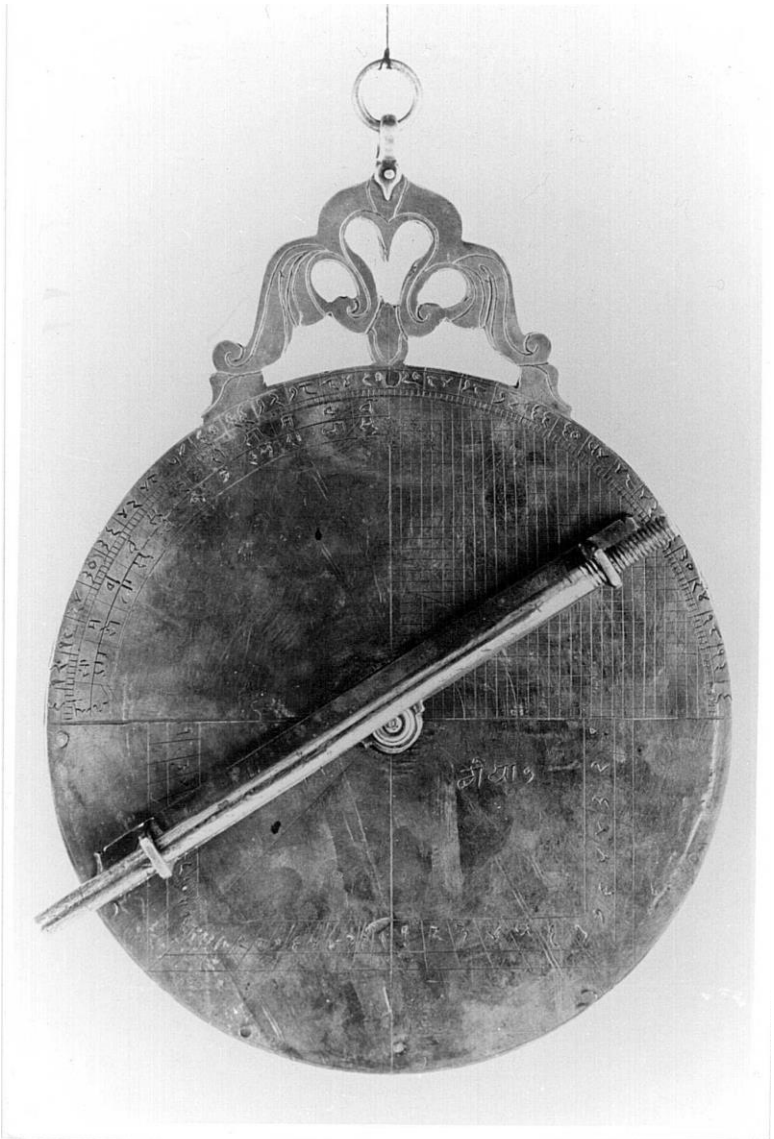


Figure C027.2 – Back of the astrolabe (photo by Alain Brieux)

PROVENANCE

Like the previous astrolabe, this one was also in the collection of Alain Brieux, Paris, at one time and was photographed by him.

C028⊙ SANSKRIT ASTROLABE ATTRIBUTABLE TO BULHOMAL[778]

Ca. 1849, Lahore

Diameter 133 mm

Rampur, Rampur Raza Library



Figure C028.1 – Front of the astrolabe (courtesy Raza Library, Rampur)

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[778] See Sarma 2003, pp. 53-57; Sarma 2010, 90-92; Sarma 2015b.

This unsigned and undated astrolabe, like the two following specimens, displays an unmistakable similarity to an Indo-Persian astrolabe produced by the versatile and prolific Lālah Bulhomal Lāhorī in AH 1266/ AD 1849, which is now with the Science Museum at London (B021). The crown has exactly the same design; in the rete, the arrangement of the circumferential ring of Capricorn, the circle of the ecliptic, the segment of the equatorial ring in the lower half, the broad equinoctial bar without any counter-change, and finally the remarkably small number of star pointers with their leaf-shape are exactly similar. The rete of the Indo-Persian astrolabe is, however, more ornate with arabesque tendrils joining the star pointers, which feature is missing in the these Sanskrit astrolabes. Bulhomal produced about thirty instruments of diverse types, both Indo-Persian and Sanskrit, between 1839 and 1850.[779] What distinguishes this astrolabe is a large astrological table engraved on the back, which shows the regents and the limits of the zodiac signs as also the regents of the decans. Such tables are to be found on the backs of the Indo-Persian astrolabes, but not in other Sanskrit astrolabes.

Components

Body (d. 133, h. 161, t. 10) with crown, rete (d. 112, t. 2) with 7 unnamed star pointers, 4 plates, alidade (length 125) with only one sight, pin, wedge, washer. One of the two sights of the alidade is missing, so also the ring.

Front

The body is surmounted by a triangular crown in which three large perforations form a pleasing pattern. A trefoil-shaped shackle is attached to the top of the crown. The limb is divided in 1° and 6° and the groups of 6° are numbered serially from 1 to 60.

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[779] On Lālah Bulhomal Lāhorī, Sarma 2010, s.v. Bhālūmal; Sarma 2015b.



Figure C028.2 – Rete of the astrolabe (courtesy Raza Library, Rampur)

RETE

The Tropic of Capricorn, the ecliptic and the northern half of the celestial equator are represented by wide circular bands. A complete equinoctial bar without any counterchanges holds these bands together. The ecliptic is divided into the twelve signs of the zodiac and labelled as *meṣa, vṛṣa, mithana* (sic! *mithuna*), *karka, siṃha, kanyā, tulā, vṛścika, dhanuḥ, makara, kumbha, mīna.* Each sign is further subdivided into groups of 6° and labelled as 6, 12, 18, 24, 30 separately for each sign. The bevelled edge carries a scale of single degrees.

There are just seven leaf-shaped star pointers, two to the south of the ecliptic and five to the north. These are, however, not named. It is very unusual to have so few star pointers; it is also unusual not to name them at all. Yet it is probable that these seven pointers indicate the following seven stars, arranged according their increasing celestial longitude:

Table C028-1 Stars on the Rete

	Star Name	Identification
1	*Rohiṇī*	α Tauri
2	*Lubdhaka*	α Canis Majoris
3	*Svāti*	α Bootis
4	*Viśākhā- mātṛ-maṇḍala*	α Coronae Borealis
5	*Abhijit*	α Lyrae
6	*Kukkuṭa-puccha*	α Cygni
7	*Pūrva-bhādrapada*	β Pegasi

PLATES

There are four plates which appear to be gilded, but the gilding is going off in patches. These plates have a small projecting bit at the top which fits into the slot cut at the corresponding point in the limb. Three plates serve the latitudes 16°—22°, 24°—28°, and 32°—38°. On these plates, altitude circles are drawn for every 6° and labelled; azimuth arcs are drawn for every 10° above the horizon and labelled. Lines are drawn for unequal hours and equal hours counted from the western and eastern horizons.

Plate of Horizons

The fourth plate has projections of multiple horizons on both the sides for the following latitudes which are inscribed at both ends of the horizons:

Plate 4a

24	32	40	48	56	64	72	80	88	90.
25	33	41	49	57	65	73	81	89	90.
26	34	42	50	58	66	74	82	90.	
27	35	43	51	59	67	75	83	90.	

Plate 4b

28	36	44	52	60	68	76	84	90.
29	37	45	53	61	69	77	85	90.
30	38	46	54	62	70	78	86	90.
31	39	47	55	63	71	79	87	90.

However, there are no declination scales. The inner side of the body is empty. No geographical gazetteer is engraved here.



Figure C028.3 – Back of the astrolabe (photo courtesy Raza Library, Rampur)

BACK

The rim is divided in 1° and 6° and labelled in 6s from 6 to 90 in each quadrant separately. The upper right quadrant contains the sine and cosine grid. There are 14 vertical and 14 horizontal parallel lines. These are labelled along the vertical and horizontal radii as 2, 4, 6, …. 26, 28, 30, starting from the centre, and once again along the twelfth vertical parallel and the twelfth horizontal parallel. The other three quadrants carry astrological tables. There are no shadow squares here.

The upper left quadrant contains the following table which is continued in the lower right quadrant:

Table C028-2 Astrological Table

bhaumaḥ	*śukraḥ*	*vuthaḥ*	*caṃdraḥ*	*sūryaḥ*	*vuthaḥ*
meṣaḥ	*vṛṣaḥ*	*mithunaḥ*	*karkaḥ*	*siṃhaḥ*	*kanyā*
vṛ śu vu maṃ śa	*śu vu vṛ śa maṃ*	*vu vṛ śu maṃ śa*	*maṃ śu vu vṛ śa*	*vṛ śu śa vu maṃ*	*vu śu vṛ maṃ śa*
6 6 8 5 5	*8 7 8 5 2*	*6 6 5 7 6*	*7 6 6 7 4*	*6 5 7 6 6*	*7 10 4 7 2*
maṃ sū śu	*vu caṃ śa*	*vṛ maṃ sū*	*śu vu caṃ*	*śa vṛ ma[ṃ]*	*sū śu vu*
śukraḥ	*bhaumaḥ*	*guruḥ*	*śaniḥ*	*śaniḥ*	*guruḥ*
tulā	*vṛścika*	*thanuḥ*	*makaraḥ*	*kumbhaḥ*	*mīnaḥ*
śa vu vṛ śu maṃ	*maṃ śu vu vṛ śa*	*vṛ śu vu śa maṃ*	*vu vṛ śu śa maṃ*	*vu śu vṛ maṃ śa*	*śu vṛ vu maṃ śa*
6 8 7 7 2	*7 4 8 5 6*	*12 5 4 5 4*	*7 7 8 4 4*	*7 6 7 5 5*	*12 4 3 9 2*
caṃ śa vṛ	*maṃ sū śu*	*vu caṃ śa*	*vṛ maṃ sū*	*śu vu caṃ*	*śa vṛ maṃ*

This huge table in 12 columns and 5 rows combines three different tables. The second row is common to all the three tables, as it provides the argument, viz., the names of the twelve signs of the zodiac. The first two rows show the regents of the zodiac signs. The second, third and fourth rows display the terms or limits of the signs. Finally, the second and the fifth rows show the regents of the decans. This data will be shown successively with English equivalents in the following three tables.

Table C028-3 Regents of the Zodiac Signs

	Sign	Regent		Sign	Regent
1	Aries	Mars	7	Libra	Venus
2	Taurus	Venus	8	Scorpio	Mars
3	Gemini	Mercury	9	Sagittarius	Jupiter
4	Cancer	Moon	10	Capricorn	Saturn
5	Leo	Sun	11	Aquarius	Saturn
6	Virgo	Mercury	12	Pisces	Jupiter

Table C028-4 Limits of the Zodiac Signs

Aries	Jupiter 6	Venus 6	Mercury 8	Mars 5	Saturn 5
Taurus	Venus 8	Mercury 7	Jupiter 8	Saturn 5	Mars 2
Gemini	Mercury 6	Jupiter 6	Venus 5	Mars 7	Saturn 6
Cancer	Mars 7	Venus 6	Mercury 6	Jupiter 7	Saturn 4
Leo	Jupiter 6	Venus 5	Saturn 7	Mercury 6	Mars 6
Virgo	Mercury 7	Venus 10	Jupiter 4	Mars 7	Saturn 2
Libra	Saturn 6	Mercury 8	Jupiter 7	Venus 7	Mars 2
Scorpio	Mars 7	Venus 4	Mercury 8	Jupiter 5	Saturn 6
Sagittarius	Jupiter 12	Venus 5	Mercury 4	Saturn 5	Mars 4
Capricorn	Mercury 7	Jupiter 7	Venus 8	Saturn 4	Mars 4
Aquarius	Mercury 7	Venus 6	Jupiter 7	Mars 5	Saturn 5
Pisces	Venus 12	Jupiter 4	Mercury 3	Mars 9	Saturn 2

This shows that, of the five limits Aries, the first is presided by Jupiter whose quantity of influence is 6, the second by Venus whose influence is 6 and so on. The total influence of all the five planets is 30° in each sign. This table appears on Indo-Persian astrolabes as the table of *ḥudūd*.[780]

Table C028-5 Regents of the Decans

Signs	Regents of Decan 1	Regents of Decan 2	Regents of Decan 3
Aries	Mars	Sun	Venus
Taurus	Mercury	Moon	Saturn
Gemini	Jupiter	Mars	Sun
Cancer	Venus	Mercury	Moon
Leo	Saturn	Jupiter	Mars
Virgo	Sun	Venus	Mercury
Libra	Moon	Saturn	Jupiter
Scorpio	Mars	Sun	Venus
Sagittarius	Mercury	Moon	Saturn
Capricorn	Jupiter	Mars	Sun
Aquarius	Venus	Mercury	Moon
Pisces	Saturn	Jupiter	Mars

In the third row and in the fifth, only the first syllables of the names of the planets are engraved. This table is identical with the table of *wujūh* on Indo-Persian astrolabes.[781]

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780 Cf. Introduction to the A-Series, 2.6.4.2.

781 Cf. Introduction to the A-Series, 2.6.4.3

In the lower left quadrant the names of the 12 zodiacal signs are arranged in the following manner:

Table C028-6 Zodiac Signs arranged according to their Rising Times at the Equator

Mithunaḥ (Gemini)	*Vṛṣaḥ* (Taurus)	*Meṣaḥ* (Aries)
Karkaḥ (Cancer)	*Siṃhaḥ* (Leo)	*Kanyā* (Virgo)
Dhanuḥ (Sagittarius)	*Vṛścikaḥ* (Scorpio)	*Tulā* (Libra)
Makaraḥ (Capricorn)	*Kuṃbhaṃ*[782] (Aquarius)	*Mīnaḥ* (Piscis)

Here each column contains zodiac signs having the same rising time at the equator. Similar arrangement can be seen also on the back of C001. In the first and third rows the names are written upside down to indicate that these rows are read from right to left. It is interesting that the enumeration of signs begins on the right as in Arabic and Persian.

The Sanskrit names of the signs and of the planets are carefully written together with the last *visarga.* However, there are some peculiarities in the choice of synonyms and in spelling. While the first row employs *bhaumaḥ* for Mars and *guruḥ* for Jupiter, these are called *maṃ[gala]* and *vṛ[haspati]* in other rows. Mercury is called *vuthaḥ* instead of *budhaḥ;* Jupiter *vṛ[haspati]* instead of *bṛhaspati*; Sagittarius *thanuḥ* instead of *dhanuḥ.*

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[782] The word is masculine; it should read *Kumbhaḥ.*



Figure C028.4 – Ornate sighting plate on the alidade (courtesy Raza Library, Rampur)

ALIDADE

An alidade of length 125 mm is pivoted to the centre at the back. The ends and the centre piece are ornate. Each half of the alidade is divided into 5 parts and labelled from the centre as 1, 12, 18, 24, 30. Actually the first number should be 6 and not 1. At the end of the division for 18 on both sides, the sighting plates are affixed. One of the sighting plates is lost. The remaining plate is elegantly fashioned like a tulip flower, in the same style as in Buhlomal's Indo-Persian astrolabes (see Figure B022.7). The pin, washer and wedge are simple and appear to be original.

BIBLIOGRAPHY

Sarma 2003, pp. 53-57.

Sarma 2010, s.v. Bhālūmal.

Sarma 2015b.

C029 SANSKRIT ASTROLABE ATTRIBUTABLE TO BULHOMAL

Ca 1849, Lahore

Diameter 135 mm

Srinagar, Sir Pratap Singh Museum



Figure C029.1 – Front of the astrolabe
(courtesy Central Asian Museum, University of Kashmir, Srinagar)

This astrolabe is identical in all respects to the previous astrolabe, with two minor differences in the upper right quadrant on the back: there are radial lines joining the

centre with every sixth degree on the rim and a quarter circle is drawn at the 17th division.



Figure C029.2 – Back of the astrolabe
(courtesy Central Asian Museum, University of Kashmir, Srinagar)

PROVENANCE

It was with the Central Asian Museum (# 80.203) of the University of Kashmir until 2015 when it was transferred to Sir Pratapsingh Museum.

C030 SANSKRIT ASTROLABE ATTRIBUTABLE TO BULHOMAL[783]

Ca. 1849, Lahore

Diameter ?

PLU

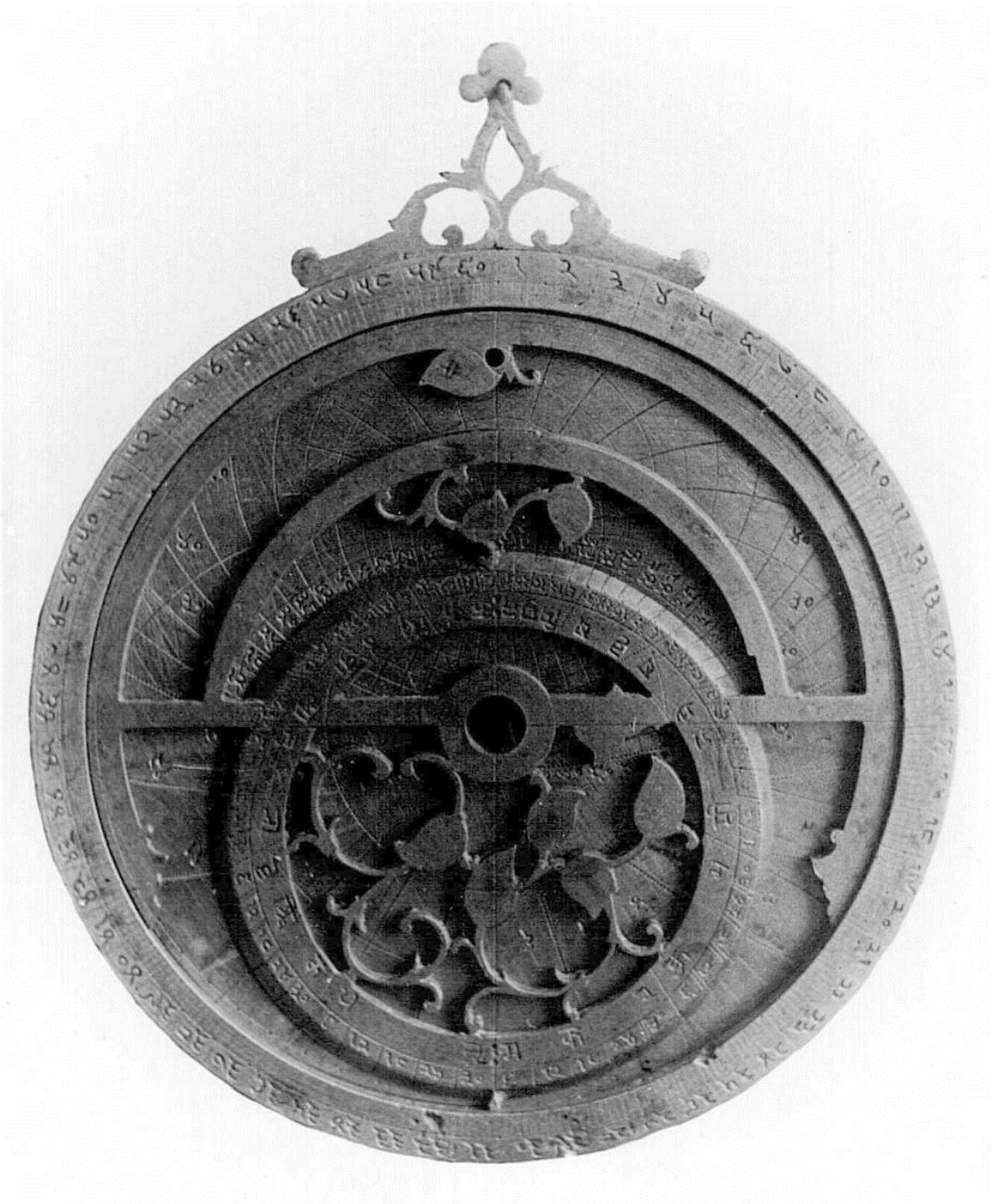


Figure C030.1 – Astrolabe attributable to Bulhomal
(courtesy Museum of the History of Science, Oxford)

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783 Entry based on a photo in the archives of the Museum of the History of Science, Oxford.

This astrolabe has close resemblance to the previous two astrolabes at Rampur and Srinagar (C028 and C029) and can be attributed to Bulhomal of Lahore. But there are some slight differences between this one and the other two. Here the shackle and ring are missing; so also the alidade, pin and horse. The rete displays eight star pointers instead of the seven in the other two astrolabes, the additional star being *Ārdrā* (α Orionis). In the other two astrolabes, the ends of the semi-circular ring of equator are curved outwards. Here they merge with the east-west bar.

The exact number of plates is not known. On the plate visible through the interstices of the rete, altitude circles are drawn for every 6° and labelled in a semi-circular arc. Azimuth lines appear to be drawn only above the horizon for every 10°. Lines for seasonal hours and their numbers are visible. If there are lines of the equal hours, these are not visible.

C031 ⊙ GURMUKHI ASTROLABE OF THE MAHARAJA OF PATIALA DESIGNED BY RISHĪKES AND MADE BY RAHĪM BAKHSH[784]

1850 Patiala, Panjab

Diameter 195 mm

Germany, PC



Figure C031.1 – Front of the astrolabe (photo by Oskar Kober)

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[784] For a detailed study, see Sarma 2012b.

This is the the most splendid specimen of the Sanskrit astrolabes with multiple plates. Moreover, this is the only known astrolabe with legends and numerals engraved in Gurmukhi script and in Panjabi language.[785] The inscription on the back states that the astrolabe was produced by the order of the Maharaja Narinder Singh of Patiala (r. 1845-1862) on a date corresponding to 14 March 1850 and that it was designed by the astrologer Rishīkes and fabricated by the artisan Rahīm Bakhsh. No other astrolabe made by Rahīm Bakhsh is known.[786]

On the plates in the astrolabe, the latitudes of all localities are mentioned in degrees and minutes, but on plate 5b which is designed for use at *Kūrmācala Almoḍā,* i.e., the town Almora in the Kumaon region, the latitude of the place is stated in degrees, minutes and seconds as 28;53,20°. The same value in degrees, minutes and seconds is given also geographical gazetteer (see Table C031-3 below, no. 39). Such precise measurement for this one locality would suggest that Rishīkes who designed this astrolabe may have hailed from Almora. Probably he was the court astrologer of the Maharaja of Patiala. Like his contemporary Bulhomal of Lahore, Rishīkes also appears to be well-versed in Sanskrit astrology and familiar with Islamic astrology. The present astrolabe contains many new features which are not met with in Sanskrit astrolabes and Indo-Persian astrolabes.

Rishīkes is the vernacular form of Sanskrit Hṛṣīkeśa. On an Arabic astrolabe which had been reworked with additional inscriptions in Sanskrit (E003), the name of Jyotirvid Hṛṣīkeśa of Kūrmācala (Kumaon) was engraved as the owner of the astrolabe.[787] Perhaps this Hṛṣīkeśa is the same as the Rishīkes who designed the present Gurmukhi astrolabe.

Components

Mater (d. 195, h. 247, t. 12) with crown, ring and shackle, rete (d. 171) for 22 stars, 6 plates, alidade with sights, pin and horse.

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785 Two other instruments with Gurmukhi legends are known: a *Cāpa-yantra* or double quadrant (K011) and a Zarqālī universal astrolabe with Arabic/Persian and Gurmukhi legends (B030).

786 The unsigned and undated double quadrant with the Gurmukhi inscriptions (K011) may also have been made by him.

787 Cf. Sarma 2010, s.v. Hṛṣīkeśa.

FRONT

This brass astrolabe is in an excellent state of preservation and looks gilded. The crown is elaborately carved and reticulated with symmetrical floral pattern on both sides. Though the pattern is identical in the front and on the back, the elevations are more pronounced in the front whereas on the back the pattern is softer. The profiles of the crown on the left and right are formed of tiered lobes. To the top of the crown is affixed a simple and small shackle, through which passes a large ring with a ribbed outer surface. The limb is graduated in single degrees and in groups of 6° and numbered serially from 1 to 60.



Figure C031.2 – Crown of the astrolabe, front view (photo by Oskar Kober)

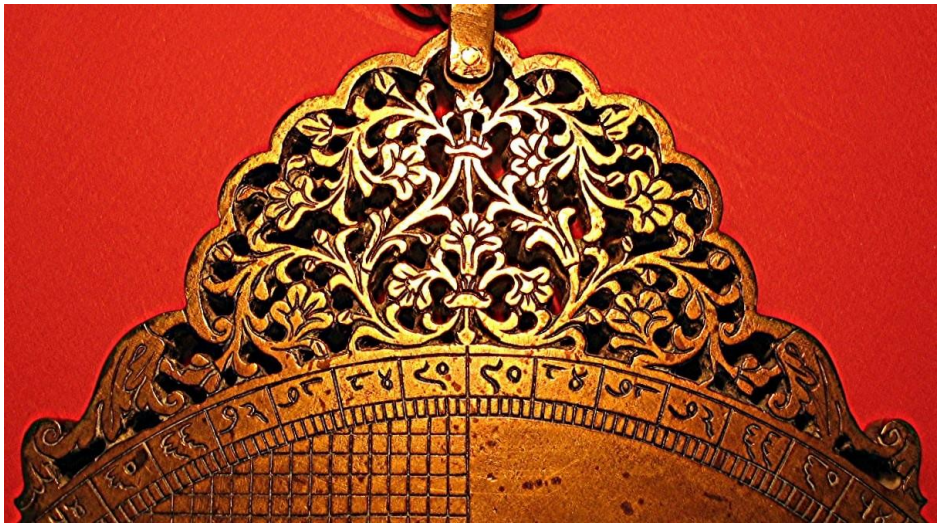


Figure C031.3 – Crown of the astrolabe, back view (photo by Oskar Kober

RETE

The rete is delicately crafted, without being overloaded with too many star pointers. The three rings containing the circles of the Tropic of Capricorn, the equator and the ecliptic are held together by the equinoctial bar with two counter changes at

equinoxes and the solsticial bar without any counter change. The ecliptic is divided into 12 signs and labelled as follows: *Mekha* (Sanskrit: *Meṣa*), *Brikha* (*Vṛṣa*), *Mithana* (*Mithuna*), *Karaka* (*Karka*), *Siṃgha* (*Siṃha*), *Kaṃnyā* (*Kanyā*), *Tula* (*Tulā*), *Brisacaka* (*Vṛścika*), *Dhana* (*Dhanuḥ*), *Makara* (*Makara*), *Kuṃbha* (*Kumbha*), *Mīna* (*Mīna*). Each sign is further subdivided in 6° and in 1°. There are 10 leaf-shaped star pointers outside the ecliptic and 12 inside. These are listed below in the order of increasing right ascension.



Figure C031.4 – Rete of the astrolabe (photo by Oskar Kober)

Table C031-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form in Sanskrit	Identification
1	*Samudrapachī*	*Samudra-pakṣī*	β Ceti

	Star Name as engraved	Full/Correct Form in Sanskrit	Identification
2	*Matsodara*	*Matsyodara*	β Andromedae
3	*Matsodarapāda*	*Matsyodara-pāda*	γ Andromedae
4	*Pra*	*Preta-śirā*	β Persei
5	*Rohiṇī*	*Rohiṇī*	α Tauri
6	*Brahāhrada*	*Brahma-hṛdaya*	α Aurigae
7	*Āradrā*	*Ārdrā*	α Orionis
8	*Lubadhaka*	*Lubdhaka*	α Canis Majoris
9	*Lubadhakabaṃdhu*	*Lubdhaka-bandhu*	α Canis Minoris
10	*Mahāpurakha*	*Mahāpuruṣa*	α Hydrae
11	*Pūrabā phālagunī*	*Pūrva-phālgunī*	δ Leonis
12	*Hasata*	*Hasta*	δ Corvi
13	*Citrā*	*Citrā*	α Virginis
14	*Marīcī*	*Marīci*	η Ursae Majoris
15	*Svātī*	*Svāti*	α Bootis
16	*Sarapadhārasira*	*Sarpadhārī-śira*	α Ophiuchi
17	*Abhijit*	*Abhijit*	α Lyrae
18	*Sravana*	*Śravaṇa*	α Aquilae
19	*Rukurapuhara*	*Kukkuṭa-puccha*	α Cygni
20	*Matasimukha*	*Aśvamukha*	ε Pegasi
21	*Satabhikhā*	*Śatabhiṣā*	λ Aquarii
22	*Purababhādra*	*Pūrva-bhādrapadā*	β Pegasi

PLATES

There are six plates, each with a small triangular projection at the bottom, which fits into a triangular slot in the limb of the mater. The plates serve 11 different localities. One plate face (6b) is devoted to astrological data and will be described at the end of this entry.

All the plates (except 6b) carry, in addition to the usual north-south and east-west diameters and the usual circles, also a projection of the ecliptic circle, which is generally not found on astrolabe plates. It is also unusual that almucantars are drawn at intervals of one and half degrees and the alternate lines are labelled as 3, 6, 9 … 90, whereas normally the almucantars have intervals of integer number of degrees. In the lower half of the plates, there are unequal hour lines, numbered from the western horizon. On 1a and 1b there are also equal hour lines drawn from the western horizon. Azimuth lines vary from plate to plate. On 1a, they are drawn for every 6° above the horizon and numbered along the local horizon only to the left of the meridian; on 1b, 4a, 4b and 6a, there are azimuth arcs for every 6° above the horizon, but only partially.

In the space between the local horizon and the Tropic of Cancer, much data is engraved which is not met with in other Sanskrit or Indo-Persian astrolabes. This data includes the name of the town for which the particular side of the plate is calibrated, its latitude (*araj,* from Arabic *ʿarḍ*) and longitude (*tūl,* from Arabic *ṭūl*), the climate (*aklīm,* from the Arabic *iqlīm*) and the name of the planetary regent (*satārā*) of this climate. The duration of the longest day at this latitude is not mentioned here, as is generally done on all Indo-Persian astrolabes and also on some Sanskrit astrolabes. As in all medieval astrolabes, the longitudes engraved here are counted from the Fortunate Isles. However, no longitudes are given for the modern cities of London and Kolkata.

More important is that on the plates of this astrolabe are mentioned the names of other towns which lie close to the latitude of the principal town and their exact latitudes and longitudes. The purpose of this enumeration is that if a town lies close to the latitude for which the plate is calibrated, then the same plate can be used in that other town as well.

The latitude for which the particular side of a plate is calibrated is mentioned at the junction of the meridian and the tropic of Cancer. The legends on the plates are reproduced below in serial order and translated into English.

Plate 1a:

30, paṭīālā araj 30|13, tūl 111|30. kurukhetra araj 30||10||, tūl 112|
yah aklīm 3 tīsarī hai, ihā kā satārā maṃgal.

[Latitude of the plate] 30°. Patiala, latitude 30;13°, longitude 111;30°. Kurukshetra, latitude 30;10°, longitude 112°. This is the third climate, its regent is Mars.

Plate 1b:

52. sahar naṃdan araj 52, aklīm cauthī 4, satārā sūraj.

[Latitude of the plate] 52°. City of London, latitude 52°, climate fourth, regent Sun.



Figure C031.5 – Plate for Patiala on latitude 30;13° (photo by Oskar Kober)

Plate 2a:

24. dūsarī duvārakā araj 24|45, tūl 59 . madīnā araj 25‖0, tūl 75‖ yah aklīm dūsarī hai ‖ ihā kā satārā brahaspat hai ‖

[Latitude of the plate] 24°. The second Dwaraka,[788] latitude 24;45°, longitude 59°. Medina, latitude 25;0°, longitude 75°. This is the second climate; its regent is Jupiter.

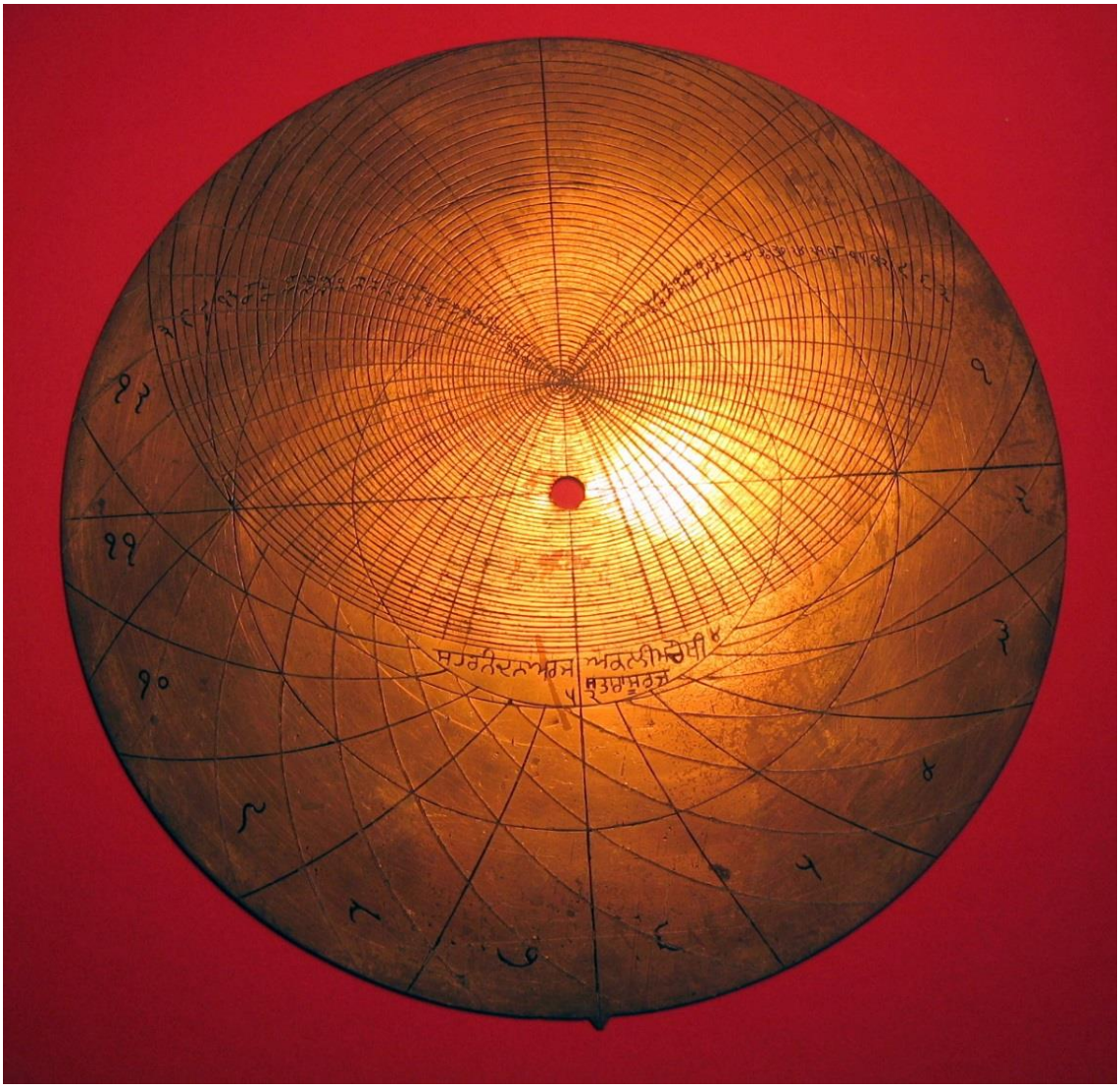


Figure C031.6 – Plate for London on latitude 52° (photo by Oskar Kober)

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[788] It is not clear what is meant by 'the second Dvārakā'; whether it distinguishes the modern city of Dwarka in Gujarat, mentioned on plate 4b, from the mythical city of the same name or refers to the island Bet Dwarka in the Gulf of Kutch. But in both cases, the longitudes of 59° and 56° are far below the actual values.

Plate 2b:

32. sahar lāhaur araj 3 ‖50‖ tūl 109|20. sahar kaṃdhār araj 33|0| tūl 107140[789]*. aklīm tīsarī. satārā maṃgal.*

[Latitude of the plate] 32°. City of Lahore, latitude 31;50°, longitude 109;20°. Qandahar, latitude 33;0°, longitude 107;40°. Third climate, regent Mars.

Plate 3a:

35. kāsmīr araj 35|1 tūl 108. kābal araj 34|30, tūl 104‖40‖ yih aklīm tīsarī satārā maṃgal.

[Latitude of the plate] 35°. Kashmir (i.e., Srinagar), latitude 35;1°, longitude 108°. Kabul, latitude 34.30°, longitude 34;30°. This is the third climate, regent Mars.

Plate 3b:

27. ajodhyā araj 27|22 tūl 115‖50. prayāg tīrath araj 26|50, tūl 115|34. aklīm tīsarī hai 3 satārā maṃgalā.

Ayodhyā, latitude 27;22°, longitude 115;50°. Prayag, the place of pilgrimage, latitude 26;50°. Third climate, regent Mars.

Plate 4a:

31. misar araj 30‖30, tūl 63‖1. multān araj 29|40, tūl 107‖35. aklīm tīsarī 3, satārā ‖ maṃgal.

[Latitude of the plate] 31°. Cairo, latitude 30;30°, longitude 63:1. Multan, latitude 29;40°, longitude 107;35°. Third climate, regent Mars.

Plate 4b:

21. burhānpur araj 21‖21, tūl 113‖0. devagiri araj 20‖34, tūl 111‖0. sūrat ba[ṃ]bai 20|0| tūl 50. makkā araj 21‖40, tūl 76‖10. kalakatā araj | 22‖, duārak araj 22|31, tūl 56. aklīm 3 satārā bahasapati.

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[789] This is clearly an error in engraving. Instead of drawing a vertical line to separate the degrees from the minutes, the engraver drew the numeral ‘one’ by mistake.

[Latitude of the plate] 21°. Burhanpur, latitude 21;21°, longitude 113;0°. Daulatabad, latitude 20;34°, longitude 111;0°. Surat [and] Mumbai, [latitude] 20;20°, longitude 50°. Mecca, latitude 21;40°, longitude 76;10°. Kolkata, latitude 22°. Dwaraka, latitude 22;31°, longitude 56°. Third climate, regent Jupiter.

Plate 5a:

18. gaṃgāsāgar araj 18‖20. golkuṃḍā haidarābād araj 18‖0‖ tūl 115‖19. bījāpur araj 17‖17, tūl 118‖0. aklīm dūsarī 2 yih kā sitārā bihasapat hai |

[Latitude of the plate] 18°. Gangasagar, latitude 18;20°. Golconda = Hyderabad, latitude 18;0°, longitude 115;19°. Bijapur, latitude 17;17°, longitude 118;0°. Second climate, its regent is Jupiter.

Plate 5b:

29. kuramācala almoḍā araj 28‖53‖20| tūl 115‖19. naipāl araj 27‖10 tūl 119‖25‖

[Latitude of the plate] 29°. Kumaon, Almora, latitude 28;53,20, longitude 115; 19. Nepal (i.e., Kathamandu), latitude 27;10°, longitude 119;25°. This is the third climate, its regent is Mars.

Plate 6a:

28‖39. dillī sahar araj 28‖39 tūl 114‖18‖ mathrā araj 26‖31‖ tūl 113‖30‖ yah aklīm tīsarī hai ihā kā satārā maṃgal hai ‖

[Latitude of the plate] 28;39°. City of Delhi, latitude 28;39°, longitude 114;18°. Mathura, latitude 26;31°, longitude 113;30°. This is the third climate; its regent is Mars.

It is interesting that on all plates, along with the latitude for which a particular plate is designed, the corresponding Ptolemaic climate (Arabic *iqlīm,* Panjabi *akalīm*) is aso mentioned. This is the only astrolabe which carries this item on the plates. Muḥammad Muqīm of the Lahore family engraves on the back of three astrolabes (A024, A041 and A051) a table of climates showing the latitudes and the hours of the longest day at the beginning, middle and end of the seven climates.

In his commentary on Mahendra Sūri's *Yantrarāja* of 1370*,* Malayendu Sūri misunderstood the Ptolemaic division of the inhabited part of the northern hemisphere

into seven climates; he wrote that the entire northern hemisphere of the earth, from the equator to the North Pole, is divided into seven climates and that these seven are governed by the planets Saturn, Jupiter, Mars, Sun, Venus, Mercury and Moon, in this order.[790]

Rishīkes, who designed the present astrolabe, obviously followed Malayendu's faulty division of climates when he assigned London on the latitude of 52° to the fourth climate. In the correct system, however, London would lie beyond the boundary of the seventh climate which varies between 49; 52° and 50;33°. The regents of the climates mentioned on the plates are also according to Malayendu Sūri. The engraver made an error in the climate number of plate 4b. The plate is calibrated for the latitude of 21° and the climate is given there as 3, but it should be 2. The regent is mentioned correctly as Jupiter.

The geographical data engraved on these plates is presented in the table below, where the columns 2, 3, 4 contain the names, latitudes and longitudes of localities as engraved on the plates and column 4 the modern names of localities.

Table C031-2 Geographical Data on the Plates

	Place Name	φ	L	Modern Name
1	Paṭīālā	30;13	111;30	Patiala
2	Kurukhetra	30;10	112;00	Kurukshetra
3	Naṃdan	52		London
4	Dūsarī (Duvārakā)	24;45	59	?

790 Malayendu Sūri, p. 18: *atha nirakṣāl laṅkā-pradeśāt meru-parvata-paryantaṃ pūrvāparadig-vyāpinaḥ sapta 7 vibhāgāḥ tadantarvartināṃ nagarāṇām akṣāṃśa-jñānārtham ādyaiḥ kalpitā santi. teṣāṃ yavanabhāṣayā ikalemeti saṃjñā kṛtā. śani-guru-bhauma-ravi-śukra-budha-somāh kramāt svāminaḥ.* Malayendu may have misunderstood the extent of the seven climates, but he is quite right about the regents of the seven climates; cf. Bīrūnī 1934, p. 238: 'With regard to the seven climates the first from the equator to its boundary is given to Saturn the first planet and the highest planet and the one with the widest orbit, because the first climate is the longest of all, the most generous in yielding the necessities of life, and its inhabitants resemble Saturn in colour and disposition. The second climate belongs to Jupiter and so on to the seventh which is allotted to the moon.'

	Place Name	φ	L	Modern Name
5	Madīnā	25;0	75	Medina
6	Lāhaur	31;50	109;20	Lahore
7	Kaṃdhār	33;0	107;40	Qandahar
8	Kāsmīr	35;1	108	Srinagar
9	Kābal	34;30	104;40	Kabul
10	Ajodhyā	27;22	115;50	Ayodhya
11	Prayāg Tīrath	26;50	115;34	Allahabad
12	Misr	30;30	63;1	Cairo
13	Multān	29;40	107;35	Multan
14	Burhānpur	21;21	113;0	Burhanpur
15	Sūrat	20;0	50	Surat
16	Baṃbai	20;0 50		Mumbai
17	Kalakatā	22;		Kolkata
18	Devagiri	20;34	111;0	Daulatabad
19	Makkā	21;40	76;10	Mecca
20	Duārak	22;31	56;	Dwarka
21	Gaṃgāsāgar	18;20		Gangasagar
22	Bījāpur	17;17	118;0	Bijapur
23	Golkuṃḍā / Haidarābād	18;0	115;19	Hyderabad
24	Kurmācal / Almoḍā	28;53 20	115;19	Almora in Kumaon
25	Naipāl	27;10	119;25	Kathmandu
26	Dillī	28;39	114;18	Delhi
27	Mathrā	26;31	113;30	Mathura

Place Name	φ	L	Modern Name



Figure C031.7 – Geographical Gazetteer (photo by Oskar Kober)

GEOGRAPHICAL GAZETTEER

In addition to the geographical data presented on the plates, a geographical gazetteer is engraved on the inner side of the mater, continuously in five concentric circles with the names and latitudes of 62 localities. It is reproduced in the table below, reading from the top and proceeding clockwise.

Table C031-3 Geographical Gazetteer

	Place Name	φ	Modern Name
	First Circle		
1	Laṃkā[791]	1;30	Sri Lanka
2	Pūrabaṃ yamkoṭi[792]	5;0	Yamakoṭi in the East
3	Somnāth	16	Somnath
4	Bījāpar	17;17	Bijapur
5	Tailang	18;0	Hyderabad
6	Gaṃgāsāgar	18;20	Gangasagar
7	Golakuṃḍā	18;0	Hyderabad
8	Sūrat	20;0	Surat
9	Baṃbaī	20;0	Mumbai
10	Devgirī	20;34	Daulatabad
11	Burhānpur	21;21	Burhanpur
12	Makā	21;40	Mecca
13	Ḍhākā Baṃgālā	22;0	Dhaka
14	Kalakatā	22;0	Kolkata
15	Bhurākachā	22;0	Bharuch
16	Raivatakācal	22;31	Girnar
17	Ahamadābād	23;0	Ahmedabad
18	Baḍā(?)yac	23;0	Bahraich?

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791 In Sanskrit astronomy, Laṅkā represents zero latitude and zero longitude. It is not clear why the value of 1;30° is given to its latitude here.

792 In Sanskrit astronomy, Yamakoṭi represents the notional point on the equator, 90° east of Laṅkā. Therefore, it its latitude should be 0°. The value of 5° given here is obviously borrowed from Indo-Persian astrolabes.

	Place Name	φ	Modern Name
19	Ujjain	23;30	Ujjain
20	Khaibar	24;0	Khybar Pass
21	Madīnā	25;0	Madina
22	Ajmer	26;0	Ajmer
23	Kāsī	26;15	Varanasi
	Second Circle		
24	Dhārā	26;20	Dhar
25	Kanaṃj	26;20	Kannauj
26	Bīkāner	26;24	Bikaner
27	Gvāliyar	26;30	Gwalior
28	Mathrā	26;31	Mathura
29	Jodhpur	26;36	Jodhpur
30	Āgarā	26;43	Agra
31	Jaipur	26;47	Jaipur
32	Gājīpur[793]	27;01	?
33	Lakhanaū	26;30	Lucknow
34	Uḍīsā	27	Puri
35	Ajudhyā	27;22	Ayodhya
36	Koil	28;0	Aligarh
37	Naipāl	28;50	Kathmandu
38	Dilī	28;40	Delhi
39	Kumāū	28;53,20	Almora

[793] There are several localities named Gazipur in the Indian subcontinent, but none seem to have this value for latitude.

	Place Name	φ	Modern Name
40	Hisār	29;40	Hissar
41	Multānā	29;40	Multan
	Third Circle		
42	Kurukhetra	30;10	Kurukshetra
43	Paṭīyālā	30;13	Patiala
44	Misar	30;30	Cairo
45	Lāhūr	31;50	Lahore
46	Khaṃdhār	33	Qandahar
47	Kābil	34;30	Kabul
48	Kāsmīr	35;1	Srinagar
49	Balap	36;41	Balkh
50	Bhoṭalāvācīna[794]	37;0	?
51	Tavrej	38;0	Tabriz
52	Samarkaṃd	39;34	Samarqand
53	Tibat	40;0	Lhasa, Tibet
54	Kubīnā	41;01	?
55	Khutan	42;0	Khotan, China
	Fourth Circle		
56	Kāsgar	44; 0	Kashgar, China
57	Kurkurūm	46; 0	Karakoram?
58	Bulgār[795]	49; 0	Bulgar

[794] The name seems to refer to Tibet (*bhoṭa*) and China (*cīna*) but its exact significance is not known.

[795] The gazetteers on the Indo-Persian and Sanskrit astrolabes end with Bulgār or Bulghar region and city. According to Gibbs & Saliba 1984, p. 201, ‘the name was given to the land of the Slavs north of the Caspian Sea around the Volga River.’

	Place Name	φ	Modern Name
59	Iṃglistān Naṃdan	52; 0	London, England
60	Cīn āraṃbh pūrab	21;0	
61	Cīn had uttar	55;0	
62	Rūs āraṃbhā	40;0	
63	Rūs had uttar	66	

The last four entries refer to the boundaries of China and Russia. About China it is stated *cīn āraṃbh pūrab* 21;0°; *cīn had uttar* 55;0°, 'the beginning of China in the east 21°; the boundary of China in the north 55°.' This is roughly correct, because the southernmost tip of the land mass of China extends in the east up to the latitude of 21° and its northern boundary reaches up to about 53°. About Russia it is stated: *rūs āraṃbhā 40;0° rūs had uttar 66°*, 'the beginning of Russia is 40;0°; the boundary of Russia in the north 66°.' In Central Asia, the Russian empire reached up to the latitude of 40°, but in the north it extends much beyond 66°.

The notion of latitude 66° as the boundary of the inhabited world is expressed in the fifth circle in a mixture of Panjabi and Sanskrit: *daraje 66 uprāt pācbhaut kā cārābhāvaḥ | had 90 devabhūmi* (?) This roughly translates to 'Beyond the degrees 66 [of latitude] there is an absence of the movement of live beings. [Up to the] boundary of 90 [degrees, it is] the land of gods.' Here the gazetteer follows Malayendu Sūri who wrote that the human habitation extends only up the latitude of 52°, that between the latitides 52° and 66° there is little human habitation because of the extreme cold and dakness (!) and that beyond the latitude of 66° are the divine regions (*devabhūmi-s*) where Kiṃnaras, Gandharvas, Vidhyādharas and Siddhas move about.[796] Thus in this gazetteer modern and mythical notions of geography rest side by side.

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[796] Malayendu Sūri, p. 18: *paraṃ dvipañcāśad-akṣāṃsān yāvan manuṣyasañcāraḥ. tadagrataḥ ṣaṭṣaṣṭyaṃśa-paryantaṃ śītabāhulyād andhakārāc ca manuṣyāṇām alpa eva sañcāraḥ. tatparataḥ kiṃnara-gandharva-vidhyādhara-siddhānāṃ pracārā devabhūmayaḥ.*

Nearly all the localities, save four (viz. Dūsarī Duārakā, Prayāg Tīrath, Duārak and Mathrā), which are mentioned on the plates are repeated in the gazetteer. In one case, there is a substantial difference: the latitude of Nepal is engraved 27;0° on the plate whereas it has a much higher value of 28;50° in the gazetteer. The latitude of Delhi is given as 28;39° on plate 6a (this is the traditional value at least from the time of Mahendra Sūri); it is rounded off to 28;40° in the gazetteer.

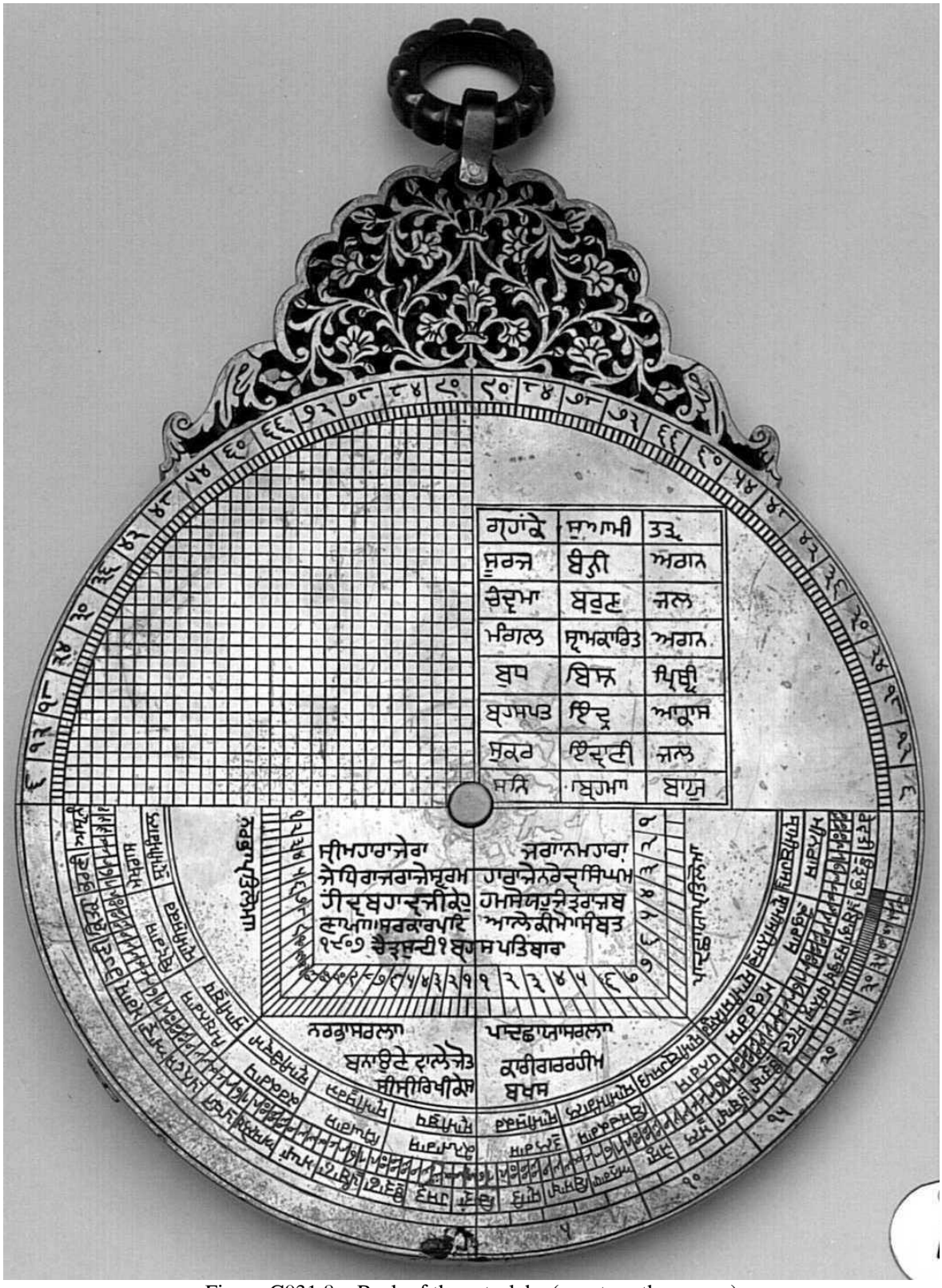


Figure C031.8 – Back of the astrolabe (courtesy the owner)

BACK

On the back of the astrolabe, the rim of the upper half carries the altitude scale, graduated in 1° and 6°. The rim around the lower left quadrant is blank, but the one

around the lower right quadrant carries a cotangent scale. The outer band is divided into unequal units carrying the numbers 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, starting from the vertical diameter and proceeding towards the horizontal diameter. Each of these divisions is further subdivided into 5 units in the inner band.

The upper left quadrant bears a sine cosine grid, consisting of 30 vertical parallels and 30 horizontal parallels. Shadow squares are engraved in the two lower quadrants. The square on the left is for a gnomon of 12. Here both the horizontal and vertical scales are divided into 12 divisions each and numbered accordingly. These divisions are further subdivided into 2 units in the outer band. Below the horizontal scale is engraved the label *narabhā saralā,* 'gnomon shadow, straight,' (i.e. umbra recta) and to the left of the vertical scale is the label *narabhā pratilomā,* 'gnomon shadow, reverse' (i.e. umbra versa).

The square on the right is meant for a gnomon of 7 feet. Here both the horizontal and vertical scales are divided into 7 divisions each and numbered accordingly. These divisions are further subdivided into 2 units in the outer band. Below the horizontal scale is engraved the label *padachāyā saralā,* 'shadow of feet, straight,' and to the right of the vertical scale is the label *pādachāyā pratilomā*, 'shadow of feet, reverse'.

Islamic astrolabes make a distinction between two kinds of shadows, viz., *ẓill aṣābiʿ,* 'shadow in digits,' thrown by a gnomon which is divided into 12 'digits', and *ẓill aqdām*, 'shadow in feet,' cast by a gnomon divided into 7 'feet'. Sanskrit astrolabes generally ignore this distinction and call both units of measurement as *aṅgula* (digit). The present astrolabe maintains the distinction and calls the shadow cast by a gnomon of 12 digits as *narabhā* and that of a gnomon of 7 feet as *pādachāyā.*

Besides these trigonometric tables, the back of the astrolabe carries much astrological data, which is rarely found on Sanskrit astrolabes. Plate 6b also carries astrological data. The astrological data in both these places appear to have been derived from sources like Kalyāṇavarman's *Sārāvalī* (ca. 800).[797] Like the geographical gazetteer, these astrological tables do not have any direct bearing on the functions of the

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797 CESS, 2.26-29; Pingree 1981, p. 88. Several chapters of the *Sārāvalī* have been translated into German in Türstig 1980, pp. 154-294.

astrolabe. These are incorporated into the astrolabes, like the geographical gazetteer, as *aide-mémoires.*

Astrological Data on the Back of the Astrolabe

The upper right quadrant contains a table showing the lords or the regents (*suāmī*, Sanskrit *svāmī*) and the essence or the related element (*tatba,* Sanskrit *tattva*) of the seven planets (*grah*), which is reproduced below.

Table C031-4 Planets and their Regents

Name of the Planet			Regent of the Planet		Essence of the Planet		
Panjabi	Sanskrit	English	Panjabi	Sanskrit	Panjabi	Sanskrit	English
Sūraj	*Sūrya*	Sun	*Baṃnhī*	*Vahni*	*Agan*	*Agni*	Fire
Caṃdramā	*Candra*	Moon	*Baruṇ*	*Varuṇa*	*Jal*	*Jala*	Water
Maṃgal	*Maṅgala*	Mars	*Svāmakārita*[798]	*Skanda*	*Agan*	*Agni*	Fire
Budh	*Budha*	Mercury	*Bisn*	*Viṣṇu*	*Prithbī*	*Pṛthvī*	Earth
Brahaspat	*Bṛhaspati*	Jupiter	*Imdra*	*Indra*	*Ākās*	*Ākāśa*	Ether
Sukar	*Śukra*	Venus	*Iṃdrāṇī*	*Indrāṇī*	*Jal*	*Jala*	Water
Sani	*Śani*	Saturn	*Brahamā*	*Brahmā*	*Vāyu*	*Vāyu*	Air

In the lower half, the shadow squares are enclosed by four concentric semi- circles. Reading from outside and from the right to the left, these semi-circles contain respectively:

1. the names of the 27 lunar mansions (*nakṣatras*);
2. *nakṣatra-pādas*, i.e. one-fourth parts of the *nakṣatras*, but labelled for each three successive *nakṣatras*, as 1, 2, 3, … 10, 11, 12. Each 9 of these *nakṣatra-pādas* constitute the related zodiac sign, as shown in the next semi-circle;
3. zodiac signs with a suffix °*rās* (Sanskrit *rāśi*); and

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[798] *Sārāvalī* 4.12 states that the regent of the planets are Agni, Varuṇa, Skanda, Viṣṇu, Indra, Śacī and Brahma; cf. Türstig 1980, p. 163. Accordingly the regent of Mars should be Skanda, also known as Kārtikeya and Ṣaṇmātṛka. Svāmakārita as engraved here is apparently a corruption of Ṣaṇmātṛka.

4. the regents of the signs, with the prefix *svāmī*.

This semi-circular table is an improvement on similar tables in Indo-Persian astrolabes, in so far as it has only 27 lunar mansions and not 28, as it shows the correspondence between the lunar mansions and zodiac signs more graphically through the *nakṣatra-pādas* and as it also adds the regents of the signs. It is interesting that in each row, the items are to be read from the right to the left, as in Islamic astrolabes.

The zodiac signs and their regents mentioned in rows 3 and 4 are as follows: [799]

Table C031-5 Zodiac Signs and their Planetary Regents

	Zodiac Sign			**Regent**			
	Panjabi	Sanskrit	English	Panjabi	Sanskrit	English	
1	*Mekh Rās*	*Meṣa-rāśi*	Aries	*Mamgal*	*Maṅgala*	Mars	1
2	*Brikh Ras*	*Vṛṣa-rāśi*	Taurus	*Sukar*	*Śukra*	Venus	2
3	*Mithan Ras*	*Mithuna-rāśi*	Gemini	*Budh*	*Budha*	Mercury	3
4	*Karak Rās*	*Karka-rāśi*	Cancer	*Caṃdramā*	*Candra*	Moon	4
5	*Siṃgh Rās*	*Siṃha-rāśi*	Leo	*Sūraj*	*Sūrya*	Sun	5
6	*Kaṃnyā Rās*	*Kanyā-rāśi*	Virgo	*Budh*	*Budha*	Mercury	6
7	*Tul Rās*	*Tulā-rāśi*	Libra	*Sukar*	*Śukra*	Venus	7
8	*Briscik Rās*	*Vṛścika-rāśi*	Scorpio	*Maṃgal*	*Maṅgala*	Mars	8
9	*Dhan Rās*	*Dhanū-rāśi*	Sagittarius	*Brahaspat*	*Bṛhaspati*	Jupiter	9
10	*Makar Rās*	*Makara-rāśi*	Capricorn	*Saniscar*	*Śanaiścara*	Saturn	10
11	*Kuṃbh Rās*	*Kumbha-rāśi*	Aquarius	*Saniscar*	*Śanaiścara*	Saturn	11
12	*Mīn Rās*	*Mīna-rāśi*	Pisces	*Brahaspat*	*Bṛhaspati*	Jupiter	12

[799] Cf. *Sārāvalī* 3.11; cf. Türstig 1980, p. 157; see also table Table C028-3.

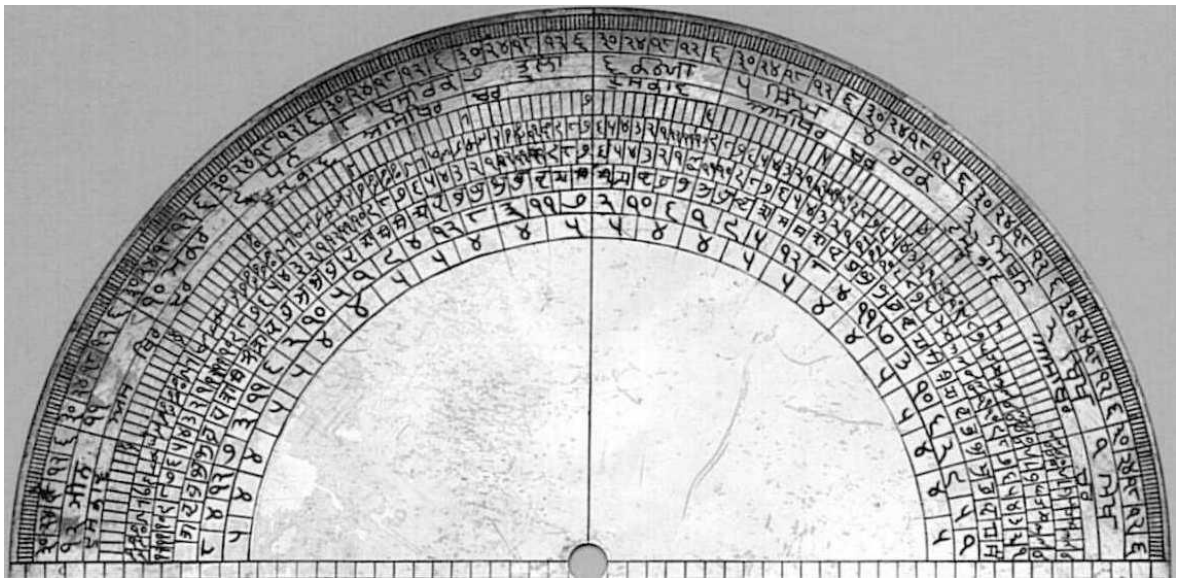


Figure C031.9 – Astrological Table on Plate 6b (courtesy the owner)

Astrological Data on Plate 6b

More astrological data is engraved on the reverse side of plate 6. Here the lower half contains a sine cosine grid of 30 horizontal and 60 vertical lines. In the upper half are ten concentric semi-circular rows containing astrological information in tabular form.

In Sanskrit astrology, the zodiac signs are sub-divided in ten different ways (*daśa-varga*) and to each part of such a sub-division a planet is assigned as its regent. These combinations are used in making predictions in horoscopy.[800] Some of these divisions are displayed on this plate. In the ten semi-circular rows in the upper half, the zodiac signs are successively divided in 12s (*dvādaśāṃśa,* duodenaries), 9s (*navāṃśa,* novenaries), 7s (*saptāṃśa,* septenaries), 5s (*pañcāṃśa*), 3s (*dreṣkāṇa,* decans) and 2s (*horā*), and to each part a planetary regent is assigned. The planets are denoted here by serial numbers of their domiciles, i.e., the signs which they govern, as shown in table Table C031-5 above. It is interesting that the material is arranged in these rows from right to left as on Islamic astrolabes. Reading from the outside, these ten rows display the following data.

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800 *Sārāvalī* 1.3; cf. Türstig 1980, pp. 53-66.

1-3. In row 3 are written the serial numbers and the names of the 12 zodiac signs; in row above it, each sign is divided in groups of 6° and numbered as 6, 12, 18, 24, 30; the first row is divided in 1°.

4. This rows shows a three-fold classification of signs, according to which Aries, Cancer, Libra and Capricorn are said to be *cara* (unsteady), Taurus, Leo, Scorpio and Aquarius *asithira* (Sanskrit *sthira,* steady) and Gemini, Virgo, Sagittarius, Pisces *dasakāva* (?) (Sanskrit *miśratanu,* mixed).[801]

5. Each sign is subdivided into 12 parts (*dvādaśāṃśa,* duordenaries) of 2½° each. The 12 cells under Aries are filled by the numbers from 1 to 12. As stated above, these numbers denote planetary regents. Under Taurus only the first cell is filled by 2, the remaining should have been filled by numbers 1 to 12 and 1. Under Gemini, the first cell carries 3. The other cells are blank; these should have been filled by numbers from 4 to 12 and 1, 2.

6. Each sign is subdivided into 9 parts (*navāṃśa*) of 3 1/3° each. These cells are numbered from right to left in groups of 12 as 1,2, 3, … 10, 11, 12.

7. Each sign is subdivided into 7 parts (*saptāṃśa*) of 4 2/7° each. These cells are numbered from right to left in groups of 12 as 1, 2, 3, … 10, 11, 12.

8. Each sign is subdivided into 5 parts (*pañcāṃśa*) of 6° each. These parts are labelled with the letters of a mercantile script known as the Lānd script; I am unable to decipher these syllable. But they do not seem indicate the limits (*ḥudūd*) of the Indo-Persian astrolabes.

9. Each sign is subdivided into 3 parts (*dreṣkāṇa,* decan) of 10° each. The cells are filled with different serial numbers of the signs. For example, the three decans under Aries bear the numerals 1, 5, 9; it means that the regents of the three decans are the same as the regents of the sign nos. 1, 5, 9, viz. Mars, Sun and Jupiter.[802] This arrangement is entirely different from that in the *wujūh* tables on the Indo-

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801 Cf. *Sārāvalī,* 3.20; Türstig 1980, p. 159.

802 *Sārāvalī* 3.14 states that the lords of the three decans of any zodiac sign are respectively the lords of the same sign and of the fifth and ninth signs; cf. Türstig 1980, p. 158.

Persian astrolabes, where the three decans of Aries are governed by Mars, Sun and Venus.[803]

10. Each sign is subdivided into 2 parts (*horā*) of 15° each. The cells are filled alternatively with the numerals 4 and 5. These numbers also stand for the regents of the signs bearing these numbers. Thus sign 4 is Cancer and its regent is the Moon; sign 5 is Leo and its regent is the Sun.[804]

The numerical data in rows 3, 4, 5, 6, 7 and 9 is tabulated below for the first six signs.[805]

Table C031-6 Astrological tables on Plate 6a

3 row	**1 Aries**	**2 Taurus**	**3 Gemini**	**4 Cancer**	**5 Leo**	**6 Virgo**
4 row	unsteady	steady	mixed	unsteady	steady	mixed
5 row *Dvādaśāṃśa* Duodenaries	1 Mars 2 Venus 3 Mercury 4 Moon 5 Sun 6 Mercury 7 Venus 8 Mars 9 Jupiter 10 Saturn 11 Saturn 12 Jupiter	2 Venus 3 Mercury 4 Moon 5 Sun 6 Mercury 7 Venus 8 Mars 9 Jupiter 10 Saturn 11 Saturn 12 Jupiter 1 Mars	3 Mercury 4 Moon 5 Sun 6 Mercury 7 Venus 8 Mars 9 Jupiter 10 Saturn 11 Saturn 12 Jupiter 1 Mars 2 Venus	4 Moon 5 Sun 6 Mercury 7 Venus 8 Mars 9 Jupiter 10 Saturn 11 Saturn 12 Jupiter 1 Mars 2 Venus 3 Mercury	5 Sun 6 Mercury 7 Venus 8 Mars 9 Jupiter 10 Saturn 11 Saturn 12 Jupiter 1 Mars 2 Venus 3 Mercury 4 Moon	6 Mercury 7 Venus 8 Mars 9 Jupiter 10 Saturn 11 Saturn 12 Jupiter 1 Mars 2 Venus 3 Mercury 4 Moon 5 Sun
6 row *Navāṃśa* Novenaries	1 Mars 2 Venus 3 Mercury 4 Moon 5 Sun 6 Mercury 7 Venus 8 Mars 9 Jupiter	10 Saturn 11 Saturn 12 Jupiter 1 Mars 2 Venus 3 Mercury 4 Moon 5 Sun 6 Mercury	7 Venus 8 Mars 9 Jupiter 10 Saturn 11 Saturn 12 Jupiter 1 Mars 2 Venus 3 Mercury	4 Moon 5 Sun 6 Mercury 7 Venus 8 Mars 9 Jupiter 10 Saturn 11 Saturn 12 Jupiter	1 Mars 2 Venus 3 Mercury 4 Moon 5 Sun 6 Mercury 7 Venus 8 Mars 9 Jupiter	10 Saturn 11 Saturn 12 Jupiter 1 Mars 2 Venus 3 Mercury 4 Moon 5 Sun 6 Mercury
7 row *Saptāṃśa* Septenaries	1 Mars 2 Venus 3 Mercury 4 Moon 5 Sun	8 Mars 9 Jupiter 10 Saturn 11 Saturn 12 Jupiter	3 Mercury 4 Moon 5 Sun 6 Mercury 7 Venus	10 Saturn 11 Saturn 12 Jupiter 1 Mars 2 Venus	5 Sun 6 Mercury 7 Venus 8 Mars 9 Jupiter	12 Jupiter 1 Mars 2 Venus 3 Mercury 4 Moon

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803 On *wujūh* tables, see the Introduction to A-Series, 2.6.4.3.

804 *Sārāvalī* 3.14 states that the lords of the *horās* in a sign with an odd number are the Sun and the Moon respectively and the lords of the *horās* in a sign with an even number are the Moon and the Sun respectively; cf. Türstig 1980, p. 158.

805 The full tables for all the 12 signs can be seen in Kaye 1918, pp. 120-126.

	6 Mercury 7 Venus	1 Mars 2 Venus	8 Mars 9 Jupiter	3 Mercury 4 Moon	10 Saturn 11 Saturn	5 Sun 6 Mercury
9 row *Dreṣkāṇa*	1 Mars 5 Sun 9 Jupiter	2 Venus 6 Mercury 10 Saturn	3 Mercury 7 Venus 11 Saturn	4 Moon 8 Mars 12 Jupiter	5 Sun 9 Jupiter 10 Saturn	6 Mercury 10 Saturn 11 Saturn

ALIDADE

The alidade in this astrolabe is surprisingly simple without any decoration or graduations. The two sights are affixed on it, which are rather too close to the centre. There is a pin to hold all the parts together. The wedge that holds the pin firmly in position is shaped like a bird with upraised wings.



Figure C031.10 – Inscription on the Astrolabe (photo by Oskar Kober)

INSCRIPTION

On the back, inside the shadow squares is an inscription which reads thus:

srī mahārāje rājagāna mahārā-
jedhirāja rājesvara mahārāje nareṃdrasiṃgha ma-
hīṃdra bahādra jī ke huha<ka>m so yahu jaṃtrarāj ba-
ṇāyā ‖ sarkār paṭiyāle kī mo<hur> ‖ saṃbat
1907 caitra sudī 1 brahasapatibār |

> ‘This astrolabe (*jaṃtrarāj*) was made by the order of Srī Mahārāje Rājagāna Mahārā-jedhirāja-Rājesvara-Mahārāje Nareṃdrasiṃgha Mahīṃdra Bahādrajī. [Under] the Seal of the Government of Patiala. Saṃbat 1907 Caitra sudī 1 Thursday (= Thursday 14 March 1850).’

Below the shadow squares are engraved the names of the designer and of the maker in the left and right halves respectively:

> *banāūṇevāle jotasī sī rishīkes*
>
> *kārīgar rahīm bakhas*
>
> ‘He who caused to be made (i.e. he who designed) Jyotiṣī Śrī Riṣīkeśa. The maker (*kārīga*r, lit. artisan) Rahīm Bakhsh.’

Though the production of astrolabes continued up to the early years of the twentieth century, the present astrolabe is arguably the last important astrolabe produced in India. It is significant that in the production of this astrolabe all three major communities of Panjab took part: the Sikh prince who commissioned the astrolabe, the Hindu astrologer who designed it and the Muslim instrument maker who produced it.

C032⊙ SANSKRIT ASTROLABE, NOT SIGNED, NOT DATED

19th century, Rajasthan

Diameter 140 mm

Jaipur, Government Maharaja's Sanskrit College



Figure C032.1 – Front of the astrolabe (photo by S. R. Sarma)

This unsigned and undated astrolabe is well crafted, with accurately drawn circles and lines, and neat calligraphy. Yet many areas are incomplete. There are also some unusual features: the ring is joined to the shackle with a hinge. To hold the plates in position, there is a tooth at the north point of the limb. In addition to this, there is also a pin projecting out of the inner surface of the mater and a hole in the corresponding place in the plates.

Components

Mater (d. 140, h. 172, t 8.5) with crown, shackle and ring, rete (d. 121.5) for 28 stars, 7 plates (d. 121.5), alidade with a sighting tube; wedge is missing.

Front

High solid crown, the profiles marked by lobes and deep circular scallops. There is no decoration on the surface of the crown. The small shackle is joined to the large ornate ring by a hinge, so that the ring can be folded flush with the shackle. The limb is graduated in 1° and 6° and numbered in 6s, separately for each quadrant as 6—90; 90—6; 6—90; 90—6.



Figure C032.2 – Rete of the Astrolabe (photo by S. R. Sarma)

RETE

The rete consists of three broad rings representing the Tropic of Capricorn, the complete equator and the ecliptic. The two ends of the Capricorn ring are bent back artistically. The three rings are held together by the equinoctial bar, without a counter change, and by the solstitial bar with one counter change. The ring of the celestial equator is complete. The ecliptic is divided into the 12 signs and labelled with the initial syllables of the names of the signs. Each sign is divided into groups of 6° and 2°, but not numbered. There are 28 star pointers, some curved like tiger's claws and some straight like daggers. Of these star pointers, 12 are outside the ecliptic and 16 inside, mostly cluttered around the central ring.

Table C032-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samadrapakṣī*	*Samudrapakṣī*	β Ceti
2	*Ma.sodara*	*Matsyodara*	β Andromedae
3	*Ma.mada*	*Matsyodara-pāda*	γ Andromedae
4	*Nehar kā*	*Nahar-tārā*	γ Eridani
5	*Pre.śirā*	*Pretaśirā*	β Persei
6	*Rohinī*	*Rohiṇī*	α Tauri
7	*Vrahmahradai*	*Brahma-hṛdaya*	α Aurigae
8	*Ādrā*	*Ārdrā*	α Orionis
9	*Mithu.pāda*	*Mithuna-pāda-dakṣiṇa*	κ Orionis
10	*Ludhvaka*	*Lubdhaka*	α Canis Majoris
11	*Ludhvakavaṃdhu*	*Lubdhaka-bandhu*	α Canis Minoris
12	*Mahāpurasa*	*Mahāpuruṣa*	α Hydrae
13	*Maghā*		α Leonis
14	*Pū.phala.nī*	*Pūrva-phālgunī*	δ Leonis

	Star Name as engraved	Full/Correct Form	Identification
15	*Siṃgha.hradai*	*Siṃha-hṛdaya*[806]	?
16	*Hasta*		δ Corvi[807]
17	*Citrā*		α Virginis
18	*Svāti*		α Bootis
19	*Marīci*		η UMa
20	*Vi.mā.maṃ*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
21	*Sarpadhārīsira*	*Sarpadhārī-śira*	α Ophiuchi
22	*Abhījita*	*Abhijit*	α Lyrae
23	*Śravaṇa*		α Aquilae
24	*Kaku.cha*	*Kukkuṭa-puccha*	α Cygni
25	*Aśvamukha*		ε Pegasi
26	*Śataviṣā*	*Śatabhiṣā*	λ Aquarii
27	*Pū.bhā.pada*	*Pūrva-bhādrapada*	β Pegasi
28	*U.mada*	*Uttara-bhādrapada*	γ Pegasi

PLATES

There are 7 plates, serving the latitudes 20°— 21°; 22°— 23°; 24°— 25°; 26°— 27°; 30°— 31°; 35°— 36°; 38°— 39°. Strangely the latitudes 29° (Delhi) and 32° (Lahore) are omitted. Altitude circles are drawn very neatly for each 2°, every third circle is highlighted with dots. There are no other lines, neither azimuth arcs nor hour lines. Each plate has a rectangular slit at the north point and above it a small hole, so

806 The name *Siṃha-hṛdaya,* 'the heart of Leo' (Arabic *Qalb al-asad*) is an alternative name for *Maghā.* Here it is engraved on the pointer of an unidentified star.

807 Wrong position.

that the tooth in the limb and pin on the inner surface of the mater slide in these and hold the plates in position. One of these would have been sufficient for this purpose.

GEOGRAPHICAL GAZETTEER

A geographical gazetteer was envisaged on the inner surface of the mater, for which 11 concentric circles were drawn, producing 12 concentric annular rings. But these spaces were not filled in.



Figure C032.3 – The inner side of the Mater (photo by S. R. Sarma)

BACK

The rim of the upper half carries altitude scales which are divided in 1° and 6°. The scales are numbered in 6s, separately for each quadrant, but starting from the south point and proceeding towards the east and west points (90—6; 6—90) which is unusual. In the upper left quadrant, there is a finely drawn sine-cosine grid, with 60 vertical parallels and 60 horizontal parallels which are numbered along the radii, from the centre up to the circumference. Each fifth line is highlighted with dots. In the upper right quadrant, there are 18 concentric arcs of the signs without any labels.

Shadow squares are drawn in the lower half. The horizontal and the vertical scales of the square on the left are divided into 7 parts each and so numbered; each part is further subdivided into 5 parts. The square on the right is divided into 6 parts, instead of 12 parts. There are no labels on the scales.



Figure C032.4 – Back of the astrolabe (photo by S. R. Sarma)

The area between these shadow squares and the circumference carries four semi-circular rows. Starting from the outside, these rows contain (i) the names of the 12 zodiac signs, spelt somewhat carelessly; (ii) a narrow band in which each sign is subdivided into 15 parts of 2° each; (iii) the initial syllables of the names of the 28 lunar mansions; (iv) each lunar mansion subdivided into 4 parts.

ALIDADE

The alidade is plain without any markings. It is equipped with a copper sighting tube. There is a pin with a broad head and hole at the end to receive the wedge, but the wedge is lacking.

C033 SANSKRIT ASTROLABE, NOT SIGNED, NOT DATED[808]

19th century, Rajasthan

Diameter 153 mm

Qatar, Doha, Museum of Islamic Art (# MW.389.2009), Ex-Leonard Linton



Figure C033.1 – Front of the astrolabe (from Linton 1980)

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[808] The entry is based on the photos and description in Linton 1980, no. 181, pp. 124-125.

COMPONENTS

Mater (d. 153) with crown, shackle and ring, rete for 23 stars, 5 plates, alidade, pin and wedge.

FRONT

A high lobed crown, formed like a rectangle with rounded corners. On the front of the crown is engraved ‖*śrī-yantrarāja*‖, lit. ‘the glorious king of instruments’ that is, ‘the precious astrolabe’. All the engravings are filled with a black substance. The limb is divided to each degree and numbered by groups of six from 1 to 60.

RETE

The equatorial circle is nearly complete. The three rings of Capricorn, equator and ecliptic are joined by the equinoctial bar with two counterchanges. In the lower half, the rings of equator and Capricorn are joined by two straight bars. There is no visible turning knob; a small triangular stub represents the Capricorn index. The ecliptic is divided into the 12 signs of zodiac and labelled with their names. There are 23 very small dagger-shaped star pointers.

Table C033-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Matsyodara*		β Andromedae
3	*Pra*	*Pretaśira*	β Persei
4	*Rohiṇī*		α Tauri
5	*Mipā*	*Mithuna-vāma-pāda*	β Orionis
6	*Ārdrā*		α Orionis
7	*Ladhavaka*	*Lubdhaka*	α Canis Majoris
8	*lu.vadhu*	*Lubdhaka-bandhu*	α Canis Minoris
9	*Mahāpuruṣa*		α Hydrae

	Star Name as engraved	Full/Correct Form	Identification
10	*Pūphā*	*Pūrvaphālgunī*	δ Leonis
11	*Hasta*		δ Corvi
12	*Citrā*		α Virginis
13	*Pulaha*		β UMa
14	*Svāti*		α Bootis
15	*Sarpadhārīśira*		α Ophiuchi
16	*Abhijit*		α Lyrae
17	*Śravaṇa*		α Aquilae
18	*ku[kkuṭa]puccha*	*Kukkuṭa-puccha*	α Cygni
19	*Aśvamuṣa*	*Aśvamukha*	ε Pegasi
20	*Śatabhiṣā*		λ Aquarii
21	*Ubhā*	*Uttara-bhādrapada*	γ Pegasi
22	?		
23	?		

PLATES

There are five plates to serve the latitudes 17°—19°; 21°—23°; 25°—27°; 29°—31°; ecliptic coordinates (unnumbered) —horizons. One would have expected a plate for 32°, but here the maker chose the latitudes at the intervals of 2°. Azimuth arcs are engraved above and below the horizon, and the intersection of the altitude circles (drawn for 3°) with the azimuth arcs are marked occasionally by small circles to aid the reading of the plate, which is an unusual feature. There are lines for equal hours, but not numbered.

GEOGRAPHICAL GAZETTEER

On the inner surface of the mater, there is a geographical gazetteer with names and latitudes of 45 localities, but no photo is available.

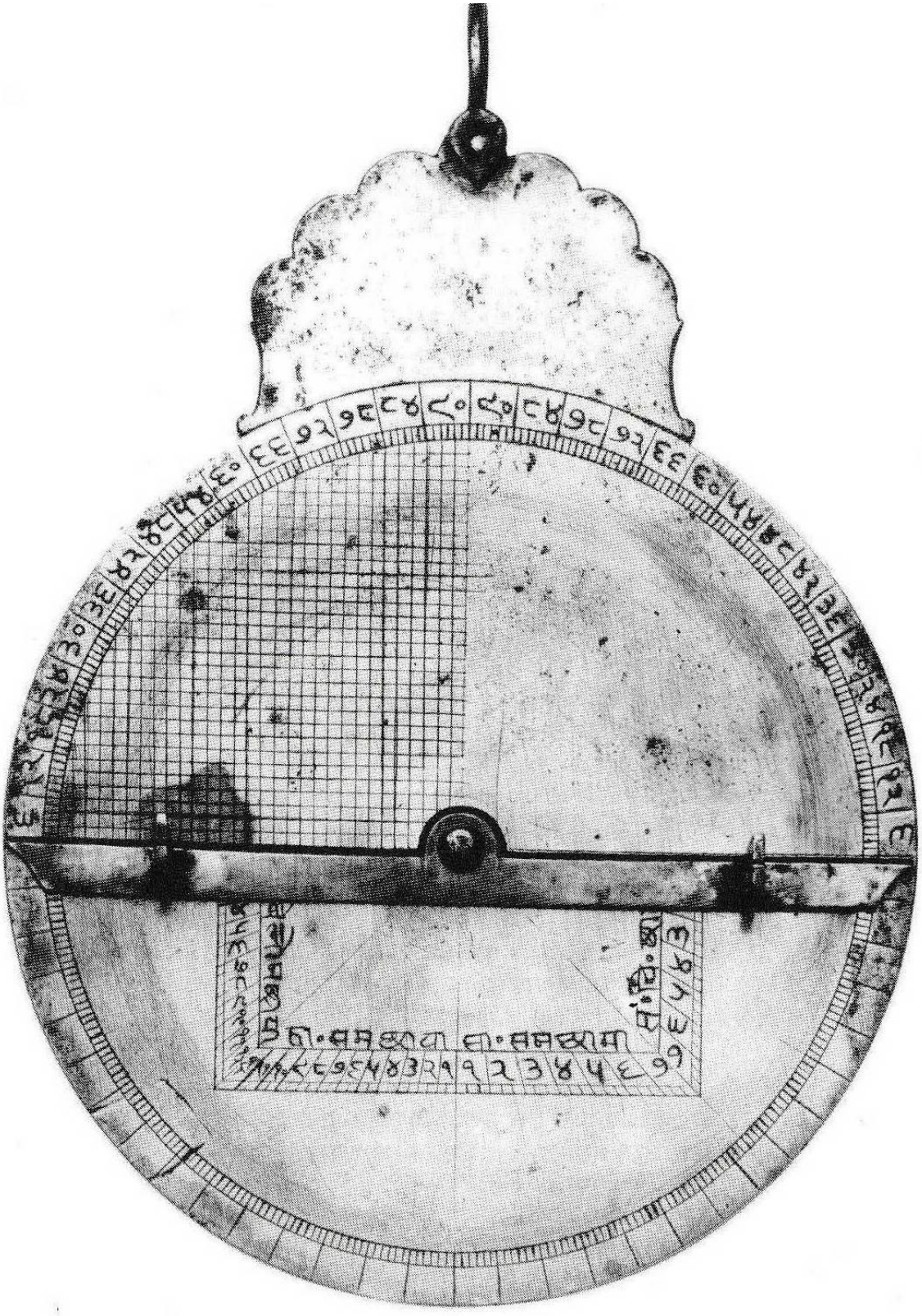


Figure C033.2 – Back of the astrolabe (from Linton 1980)

BACK

The rim of the upper half carries altitude scales, divided in 1° and 6° and numbered by 6s (6—90; 90—6). The rim on the lower half also carries a similar scale divided in 1° and 6°, but not labelled. The upper left quadrant carries a sine-cosine grid with 30 horizontal and 30 vertical parallels. The upper right quadrant is blank. In the lower half are the shadow squares, on the left for a base of 12 and on the right for a base of 7. The divisions are numbered and scales are labelled, not quite correctly. Vertical scale on the left: *bilomachāyā* (sic! *vilomachāyā,* 'umbra versa); horizontal scale on the left: *dvāsamachāyā* (sic! *dvādaśāṅgula-sama-chāyā,* 'umbra recta of 12 digits); horizontal scale on the right: *sā. samachāyā* (sic! *saptāṅgula-sama-chāyā,* 'umbra recta of 7 digits); vertical scale on the right: *sa. bi. chāyā* (sic! *saptāṅgula-viloma-chāyā,* 'umbra versa of 7 digits').

The catalogue states that 'the alidade is equipped with a sighting- tube in addition to pin-holes in the sights', but the photo shows just a plain straight alidade with two sights.

BIBLIOGRAPHY

Linton 1980, no. 181, pp. 124-125.

C034 SANSKRIT ASTROLABE DESIGNED BY HARIDATTA AND MADE BY LAKṢMĪNĀRĀYAṆA[809]

1883 Kuchaman, Rajasthan

Diameter 333 mm

Qatar, Doha, Museum of Islamic Art (# MW.395.2007)

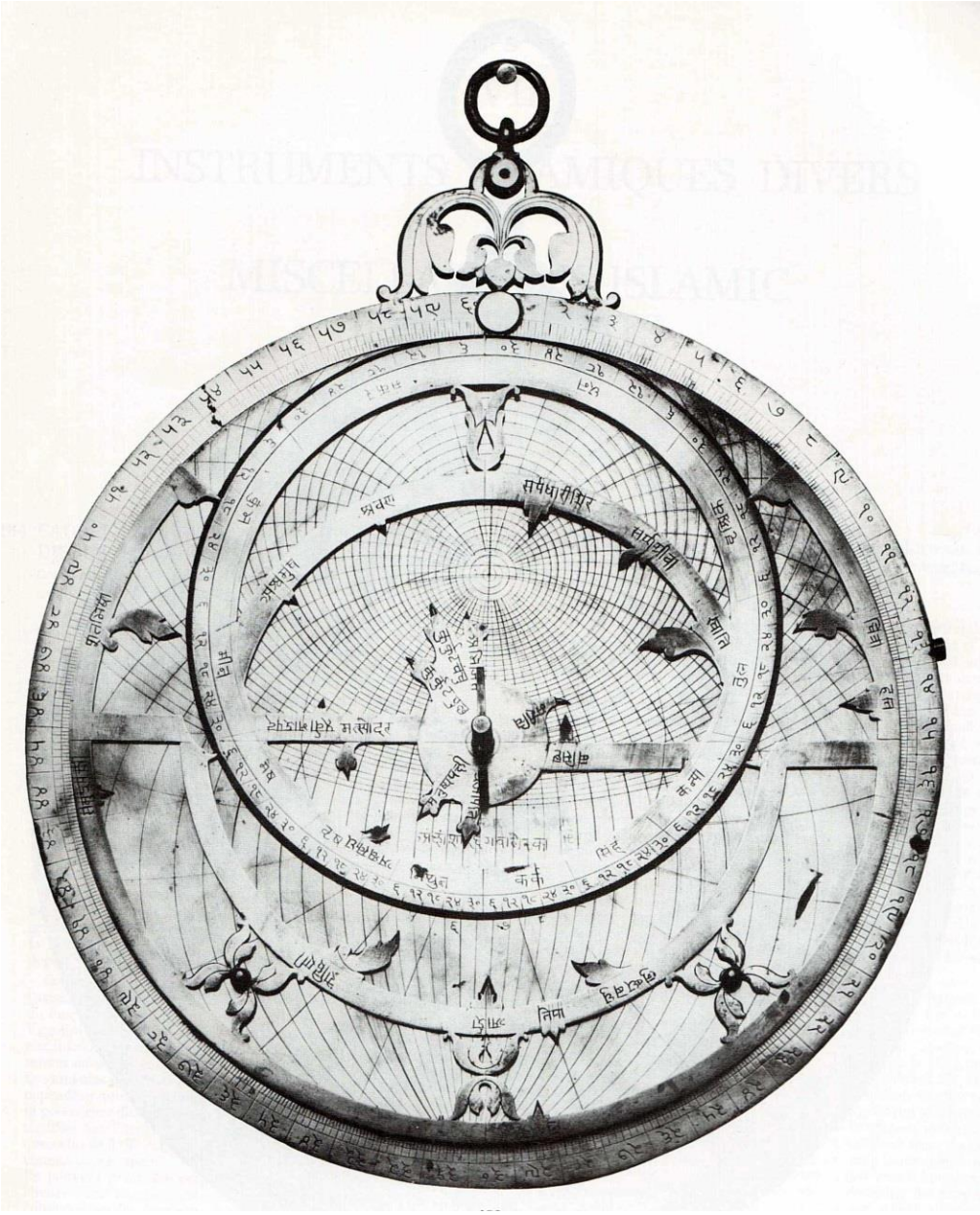


Figure C034.1 – Astrolabe by Lakṣmīnāryaṇa (photo from Linton 1980)

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[809] The entry is based on the description and photos in Linton 1980, No. 183, pp. 126-127. The interpretation of the inscription in Linton 1980 is very wrong; so too are the general statements about the style etc.

Lakṣmīnārāyaṇa,[810] master artisan (*ustād*) of Kuchaman in Rajasthan (27;09° N, 74;51° E) is known through five astrolabes; one of these is not dated (D038); the others are made in 1883 (C034), 1887 (D035), 1902 (D036) and 1903 (D037) respectively. The last two are the very last traditional astrolabes made in the twentieth century. The astronomer (*jyotirvid*) Jayakṛṣṇadāsa designed the undated astrolabe as well those of 1887 and 1902, while his son Haridatta designed those of 1883 and 1903. Thus both the father and son were active at the same time in designing[811] astrolabes which the master artisan Lakṣmīnārāyaṇa fabricated.

Of the five astrolabes produced by this group, the present astrolabe is the only one with multiple plates; the rest have a single plate calibrated to the latitude of 27°.

Components

Mater (d. 333) with crown, shackle and ring, rete for 22 stars, 4 plates, alidade with a sighting tube, pin and wedge.

Front

A very large astrolabe with a small crown in the form of an inverted lotus. The shackle is rather small, but the ring is large. The limb is divided in ½°, 1° and 6°. Groups of 6° are numbered serially from 1 to 60.

Rete

The broad ring of Capricorn, an almost complete ring of equator which is interrupted at its intersections with the ecliptic and a much broader ring of the ecliptic are held together by the equinoctial bar, which has one counter change at the centre. The rings of the ecliptic and the equator are jointed in the upper part by an ornate piece, and in the lower part by three X-shaped struts which are formed by joining base to base two lotus-like forms of the crown. The ecliptic is divided into the 12 zodiac signs and labelled with their names. Each sign is divided into groups of 6° and numbered in 6s. There are 22 star-pointers (catalogue says wrongly 24); some are leaf-shaped and some others dagger-shaped.

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810 Cf. Sarma 2010, s.v. Lakṣmīnārayaṇa.

811 In all these five astrolabes the past participle *kṛtam* (lit. done) is used in the sense of ‘designed’.

Table C034-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Matsyodara*		β Andromedae
2	*Aśvaskaṃdha*[812]	*Pretaśira*	β Persei
3	*Manuṣyapakṣī*	*Manuṣyapārśva*	α Persei
4	*Rohiṇī*		α Tauri
5	*Prajāpati*		δ Aurigae
6	*Ārdrā*		α Orionis
7	*Nipā*	*Mithuna-dakṣiṇapāda*	β Orionis
8	*Lubdhabadhu*	*Lubdhaka-bandhu*	α Canis Minoris
9	*Hasta*		δ Corvi
10	*Citrā*		α Virginis
11	*Basiṣṭa*	*Vasiṣṭa*	ζ Ursae Majoris
12	*Marīci*		η Ursae Majoris
13	*Svāti*		α Bootis
14	*Sarpagrīvā*		α Serpentis
15	*Sarpadhārī-śira*		α Ophiuchi
16	*Abhijit*		α Lyrae
17	*Kurkuṭacaṃcu*	*Kukkuṭa-cañcu*	β Cygni
18	*Śravaṇa*		α Aquilae
19	*Kukkuṭa-puccha*		α Cygni
20	*Aśvamuṣa*	*Aśvamukha*	ε Pegasi
21	*Śatabhiṣā*		λ Aquarii

[812] This star pointer is wrongly named *Aśvaskandha* β Peg; it is actually *Pretaśira* β Per.

	Star Name as engraved	Full/Correct Form	Identification
22	*Pūrvābhādrapadā*		β Pegasi

PLATES

According to Linton 1980, there are 4 plates to serve 17°—24°; 19°—27°; 22;36° —26°; 25°30' —31°. No photos are available of the plates. In the photo of the front, the plate for 26° can be seen beneath the rete. It carries altitude circles for every 2°, azimuth arcs above and below the horizon for every 6°, and equal hour lines. Altitude circles and azimuth arcs are not numbered. The hour lines appear to be numbered from the eastern horizon. Under the rete can be seen the numbers 5, 6, 7, 8. At the centre of this plate is written *akṣāṃśā 26 gavāler kā,* 'degrees of latitude 26, of Gwalior'. Here *kā* is Hindi genitive particle. Probably the other plates are also engraved in this manner. The inner surface of the mater is blank; there is no geographical gazetteer.

BACK

No photo of the complete back is available, except that of the shadow squares with the inscription. The Linton catalogue merely says "degree scale"; it is not known how the scale is numbered and what graphs occupy the upper two quadrants. The labels on the shadow squares read *dvādaśāṃgula-śaṃku-loma-chāyā* (umbra recta of the gnomon of 12 digits)*; dvādaśāṃgula-śaṃku-biloma-chāyā* (umbra versa of the gnomon of 12 digits)*; saptāṃgula-śaṃku-loma-chāyā* (umbra recta of the gnomon of 7 digits)*; saptāṃgula-śaṃku-biloma-chāyā* (umbra versa of the gnomon of 7 digits).[813]

INSCRIPTION

Inside the shadow squares is the following inscription in four lines.

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[813] Here umbra recta is called *loma-chāyā,* under the erroneous impression that *loma* is the opposite of *viloma*; the correct expression is *sama-chāyā.*

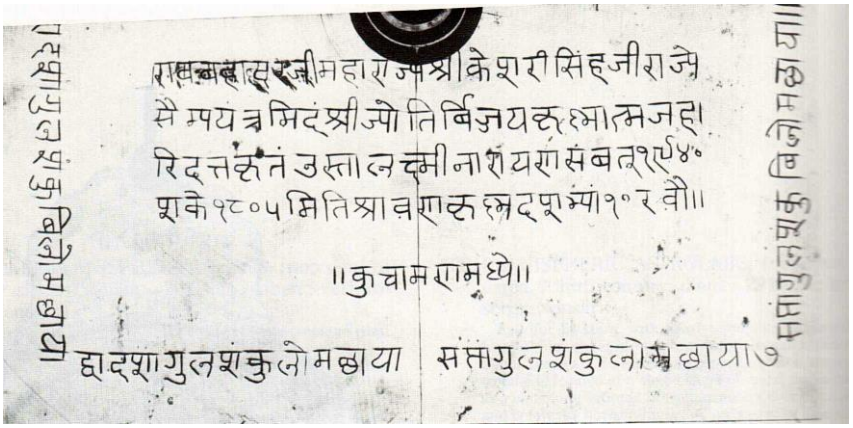


Figure C034.2 – Inscription on the Astrolabe (photo from Linton 1980)

~~*rāvabahādūrajī*~~ *mahārājya (sic! rāja) śrī-keśarīsiṃhajī rājye*
saimya (sic! saumya) yantram idaṃ śrījyotirbij-jayakṛṣṇātmaja-ha
ridatta-kṛtaṃ ustā[da] lakṣmīnārāyaṇa saṃbat 1940
śake 1805 miti śrāvaṇa-kṛṣṇa-daśamyāṃ 10 ravau ‖
‖kūcamaṇamadhye ‖

‘In the kingdom of (Rāo Bahādur-jī, a British colonial title that was scratched out in favour of a grander title ‘Mahārāja’ which was, however, spelt incorrectly as ‘Mahārājya’) Mahārāja Śrī Keśarīsiṃha, this northern astrolabe (saumyaṃ yantram, lit. northern instrument) was designed (kṛtaṃ) by Haridatta, son of the astronomer Jayakṛṣṇa, [and was made by] the master artisan (ustād) Lakṣmīnārāyaṇa. Saṃvat 1940, Śaka 1805, Sunday, the tenth day of the dark half of the month of Śrāvaṇa (= Sunday, 29 July 1883). In [the city of] Kuchaman.’

Provenance

Formerly in the private collection of Leonard Linton, Point Lookout, Long Island, until its dispersal in 1980.

Bibliography

Linton 1980, No. 183, pp. 126-127.

C035 ⦿ SANSKRIT ASTROLABE, NOT SIGNED, NOT DATED

Late 19th century, probably Kuchaman, Rajasthan

Diameter 304 mm

Paris, PC



Figure C035.1 – Front of the astrolabe (photo by S. R. Sarma)

A heavy and well-crafted piece; the crown is elegant in the form of an inverted lotus flower. The crown with the inverted lotus and the rete are very similar to those made by Lakṣmīnārāyaṇa at Kuchaman (C034 and D038). However, the back differs

from the backs in the astrolabes signed by Lakṣmīnārāyaṇa. Even so, the present astrolabe may also have been made by Lakṣmīnārāyaṇa, or somebody else at Kuchaman, partly in imitation of the astrolabes by Lakṣmīnārāyaṇa towards the end of the nineteenth century. Though elegantly made, the rete has several flaws.

COMPONENTS

Mater (d. 304, h. 407, t. 15) with crown, shackle and ring; rete (d. 280), six plates; there is no alidade; pin and horse may be later replacements.

FRONT

The limb is divided in 1°, 2° and 6° and is numbered in 6s, separately in each quadrant from 6 to 90 (6—90; 6—90; 6—90; 6—90).



Figure C035.2 – Rete of the Astrolabe (photo by S. R. Sarma)

RETE

The ring of the equator is almost complete. The three rings of the Tropic of Capricorn, equator and ecliptic are held together by the equinoctial bar with two counterchanges. The lower segment of the equinoctial ring and the ring of the Tropic of Capricorn are joined together by three X shaped ornate supports which appear in the

astrolabes made by Lakṣmīnārāyaṇa at Kuchaman. The support in the middle has a different design, matching with the arches under eastern and western ends of the east-west bar. A similar arch joins the rings of the equator and the ecliptic in the upper half. The ecliptic is divided into the 12 signs and labelled with their names; each sign is divided into groups of 6° and numbered; the bevelled edge is graduated in 1°. There are 22 dagger-shaped star pointers. Some of these are wrongly placed (marked by * in the list below); some are wrongly named. The following is roughly the sequence in increasing order of right ascension.

Table C035-1 Stars on the Rete

	Star Name as engraved	Correct/Full form	Identification
1	*Rohiṇī*		α Tauri
2	*Mi.vā.pāda*	*Mithuna-vāma-pāda*	β Orionis
3	*Lubdhaka*		α Canis Majoris
4	*Ārdrā*		α Orionis
5	*Brahmahṛdaya**		α Aurigae
6	*Mi.da.pāda*	*Mithuna-dakṣiṇa-pāda*	κ Orionis
7	*Lubdhakabandhu*		α Canis Minoris
8	*Brahmā*	*Marīci*	η Ursae Majoris
9	*Pūrvā Phālgunī*		δ Leonis
10	*Hastā*		δ Corvi
11	*Citrā*		α Virginis
12	*Siṃhahṛdaya**		α Leonis
13	*Svāti*		α Bootis
14	*Marīci**		η Ursae Majoris
15	*Sarpadhāriśira*		α Ophiuchi

	Star Name as engraved	Correct/Full form	Identification
16	*Viśākhā-mātṛ-maṇḍala**		α Coronae Borealis
17	*Śravaṇa*		α Aquilae
18	*Aśvamukha*		ε Pegasi
19	*Pūrvabhādrapadā*		α Pegasi
20	*Śatabhiṣā*		λ Aquarii
21	*Uttarā bhā*	*Uttara-bhādrapadā*	γ Pegasiasi
22	*Samudrapakṣī*		ι Ceti

PLATES

There are six plates, each side calibrated for a different latitude, but without any label. The latitudes range from 24° to 33°. Almucantars are drawn for every 2° or 3°, azimuths for every 6° above and below the horizon and unequal hour lines. None of these lines are numbered.



Figure C035.3 – Geographical Gazetteer (photo by S. R. Sarma)

GEOGRAPHICAL GAZETTEER

On the inner side of the mater is inscribed a geographical gazetteer in two concentric circles. In the outer circle are inscribed the names of twenty-three towns with their longitudes and latitudes. There are some orthographic errors, which are silently corrected in the following transcription.

Table C035-2 Geographical Gazetteer

	Towns (*nagarāṇi*)	**L (*deśāntara*)**	**φ (*akṣāṃśa*)**	**Modern Names**
1	Sūrata	110;0	21;26	Surat
2	Bharaveva	111;5	29;47	?
3	Āṇaṃda	108;0	23;0	Anand
4	Somanātha	103;7	17;0	Somnath
5	Ajanera	111;5	26;0	Ajmer
6	Āgarā	115;4	26;43	Agra
7	Vārāṇasī	117;20	26;15	Varanasi
8	Pālanapura	119;6	26;36	Palanpur
9	Kanoja	114;50	26;35	Kannauj
10	Odha	108;6	27;22	Oudh =Ayodhya =Faizabad
11	Ḍillī	113;35	28;32	Delhi
12	Hāṃsī	111;25	26;45	Hansi
13	Sthanoddhāra	112;33	30;10	Thanesar
14	Lāhora	109;20	32;5	Lahore
15	Mulatana	107;35	29;40	Multan
16	Ujjapitra	112;50	23;30	Ujjain
17	Sāroṃja	113;6	24;10	Sironj
18	Burānapura	112;0	21;21	Burhanpur
19	Hosanārāda	111	20;30	Hoshangabad
20	Amadānagara	107;40	23;0	Ahmednagar
21	Vijāura	104;20	17;0	Bijapur
22	Galakuḍā	115;19	18;4	Golkonda = Hyderabad
23	Junera	110.0	18;48	Junnar, Maharashtra

The names of the 12 towns in the inner circle are so garbled that none can be identified with any certainty. They are not reproduced here.

BACK

The rim of the upper half carries the altitude scale which is divided in 1° and 6° and labelled as 6—90; 90—6. In the upper left quadrant, there is a sine graph with 30 equi-distant horizontal lines. In the upper right quadrant there are six declination arcs, which are labelled along the vertical radius from the centre onwards as *Karka, Siṃha, Kanyā, Tulā, Vṛścika, Dhanu* (i.e. from Cancer to Sagittarius, from the summer solstice to winter solstice) and along the horizontal axis from the outer boundary towards the centre as *Makara, Kumbha, Mīna, Meṣa, Vṛṣabha, Mithuna* (i.e. Capricorn to Gemini, from the winter solstice to summer solstice). On the arcs is plotted a sigmoid graph indicating the meridian altitude of the sun; the label states *madhya-rekhā,* the 'middle line,' but there is no specification for which latitude this curve is meant.



Figure C035.4 – Back of the astrolabe (photo by S. R. Sarma)

In the two lower quadrants, there are shadow squares of 12 and 7 divisions. These are labelled quite correctly as *dvādaśāṃgulaśaṃkor viloma-chāyā* (umbra versa of the gnomon of 12 digits), *dvādaśāṃgulaśaṃkos sama-chāyā* (umbra recta of the gnomon of 12 digits), *saptāṃgulaśaṃkos sama-chāyā* (umbra recta of the gnomon of 7 digits), *saptāṃgulaśaṃkor viloma-chāyā* (umbra versa of the gnomon of 7 digits). Within the square are two concentric arcs, the inner one filled with the names of the 12 zodiac signs and the outer one with the names of the 28 corresponding lunar mansions.

BIBLIOGRAPHY

Tesseract Catalogue 18, item 27.

C036 SANSKRIT ASTROLABE, NOT SIGNED, NOT DATED[814]

Late 19th century

Diameter 154 mm

PLU, ex-London, Christie's, ex-Frankfurt, PC



Figure C036.1 – Front of the astrolabe (photo by the former owner)

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814 Entry based on the photos and measurements kindly provided in 2006 by the then owner; cf. Sarma 2008c, pp. 17-23.

This astrolabe is neither signed nor dated. But in the geographical gazetteer, Jaipur is mentioned together with its latitude at 27°. Since this city was founded by Sawai Jai Singh around 1728, the present astrolabe must have been produced thereafter. But the crudely cut rete with several star names engraved on wrong pointers, latitude plates engraved only on one side and, above all, the lines on the plates etched with acid and not engraved indicate that it is a recent copy. This is not to suggest that it is one of the modern fakes which are produced in great numbers at Muradabad, but an intelligently made copy, probably of the late nineteenth century.

The different elements in this astrolabe have similarities to different extant astrolabes. It is difficult to say whether there existed an astrolabe with all these features which was copied here or whether the maker of this astrolabe had copied the elements from different astrolabes. The X-shaped struts that join the ring of the Tropic of Capricorn and equatorial ring are similar to those in the astrolabes made at Kuchaman also in the late 19th century (see C034 and C035). The plates for 25°, 27°, ecliptic coordinates, horizons and the double projection of 0° and 90° are exactly like the same in Rāghavajit's astrolabe of 1669 (C008).

There exist at least other copies, which will be listed below. All these are identical in all respects including the size, but the floral designs on the crowns are different in each piece. It is intriguing why the artisan who could produce such elegant crowns did not engrave the latitude plate by hand and why he did not equip the astrolabes with alidades.

Components

Mater (d. 154, h. 189, t. 11.7) with crown, shackle and ring, rete for 26 stars (d. 138.4), 5 plates (138.6) engraved only on one side, pin and wedge, but no alidade.

Front

An elegantly crafted crown, with its surface covered on both sides with an identical floral design in bas relief, and surmounted by a trifoliate finial. The shackle is well made, the ring is large.

The limb is divided in 1° and 6° and the groups of 6° are numbered serially from 1 to 60. The figure 9 looks almost like the figure 8 with tiny curves at the two terminals. At the north point of the limb, there is an oblong tooth to hold the plates in position.

RETE

In the rete the rings of Capricorn, equator and the ecliptic are almost fully represented. These are held together by a broad equinoctial bar without any counter change. In the lower half, the equator ring and that of Capricorn are joined by ornate X-shaped supports, which are reminiscent of astrolabes made in Kuchaman. The ecliptic is divided into 12 signs of zodiac and labelled, each sign is divided into groups of 6° and labelled.



Figure C036.2 – Rete of the astrolabe (photo by the former owner)

There are 26 named dagger-shaped star pointers, 10 outside the ecliptic and 16 inside. However, in four cases the names are engraved on wrong pointers (these are marked with * in the list below) and no pointer is provided for α Leonis, although the

name *simha-hṛdaya* is engraved on the equinoctial bar. The stars are listed below, according to increasing right ascension.

Table C036-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
01	*Samudrapakṣī*		β Ceti
02	*Matsyodara*		β Andromedae
03	*Pre. si.*	*Preta-śirā*	β Persei
04	*Matsyodapāda*	*matsyodara-pāda*	γ Andromedae
05	*Rohiṇī*		α Tauri
06	*Bapahadaya*	*Brahma-hṛdaya*	α Aurigae
07	*Mithuvāma*	*Mithuna-vāma-pāda*	β Orionis
08	*Ādrā*	*Ārdrā*	α Orionis
09	*Lubdhaka*		α Canis Majoris
10	*Lubdhakabaṃdhu*		α Canis Minoris
11	*Mahāpuruṣa*		α Hydrae
12	*Maricī**		η Ursae Majoris
13	*Siṃhahṛdaya*		α Leonis (no star pointer)
14	*Pūrvāphālgu*	*Pūrvāphālgunī*	δ Leonis
15	*Hasta*		δ Corvi
16	*Citrā*		α Virginis
17	*Abhijit**		α Lyrae
18	*Svāti*		α Bootis
19	*Sarpadhātiḥ*	*Sarpadhārīśira*	α Ophiuchi
20	*Viśākhāmātṛmada**	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis

	Star Name as engraved	Full/Correct Form	Identification
21	*Kukkuṭapuccha**		α Cygni
22	*Śravaṇa*		α Aquilae
23	*Pūrvābhādrapa**	*Pūrva-bhādrapadā*	β Pegasi
24	*Aśvamukha*		ε Pegasi
25	*Śatabhiṣā*		λ Aquarii
26	*Uttarābhā*	*Uttara-bhādrapadā*	γ Pegasi

PLATES

The five plates carry projections only one side, the other side being blank. While the letters and numerals are written by hand on the rest of the astrolabe, here on the plates they appear to have been stamped by the leaden fonts as used in a printing press.

Plate 1

This plate is for latitude of 25°. Altitude circles are drawn for 6° and numbered. Azimuths are drawn for 15° below the horizon and numbered. Below the eastern and western ends of the horizon line are written *pū[rva],* 'east' and *pa[ścima],* 'west'. There are lines for unequal hours and equal hours numbered from the western horizon. In the centre is written: *akṣāṃśa 2 horā 13,* 'latitude 25°; maximum daylight 13 hours.'



Figure C036.3 – Plate for the latitude of 25° (photo by the former owner)

Plate 2

This plate is for the latitude of 27°. The altitude circles, azimuth circles and the hours lines are as in Plate 1. In the centre of the plate is written *akṣāṃśa 27 horā 1342,* 'latitude 27°, maximum daylight 13;42 hours.'

Plate 3

This plate is with a double projection for 0° in the upper half and for 90° in the lower half for 90°. Below the horizontal diameter on the west is engraved *tirakṣa,* wrongly for *nirakṣa* 'terrestrial equator'. At the bottom, to the left of the meridian, is

the label *paramā akṣāṃśa* (sic! *paramākṣāṃśa*), ‘the ultimate latitude’ meaning latitude 90°. This plate closely resembles the same in Rāghavajit’s astrolabe of 1669 (C008).

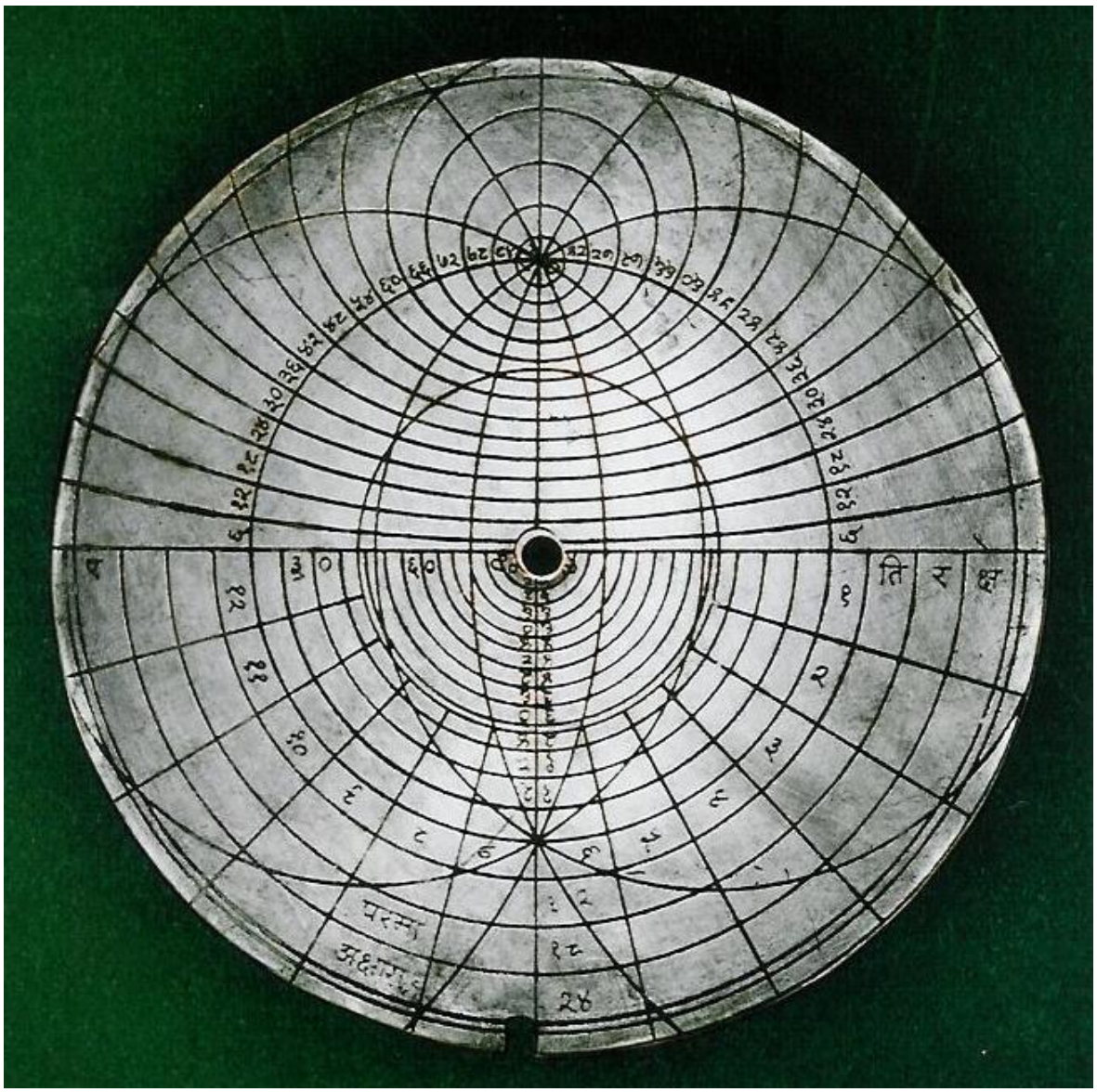


Figure C036.4 – Plate for the latitudes 0° and 90° (photo by the former owner)

Plate 4.

Ecliptic Coordinates. Inscription: *akṣārā 66* wrongly for *akṣāṃśa 66*, ‘latitude 66°’. There are no projections for the equator and the Tropic of Cancer. Almucantars for 6°, labelled along the meridian from 6 to 90. Azimuth lines for 10°, labelled separately for each zodiac sign as 10, 20, 30; for *meṣa* to *kanyā* outside the ecliptic; for *tulā* to *mīna* inside the ecliptic. The plate closely resembles the same in Rāghavajit’s astrolabe of 1669 (C008).

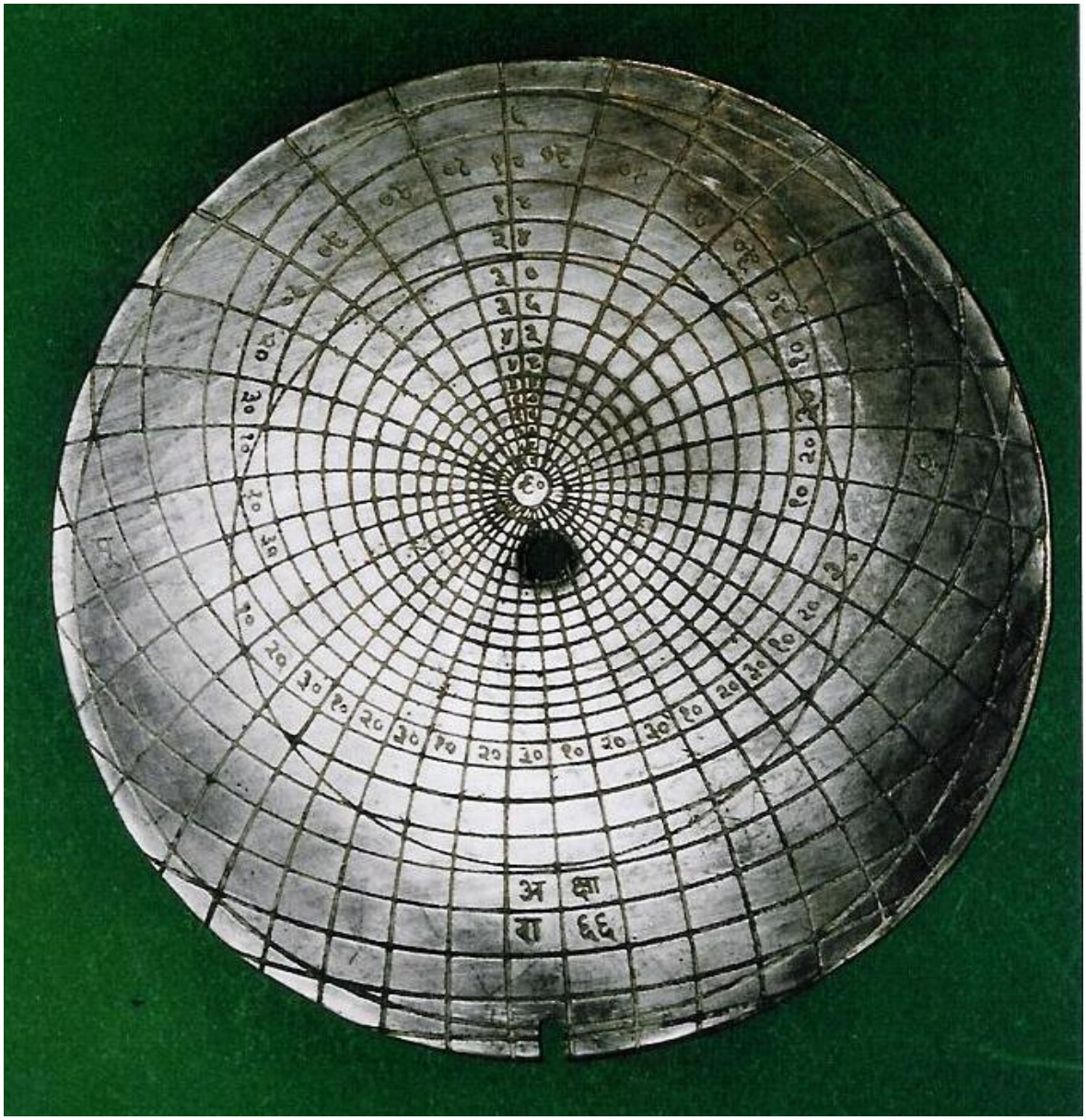


Figure C036.5 – Plate of ecliptic coordinates (photo by the former owner)

Plate 5.

Multiple Horizons. There are four sets of half horizons, eight for each quadrant, labelled twice along the vertical / horizontal side and the arc of the quadrant. These are drawn for latitudes from 4° to 66° at intervals of 2°. Along the radii are marked the scales of declination, with the divisions reading 6, 12, 18, 23. The last value is the maximum declination ε. This plate also closely resembles that of Rāghavatjit (C008).

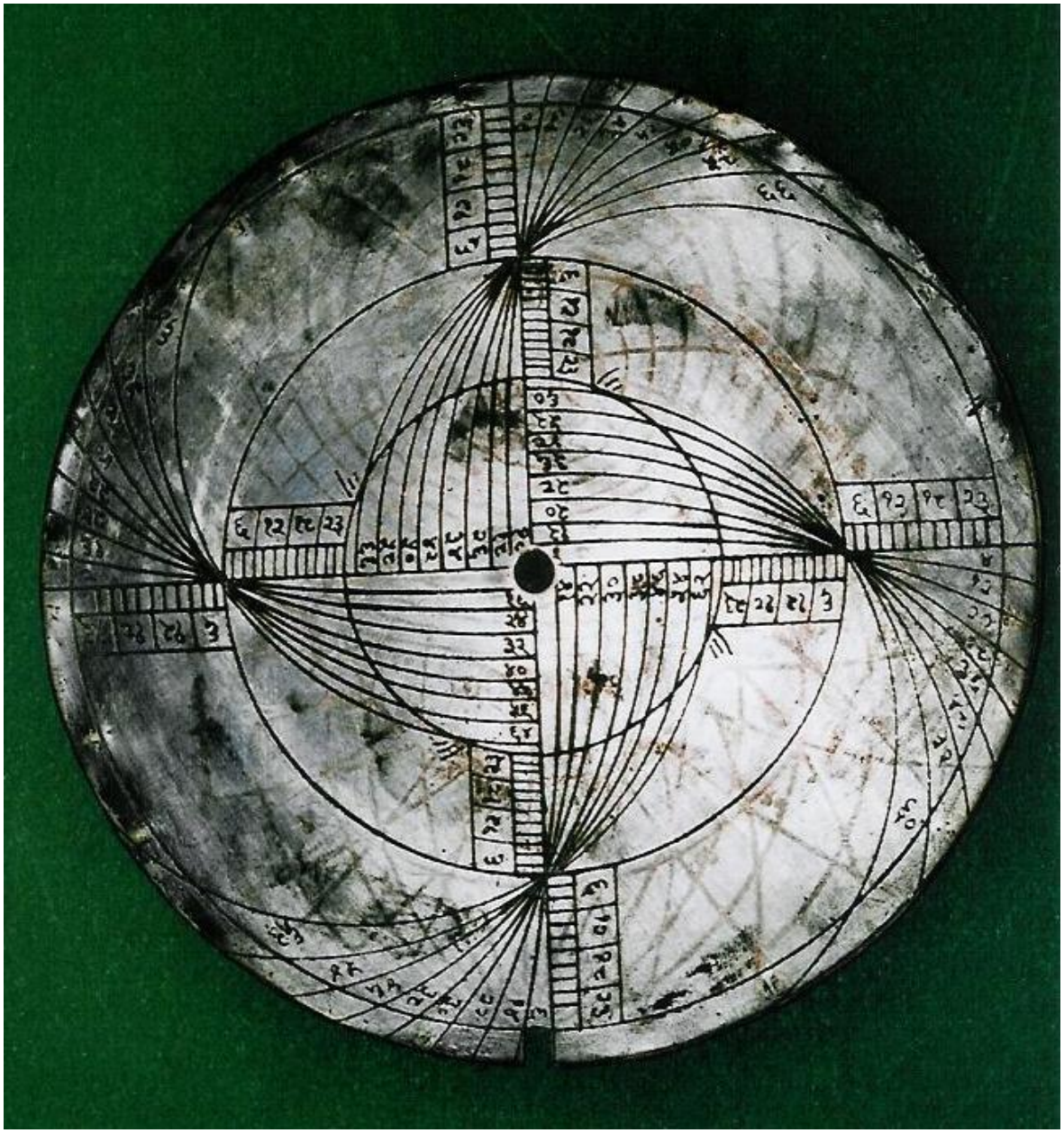


Figure C036.6 – Plate of horizons (photo by the former owner)

Geographical Gazetteer

The geographical gazetteer is engraved on the inner surface of the mater in a grid of eight annular rings, but only four of these are filled with the names and latitudes of 48 places. These contain many names which occur here for the first time, such as, Jaisalmer, Bikaner, Udaipur, Mathurā, Badarīnātha and Haridvāra. Six of these names are in locative singular (which is the practice), though not correctly transcribed here.

This gazetteer is put together, rather indiscriminately, from diverse sources. Three cities are mentioned twice. Qandahar in modern Afghanistan is mentioned twice (no. 7 Kadāra 33° and no. 23 Kadhāra 33°). No. 14 Ḍholatāvāda 20;30° and no. 32 Devagirau 20;34° are identical, for the Yādava capital Devagiri was renamed Daulatabad after the

Muslim conquest. Again, Golconda (modern Hyderabad) appears twice in two designations: no. 42 Molakuḍā (sic! for Golakoṇḍa) 18° and No. 16 Taila[ṃ]ge 18°. Trilinga or Tailanga is actually the designation for southern Deccan.

The numerals engraved here are slightly different from those engraved on the surrounding rim. In both places the 9 has a peculiar shape. In the gazetteer, ‘dvā’ and ‘kṣa’ have very peculiar shapes.

The places are listed below, starting from the top and proceeding clockwise:

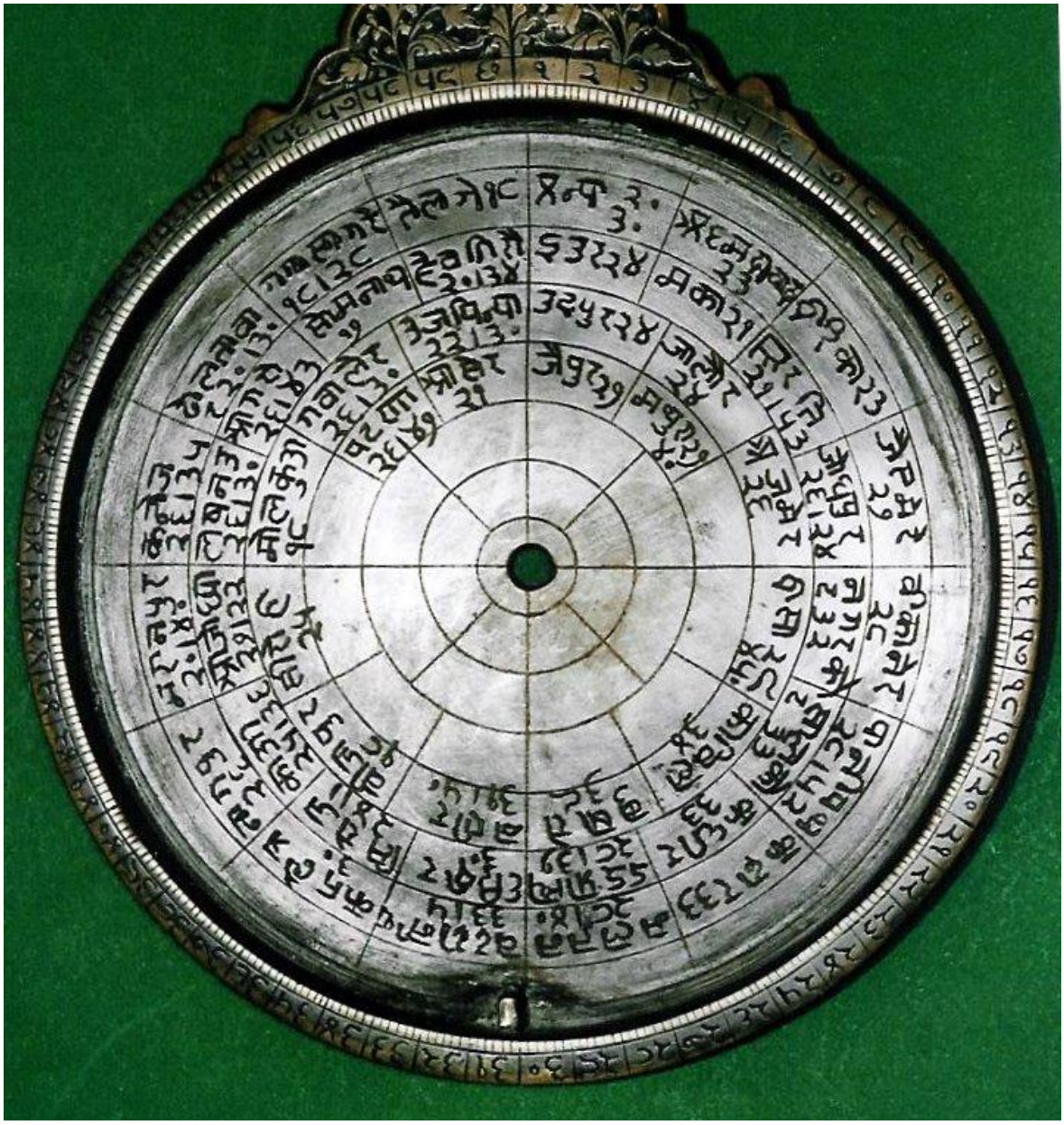


Figure C036.7 – Geographical gazetteer (photo by the former owner)

Table C036-2 Geographical Gazetteer

	Place Name	φ	Modern Name
	First Circle		
1	-nyā	20;30	?
2	Ahamadāvāda	23	Ahmedabad
3	Dvārikā	23	Dwaraka
4	Jaisa[la]mere	27	Jaisalmer
5	Vīkanera	28	Bikaner
6	Pānīpatha	28;52	Panipat
7	Kadāra	33	Qandahar (see 23 below)
8	Malatāna	28;40	Multān
9	Vadarīnātha	33;5	Badrinatha
10	Karukṣetra	30	Kurukshetra
11	Nāgapura	26	Nagpur ?
12	Bharānapura	20;44	Burhanpur
13	Kanoja	26;35	Kannauj
14	Ḍholatāvāda	20;30	Daulatābād (see 32 below)
15	Ga[ṃ]gāsāgare	18;28	Gangasagar
16	Taila[ṃ]ge	18	Hyderabad (see 42 below)
	Second Circle		
17	*ura	24	?
18	Makā	21	Mecca
19	Sūrati	21;53	Surat
20	Jodhapura	26;24	Jodhpur

	Place Name	φ	Modern Name
21	Nāgarakoṭa	32	?
22	Sālakoṭa	33	Siyalkot
23	Kadhāra	33	Qandahar (see 7 above)
24	I[n]draprāstha	28;37	Indraprastha = Delhi
25	Haridvāra	30	Hardwar
26	Siroja	24;1	Sironj
27	Kāsī	25;36	Varanasi
28	Ajodhyā	27;22	Faizabad (lat. too high)
29	Laṣanaü	26;30	Lucknow
30	Āgaro	26;43	Agra
31	Somanātha	17	Somnath
32	Devagirau	20;34	Daulatabad (see 14 above)
	Third Circle		
33	Uda[ya]pura	24	Udaipur (lat 27;42!)
34	Jālaura	24	Jalore
35	Ajamera	26	Ajmer
36	Dvāsā	29;45 ?	Hansi ?
37	Kāvila	34	Kabul
38	Buṣāro	39	Bukhārā
39	**īra	31;50	?
40	Vījāpura	18	Bijapur
41	Sīrohā	25	Sirohi

	Place Name	φ	Modern Name
42	Molakuḍā	18	Golconda = Hyderabad (see 16 above)
43	Gavālera	26;30	Gwalior
44	Ujjayinyā	22;30	Ujjain
	Fourth Circle		
45	Jaipura	27	Jaipur
46	Mathurā	27;40	Mathura
47	Paṭaṇā	26;47	Patna
48	Āsera	21	Asirgarh

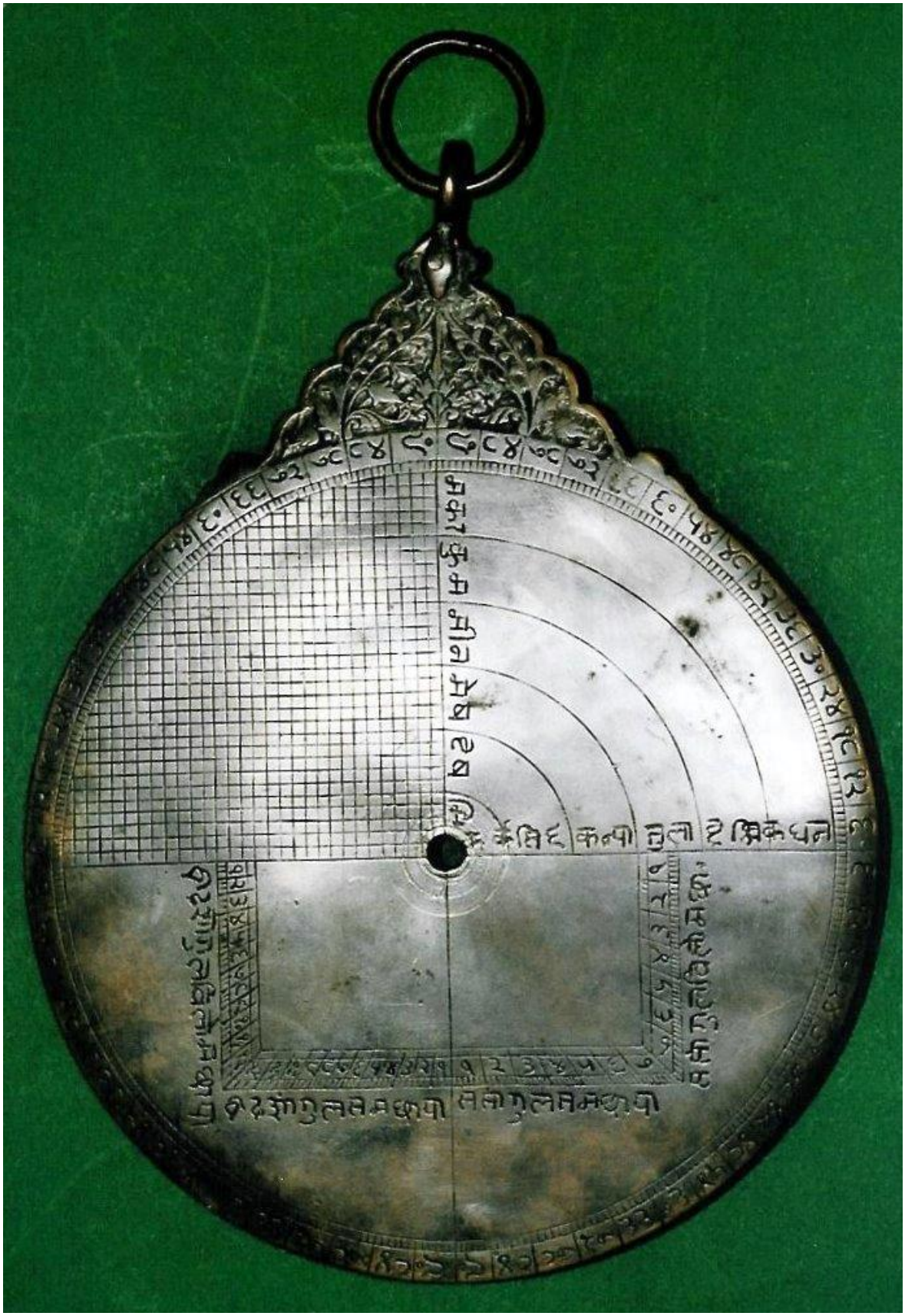


Figure C036.8 – Back of the astrolabe (photo by the former owner)

Back

The rim in all the four quadrants is divided in 1° and 6° and numbered in 6s, from 6 to 90, separately for each quadrant, starting from the east and west points and reaching up to the south and north points (6—90; 90—6; 6—90; 90—6). The upper left quadrant contains a sine-cosine graph with 30 equidistant horizontal and 30 equidistant vertical parallels. In the upper right, there is a solar quadrant with quarter circles for each 30° of solar longitude, labelled from the summer solstice to winter solstice along the horizontal axis (*karka, si[ṃ]ha, kanyā, tulā, vṛścika, dhana !*) and from the winter solstice to the summer solstice along the vertical axis (*makara, ku[ṃ]bha, mīna, meṣa, vvṛṣa, mi[thuna]*). The letter 'ha' is unusual; it resembles more the number '6'.

Shadow squares in the two lower quadrants, on the left for a gnomon of 12 digits and on the right for a gnomon of 7 digits. The scale is divided for each digit, and then in one-thirds of the same. The labels are *dvādaśā[ṃ]gula-viloma-chāyā* (umbra versa of 12 digits), *dvādaśāṃgula-sama-chāyā* (umbra recta of 12 digits), *saptāṃgula-sama-chāya* (umbra recta of 7 digits) and *saptāṃgula-viloma-chāya* (umbra versa of 7 digits).

Other Copies

The artisan appears to have produced at least three other copies of this astrolabe. The first is in a private collection in Mumbai (C037); another one is in a private collection in Dallas; a third one came up for auction at Christie's, London, on 6 April 2011, sale 5674, lot 82. There may be more copies. The copy that I had seen Mumbai will be described in the next entry. It is not necessary to document the copies.

Provenance

In 2006, the astrolabe was with a private collector in Germany who bought it in India. I understand that it came up for auction at Christie's, London, on 22 April 2010, sale 5489, lot 53 and again on 23 September 2010, sale 5490, lot 42.

Bibliography

Sarma 2008d.

C037⊙ SANSKRIT ASTROLABE, NOT SIGNED, NOT DATED

Late 19th century

Diameter 148 mm

Mumbai, PC



Figure C037.1 – Front of the astrolabe (photo by S. R. Sarma)

Like the previous item, this too is a copy, somewhat inferior in production. The ornamental designs on the front and back of the crown are different. Otherwise, this astrolabe carries the same projections and the same numerals and labels (including the same or more errors), as is evident from the illustrations.

COMPONENTS

Mater (d. 148, h. 184, t. 11.5) with crown, shackle and ring, rete with 26 stars, 5 plates engraved only on one side; no alidade, pin and wedge.

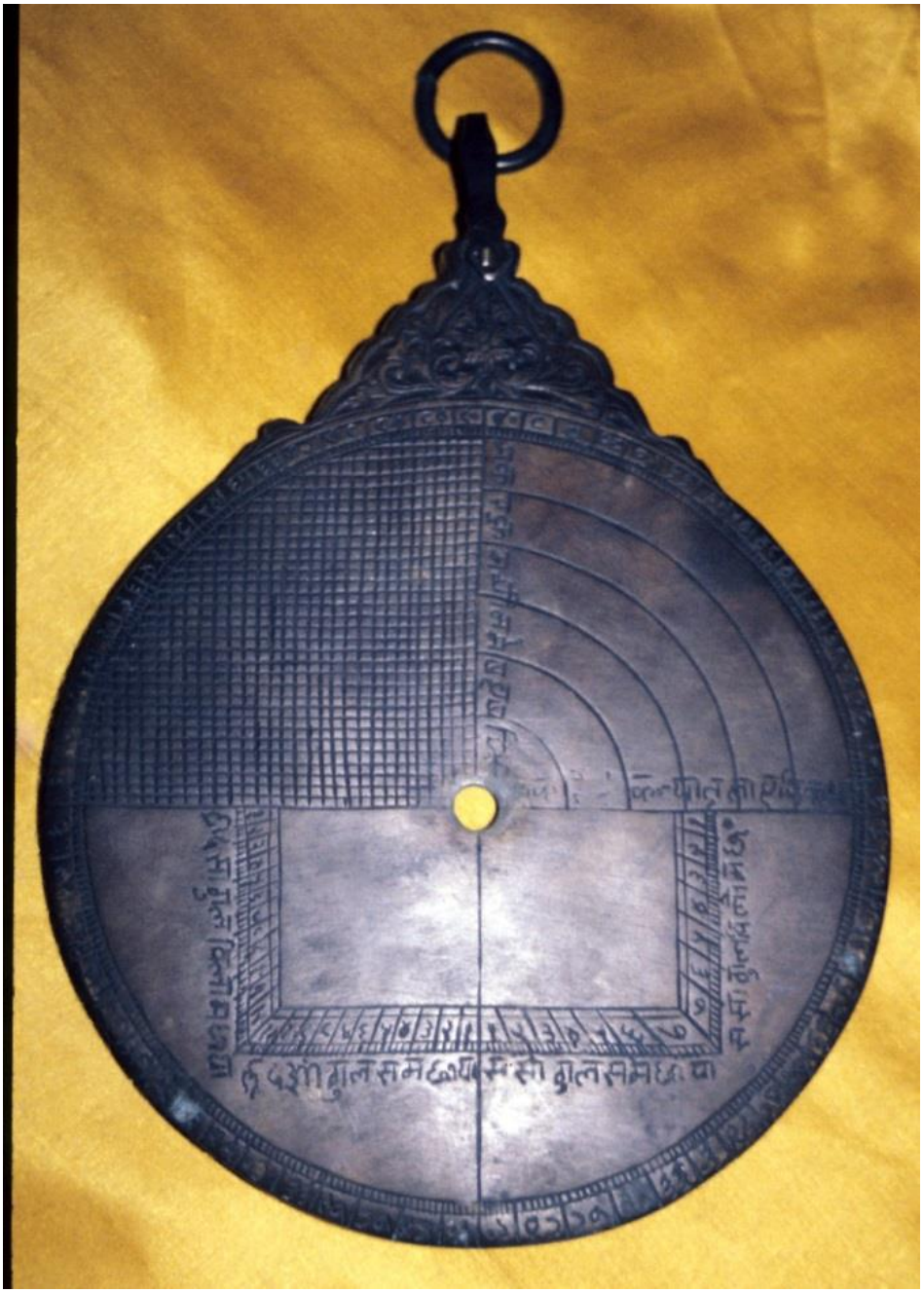


Figure C037.2 – Back of the astrolabe (photo by S. R. Sarma)

C038 SANSKRIT ASTROLABE WITH A RECTANGULAR CROWN, NOT SIGNED, NOT DATED

19th century, place of manufacture unknown

Diameter ?

PLU

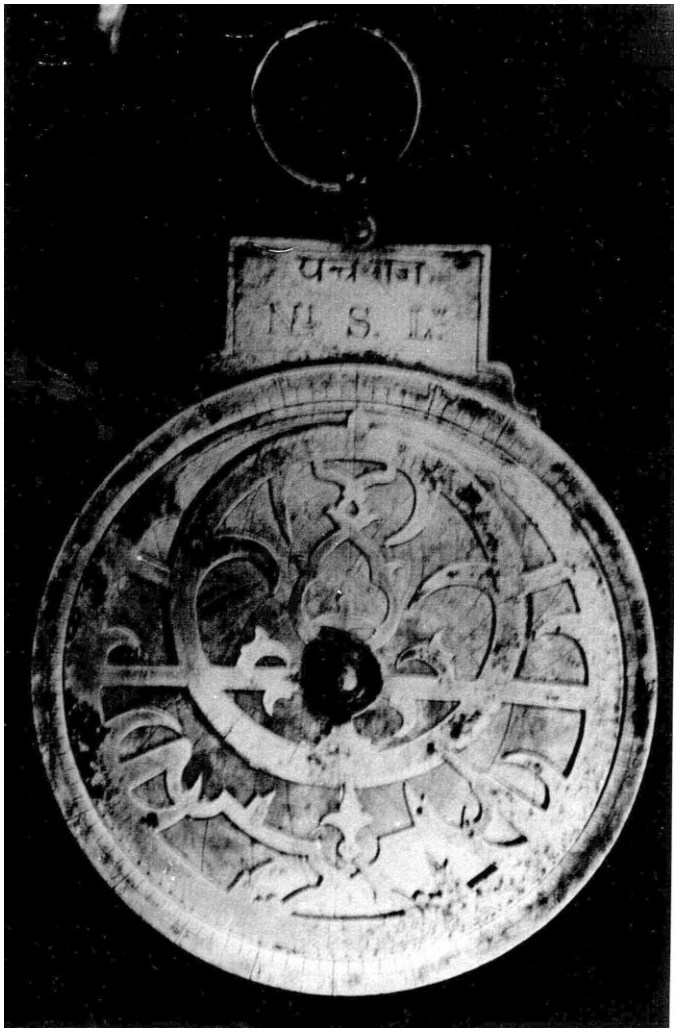


Figure C038.1 – Front of the astrolabe (courtesy Museum of the History of Science, Oxford)

In the archives of the Museum of the History of Science, Oxford, there are four photos of a strange astrolabe with an ugly rectangular crown on which is engraved *yantrarāja* (in Devanagari) and below it (in Roman letters) N^{I}. S. L^{w}. (initials of the name of a European who commissioned it?), a small shackle and a very large ring. There is a regular mater with a raised rim, the inner side filled with a gazetteer-like table. The latitude plate appears to have been calibrated for 24°. Maybe there are more plates. The photos are very dark and not sharp; much cannot be gleaned there.

FRONT

The limb seems to be divided in 3° in the inner band and in 15°in the outer band. In the outer band the two digit numbers are engraved one each on either side of the division mark, in counter-clock direction. The numbers 15, 30, 35 are visible to the left of the south point; the other numbers are not visible.

RETE

The rete is of the 'bird in the cage type'. It consists of two broad rings of the Tropic of Capricorn and the ecliptic, held together by the equinoctial bar without counter change. The space between these rings and inside the ecliptic ring is filled by an inelegant tracery containing the star pointers. From the available photos, the number of the star pointers cannot be ascertained, nor can a single star name be discerned.

PLATE

One plate face can be seen in the photos. Here almucantars are drawn for every 6° and numbered. Azimuths are drawn above the horizon for every 15°. Lines are drawn for equal hours counted from the western horizon. The plate appears to have been made for the latitude of 24°.



Figure C038.2 – Plate of the astrolabe (courtesy Museum of the History of Science, Oxford)

INNER SIDE OF THE MATER

On the inner side of the mater is a grid of five annuli, three of which are filled, not with a geometrical gazetteer as one would expect, but with the names of astrolabe stars followed by some numbers. In the two upper cells of the outer annulus can be discerned *Kukkuṭapuccha 30* (α Cygni) and *Aśvanābhi 1* (δ Pegasi). In the middle annulus there is *Matsyodara 3* (β Andromedae). In the inner annulus has *Samudrapakṣī* 32 (β Ceti), *Asvinī* 6 (γ Ari), *Rohiṇī 8* (α Tauri). Others cannot be deciphered. There appear to be 32 such star names.

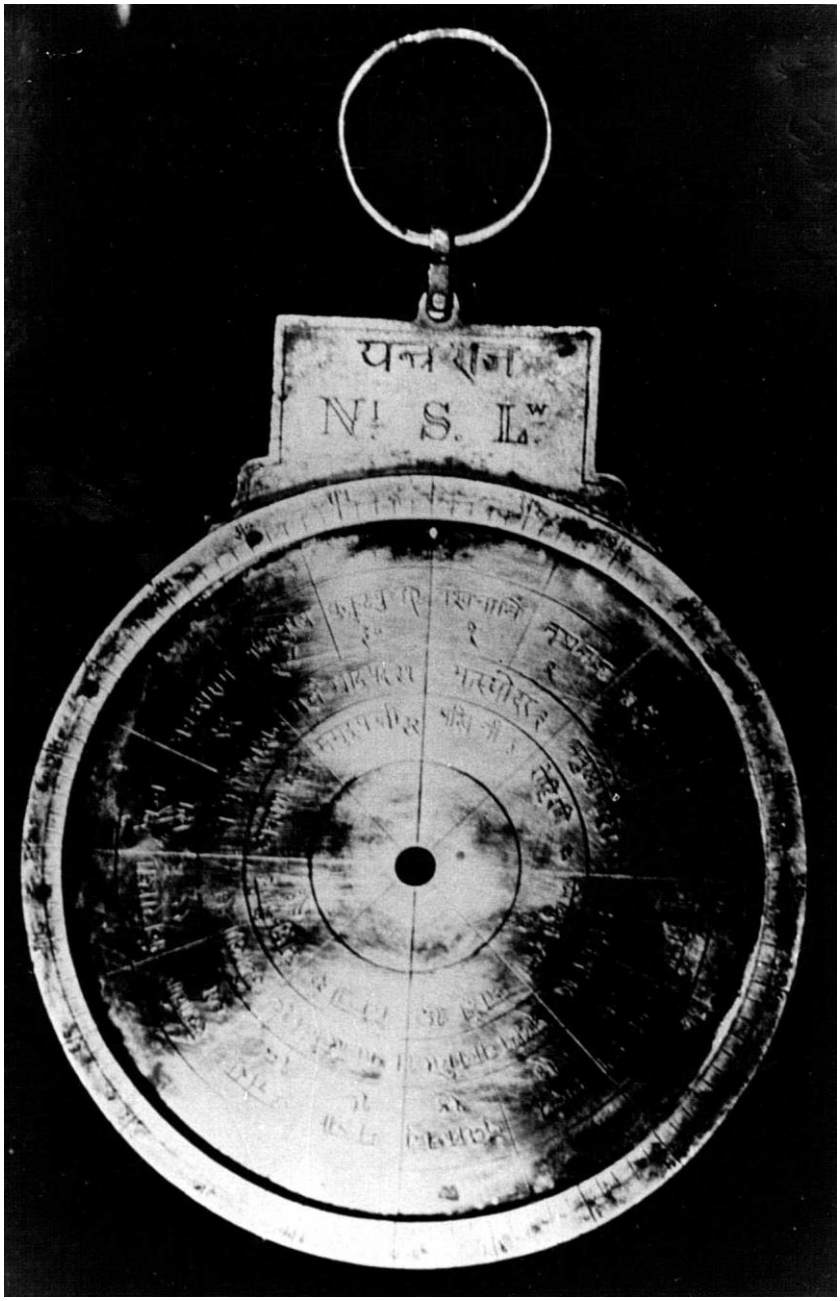


Figure C038.3 – Inner side of the mater (courtesy Museum of the History of Science, Oxford)

BACK

On the rim is engraved a scale in three bands. The middle band appears to be divided in 3°. In the lower half some undecipherable numbers are visible in the inner band. The two upper quadrants are blank. However, to the left of the vertical radius are engraved some numbers, starting from the centre and proceeding to the south point, these are 30, 35, 60, 72, 88.

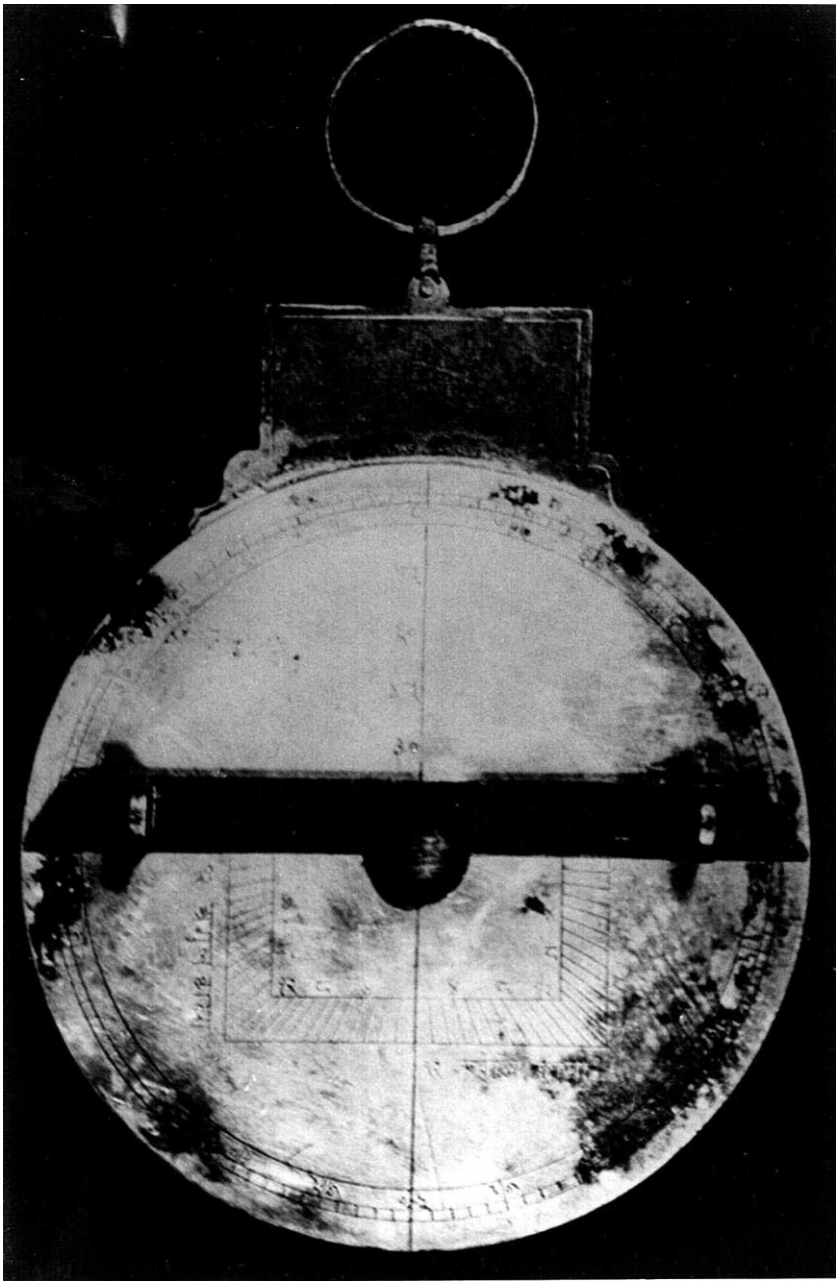


Figure C038.4 – Back of the astrolabe (courtesy Museum of the History of Science, Oxford)

In the lower half are the shadow squares, of 12 to the left, and of 7 to the right. The scales are divided accordingly. The vertical scale on the left has the label *12 aṃgula chāyā,* ’12 digit shadow’; the horizontal scale has no label. The horizontal scale on the right has a label which cannot deciphered; the vertical scale does not seem to have a label.

Since most of the engravings cannot be deciphered, it is not possible to decide conclusively whether it is a fake or a genuine, but unusual, astrolabe. The strange and inelegant crown, star names in the table on the inner surface of the mater, and even the style of the scales on the limb are causes for suspicion. On the other hand, the lines of equal hours on the plate is an interesting but rare feature.

D. SANSKRIT ASTROLABES WITH SINGLE PLATES

INTRODUCTION

An astrolabe with a single plate designed for a particular locality is a simplified but very pragmatic or utilitarian version of the conventional astrolabe. Except for the limitation that it can be used only at a single latitude and not in all the seven climates, it can perform nearly all the functions envisaged for the astrolabe. The major advantage is that its construction is much easier and therefore the time and cost of production are considerably less. Such versions are not known elsewhere;[815] they seem to have been developed mainly in the Sanskrit milieu, in particular in Rajasthan, quite likely by the astronomer-prince Sawai Jai Singh (1688-1743) who is otherwise well-known for the huge masonry instruments with which he set up observatories at Jaipur, Delhi, Benares, Ujjain and Mathura.[816]

Jai Singh experimented at first with larger versions of some portable instruments of Islamic tradition. One of these was a very large brass astrolabe plate which he got constructed with a diameter of 2115 mm and had it calibrated for the latitude of his capital city at 27° (D001). Since the pin would not have been able to bear the weight of the full rete which needs to be rotated around the pin, he reduced the rete to the minimum, and had the ecliptic and the star pointers engraved on the latitude plate itself. Even then the difficulty of mounting and manipulating this large astrolabe remained. Therefore, he abandoned these large portable metal instruments and designed masonry

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815 A single plate astrolabe calibrated for the latitude of 34° and inscribed in Kufic characters is described by Morley 1856, pp. 34-36, Figs. xviii-3 (suspensory apparatus), xx-24 (rete), xxi-42 (alidade) and xxi-49 (wedge). It had a diameter of 225 mm and was 'evidently of modern date'. It may have been produced in Damascus, but did they still Kufic script in 'modern' times? Morley saw it in the museum of the East-India House. Many artefacts from there were transferred to the Victoria and Albert Museum, London. Probably, it is still in this museum.

816 The fifth observatory at Mathura exists no longer. Today these historic observatories are called by the vulgar name 'Jantar Mantar' which literally means 'magical diagram and magical incantation'. This name was originally given to Jai Singh's Observatory at Delhi by people on the street who did not understand the purpose of these huge structures. In recent times this name was thoughtlessly extended to all the observatories by the authorities; it is employed also in Government of India's application to the UNESCO for grating heritage status to the Jaipur Observatory! It is ironic to call these unique scientific monuments by an unscientific name derived from the realm of the occult. It is better to call them Jai Singh's Observatories.

instruments of very large dimensions in order to achieve very minute readings on the scales.

Although he did not consider the astrolabe suitable for minute observations, Jai Singh had a great respect for the astrolabe as an excellent tool for demonstration and teaching. He collected some of the best Mughal astrolabes fashioned by Ḍiyā' al-Dīn Muḥammad of the Lahore family (A072, A090 and A091), composed a manual on the astrolabe in Sanskrit prose entitled *Yantrarāja-racanā,*[817] commissioned the translation of Naṣīr al-Dīn al-Ṭūsī's *Risālat al-Usṭurlāb,* which is popularly known as *Bist Bāb* (twenty chapters) from the Persian into Sanskrit,[818] and sponsored the composition of a Sanskrit manual *Sarvadeśīya-jarakālī-yantra* on the universal astrolabe designed by al-Zarqālluh, on the basis of the *Zarqālī* astrolabe made by Ḍiyā' al-Dīn Muḥammad which he had with him (A091).[819]

He also realized that the best way to popularize the astrolabe is to keep it to the essentials and remove the peripherals. That is to say, to make it with a single plate calibrated to one particular latitude. He seems to have commissioned several astrolabes with single plates calibrated for the latitude of his capital city Amber (and later Jaipur) at 27° and distributed these among the astronomers at his court.

There is evidence to show that Jai Singh established a manufactory for the production of Sanskrit astrolabes where some astrolabes with multiple plates where made (C020 and C021), but its main production was the single plate astrolabes for the latitude of Jaipur at 27°. At his Observatory at Jaipur today, there are preserved several single plate astrolabes in various stages of completion (D077-D089), indicating that this manufactory was abruptly closed, probably because of his death.

But the production of single plate astrolabes continued in Jaipur and elsewhere in Rajasthan. Writing in 1902, Lieut. A. ff. Garrett who was responsible for the restoration of the Jaipur Observatory, states: 'The Yantra Raj seems to have been a favourite instrument, and it is still used by the pandits of the present day. It is made in all sizes,

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817 *Yantrarāja-racanā,* ed. Kedāranātha Jyotirvid, Jaipur 1953.

818 Bhattacharya 1979.

819 Cf. Sarma 1996b.

from the huge brass dial 7 ft. in diameter now hanging from masonry supports in the Observatory, down to pocket instruments a few inches across.'[820]

Today there exist some ninety and odd Sanskrit astrolabes with single plates in museums and private collections all over the world. Almost all of these were produced in Rajasthan, except two (D058 and D071) which were made in Gujarat.[821] In Rajasthan, these were produced not only in Jaipur (latitude 27°), but in several other places like Kuchaman (27°), Jodhpur (26°), Bikaner (28° or 28:16°), Bundi (25;30°) and Tonk (26°). Interestingly astrolabe D059 was made in Kuchaman, but with a plate calibrated for latitude 24° for use at Calcutta, the capital of the British Colonial Government in the nineteenth century. Very few of these astrolabes carry the names of the designer or maker or date. The earliest dated one was made in 1742 (D002) and the last one in 1903 (D037).

Being utilitarian devices, these are without any ornamentation. The crown and the plate are cut out in one piece from the same sheet of brass. The crown is solid and profiles are made up of ogees at the base followed by tiered lobes. The only exception are some astrolabes produced at Kuchaman. In an astrolabe made before 1828 (D034), the crown is fashioned in the form of a stylized lotus. This is emulated in several astrolabes made at this place, in some successfully (D038) and in others in a very rudimentary form (especially D035, D036 and D037). No other decorations were attempted on the crown.

In the majority of astrolabes, the scale on the rim is divided in 1° and 6° and numbered in 6s from 1 to 60. Thus the degree scale functions as the *ghaṭī* scale where 6° equal 1 *ghaṭī.* On the plate are drawn the two diameters and the three concentric circles of the Tropic of Capricorn, the equator and the Tropic of Cancer. Upon these are traced altitude circles at intervals appropriate to the size of the plate. Azimuth arcs are

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820 Garrett & Guleri 1902, p. 57.

821 These are constructed in a peculiar manner. The front with the crown and the circular scale was cut of a thicker sheet and the back with the crown was made separately out of another sheet. Then these parts were joined with a series of rivets along the entire circumference, leaving space to accommodate just one latitude plate and the rete. Interestingly, the earliest dated astrolabe in the world, namely the one made by Nasṭūlus in 926-7, was constructed in a similar fashion; cf. King 2005, pp. 470-484: 'Nasṭūlus and his two surviving astrolabes,' esp. p. 473: 'The throne and rim are cast as one, and to this the back is riveted in several places.'

generally drawn, sometimes above the horizon, sometimes below the horizon and some other times both above and below the horizon. In the lower half are traced lines for seasonal hours, but lines for equal hours are rare.

In the rete, the rings of Capricorn, equator and ecliptic are completely represented. In most cases, the equator ring has counter changes at the two equinoxes. Here also, the astrolabes made in Kuchaman form an exception. In these astrolabes, ornate bridges connect the equator ring to the ecliptic ring in the south and to the Capricorn ring in the north. The star pointers are usually of the dagger type.

On the back, the upper half of the rim is engraved with altitude scales; sometimes, the lower half is engraved with degree scales, sometimes it is blank. Generally, a trigonometric quadrant is drawn in the upper left, occasionally in the upper right. Declinations arcs are drawn very rarely. In the lower half, there are usually shadow squares. Astrological tables are added in just four astrolabes (D017, D032, D050 and D069). As in the C-series, here also there are often empty spaces on the back. In the majority of cases, the alidade is fitted with a sighting tube.

There are some unusual astrolabes which deserve a special mention. Three astrolabes (D002, D003 and D004) are made in the style of the Great Astrolabe with minimal rete and with the latitude plate engraved with the ecliptic circle and star positions.

Three other astrolabes (D005, D006 and D007) are equipped in the front with a ruler in which a cursor moves along a graduated longitudinal slit. Besides the three complete rings of Capricorn, equator and ecliptic in the rete, there is also a fourth ring representing the Tropic of Cancer. On the back are drawn two pairs of shadow squares one inside the other, but numbered differently in each astrolabe, suggesting that the astrolabe designer was experimenting with this innovation.

Moreover, D005 is very unique: it is equipped with a northern rete and a southern rete and the two sides of the plate carry respectively the northern and the southern projections for latitude 27°.

Since very few of these single plate astrolabes are dated, chronological arrangement is not possible in this section. Hence, astrolabes are arranged according to the latitudes for which they are made. Towards the end of the section are added some 20 astrolabes and astrolabes parts which are unfinished.

Lest this section does not conclude with these unfinished parts, two extraordinary astrolabes are placed at the end; these were designed by Gaṅgāsahāya with long and scholarly inscriptions which were faultlessly engraved by talented artisans.

This section closes with a modern card-board astrolabe made in ‘Sanskrit style’ by James E. Morrison. In certain respects, it is an improvement on the existing Sanskrit astrolabes and Sawai Jai Singh would have been pleased about it.

ASTROLABES FOR LATITUDE 27° WITH STARS MARKED ON THE PLATE

Among the Islamic astrolabes there are a few specimens where the ecliptic and star positions are marked on the latitude plate. The earliest probably is an astrolabe made by ᶜUmar b. Dawlatshāh b. Muḥammad al-Kirmānī in 726/1325, only the mater of which survives. A geographical gazetteer is engraved on the inner surface and the back is designed as the latitude plate for 36° with the attitude circles, azimuth arcs and hour lines. On this plate are also marked a graduated ecliptic and 30 named star positions by dots enclosed in circles. The rete of this unusual astrolabe has not survived and we do not know how it was designed.[822]



Figure D1 – Astrolabe by ᶜUmar b. Dawlatshāh al-Kirmānī (from Linton 1980)

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822 Linton 1980, no. 163, pp. 90-91. King 2005, pp. 55-57, states that an 'early variety of astrolabe in which astrolabic markings for a specific latitude and the projection of the ecliptic and stars are all on a single plate is known from textual souces and two examples,' but does not mention the second astrolabe or the textual sources.

Ḍiyā' al-Dīn Muḥammad of Lahore followed this style in the small north-south astrolabe which he made in 1085/1674 (A090). This astrolabe consists of a single plate one side of which is engraved as a latitude plate for 33° N; on this plate is superimposed a northern projection of the ecliptic circle together with the positions of 46 stars. The reverse side of the plate is made for latitude 35° N on which a southern projection of the ecliptic circle is drawn and the positions of the same 46 stars, but with southern orientation, are marked. The rete consists of just the ecliptic ring and the alidade is is fitted with a sighting tube.

This astrolabe was collected by Sawai Jai Singh together with some other Lahore astrolabes. He appears to have followed its style when he commissioned a large astrolabe with a minimal rete and the star positions marked on the plate (D001). The same style was followed in three small astrolabes which were made at Jaipur for its latitude of 27° (D002 – D004). Making observations with such an astrolabe is somewhat more complicated than with the common astrolabe.[823]

Another specimen of this nature is the unfinished astrolabe D078 with a minimal rete. On the two sides of the plate, projections are drawn for latitudes 27° and 30° respectively, but no star positions are marked on either side, nor are there any numbers or labels. A minimal rete is to found also with the astrolabe D075 which is likewise imcomplete.

While the astrolabes mentioned above are equipped with minimal retes, D033 has a normal rete with 22 star pointers, but the positions of 9 stars are also marked on the plate.

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[823] For a detailed procedure of using this astrolabe, see Sharma 2016, pp. 182-183.

D001⊙ THE GREAT ASTROLABE FOR LATITUDE 27° COMMISSIONED BY SAWAI JAI SINGH

Ca. 1720, Jaipur

Diameter 2115 mm

Jaipur, Jai Singh's Observatory

CCA 83



Figure D001.1 – Front view of the Great Astrolabe (photo by S. R. Sarma)

Sawai Jai Singh experimented with large brass instruments before he designed the huge astronomical instruments in masonry for greater accuracy. One such large brass instrument that still survives is this Great Astrolabe. It must have been made around 1720. It consists of a single plate, the front side of which is calibrated for the latitude of Jaipur at 27° with the altitude circles, azimuth arcs and hour lines. The back is uninscribed und unpolished. A standard rete of matching dimensions with several star pointers would have been too heavy for the pin to bear. Therefore a minimal rete was chosen which consists just of the ecliptic circle. The positions of some 56 stars are marked on the plate itself and also the ecliptic circle. The alidade is fitted with a sighting tube. But soon Jai Singh abandoned this large astrolabe and other large brass instruments in favour of the masonry instruments.

During the renovations 1901-2 under Maharaja Madho Singh II, this great astrolabe and some other abandoned brass instruments were set up with appropriate supports next to the masonry instruments in the open grounds of Jai Singh's Observatory at Jaipur. This display offers some idea how Jai Singh's instrumentation developed from portable instruments to the masonry ones.[824] The Great Astrolabe is suspended from a wooden beam inside a masonry structure specially erected for this purpose. This, of course, could not have been the manner in which it was originally suspended when it was actively used for observation at the time of Jai Singh. Now the lower rim of the astrolabe practically touches the ground. This could not have allowed an astronomer to position himself below the instrument and observe a star through the sighting tube. The detachable rete and the alidade-cum-sighting tube are kept in the stores.

Next to this astrolabe is suspended an iron disc of about the same dimensions and outline as a companion piece.[825] It is made by riveting 55 to 60 iron sheets. A degree scale is engraved on its rim as in the Great Astrolabe, but nothing else which would

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[824] These metal instruments now on display in the open grounds are, besides the Great Astrolabe and its the companion piece, the pair of *Cakra-yantras,* the *Krāntivṛtta-yantra* and the *Unnatāṃśa-yantra.*

[825] Gunther 1932, p. 214, lists this piece as no. 82 and the Great Astrolabe as no. 83, and the CCA follows him.

qualify it as an astronomical instrument. For what purpose it was fabricated will remain a mystery. [826]



Figure D001.2 – The rete and alidade of the Great Astrolabe, with the Observatory staff P. S. Meena (left) and Babulal Vijay (right).In the background can be seen the Great astrolabe (right) and its companion piece (left). (photo by S. R. Sarma)

Components

Plate with crown (d. 2115, h. 2430, t. 150 in the middle to 125 at the edges, wt. ca. 400 kg), ring, shackle, rete, alidade with a sighting tube, pin, bolt.

Front

Medium sized crown with 7 lobes all around. The astrolabe is suspended from a wooden beam set on two masonry pillars by means of a simple stirrup-shaped shackle, a hook and ring.

The detachable rete, alidade and pin are not displayed in the open. They are kept in the stores.

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826 Sharma 1984, p. 182: 'The purpose of this instrument is not clear. One thing, however, is certain—that in itself, the instrument cannot be an astrolabe […] Possibly the unit had been meant to be the back support for a brass astrolabe that was never completed.'

The degree scale on the rim is divided in 1/6°, 1° and 6° but not labelled. Each of the larger divisions of 6° represents one *ghaṭī*.

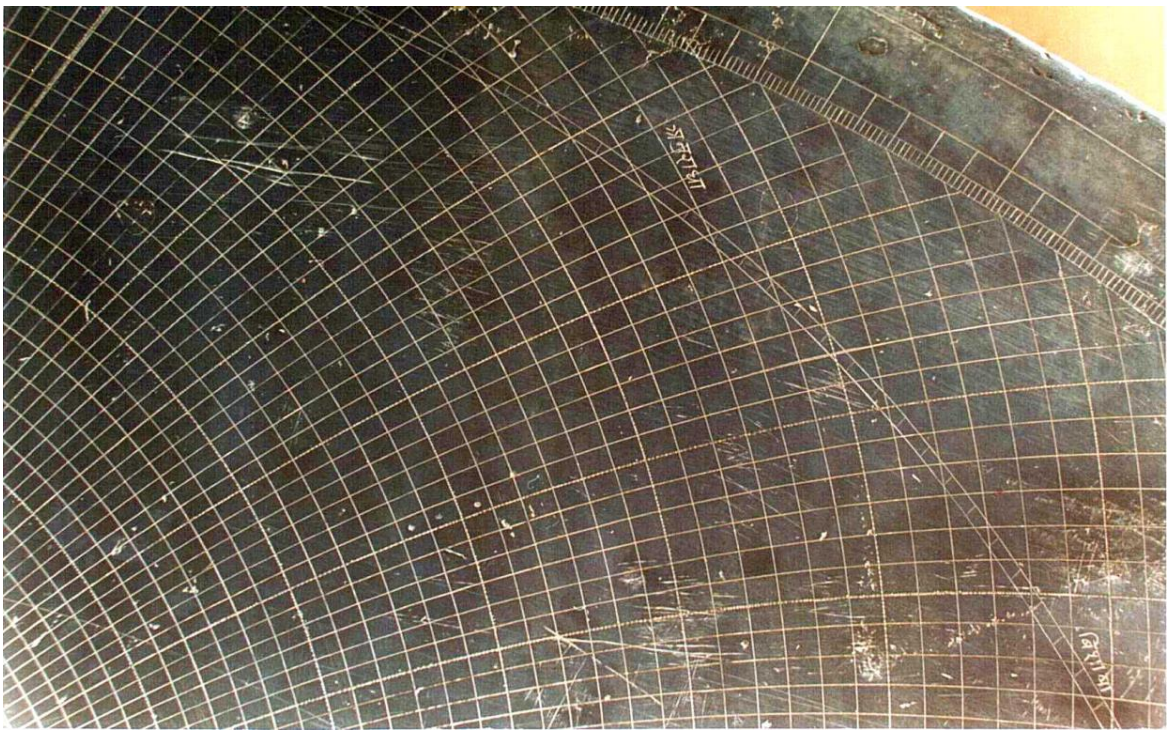


Figure D001.3 – Front of the plate. Detail showing the degree scale on the rim, altitude circles (somewhat vertical in this photo), azimuth arcs (horizontal) and the graduated ecliptic band stretching from the bottom right to the midpoint at the top (photo by S. R. Sarma)

Inside the *ghaṭī* scale there are concentric circles of Capricorn, equator and Cancer. In addition, a graduated ecliptic ring was drawn in such manner that it touches the Capricorn circle in the south and the Cancer circle in the north.

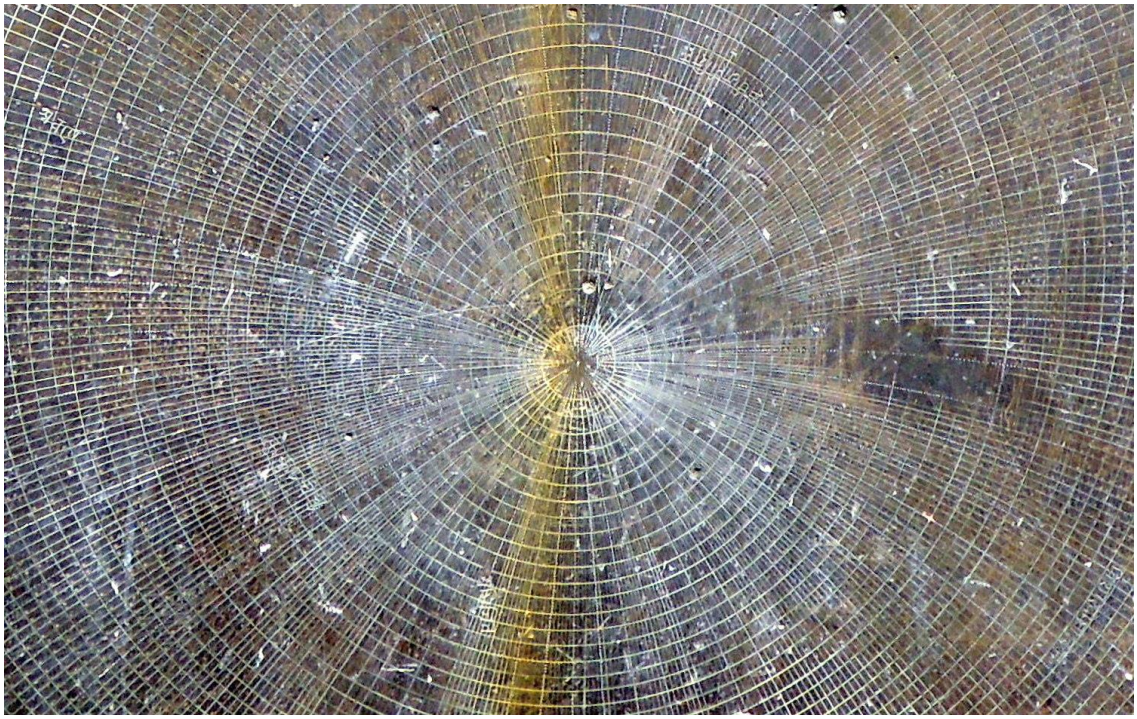


Figure D001.4 – Zenith on the Astrolabe. The concentric circles around the zenith are the altitude circles and those converging at the zenith are the azimuth arcs (photo by Dr Owen Cornwall).

Altitude circles are drawn for each degree, with every sixth dotted. Azimuth arcs drawn also for each degree above and below the horizon; every sixth is dotted. There are lines for seasonal hours. None of these are numbered. Below the line of horizon is engraved *akṣāṃśāḥ* 27 (degrees of latitude 27).

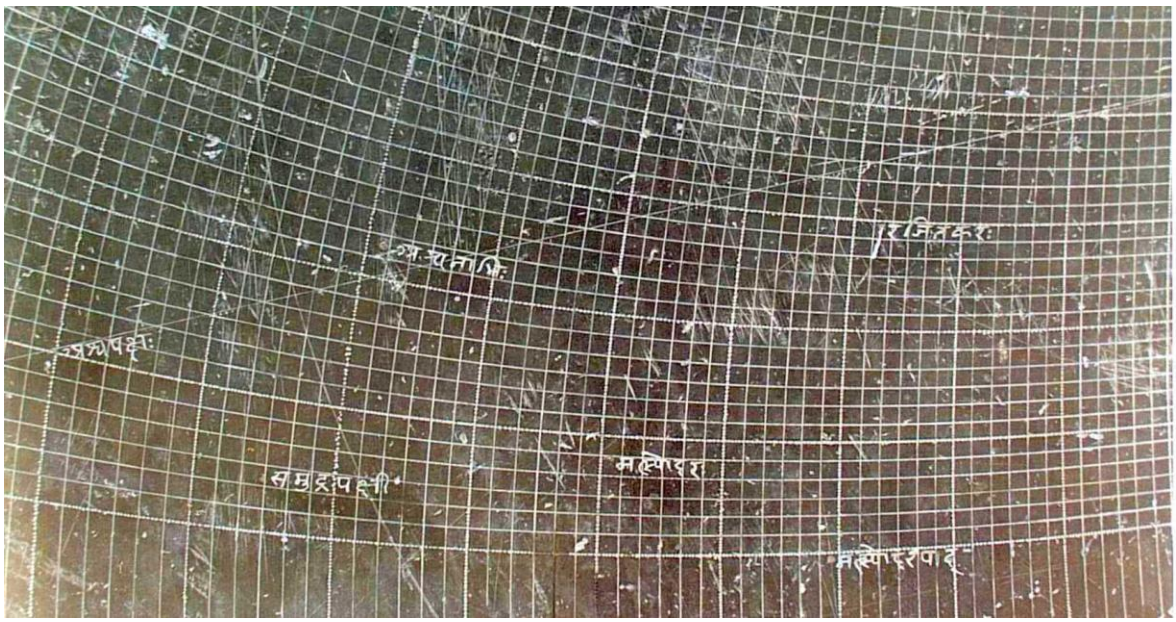


Figure D001.5 – Star names engraved on the left part of the plate; the first horizontal curve at the bottom is the local horizon (photo by S. R. Sarma)

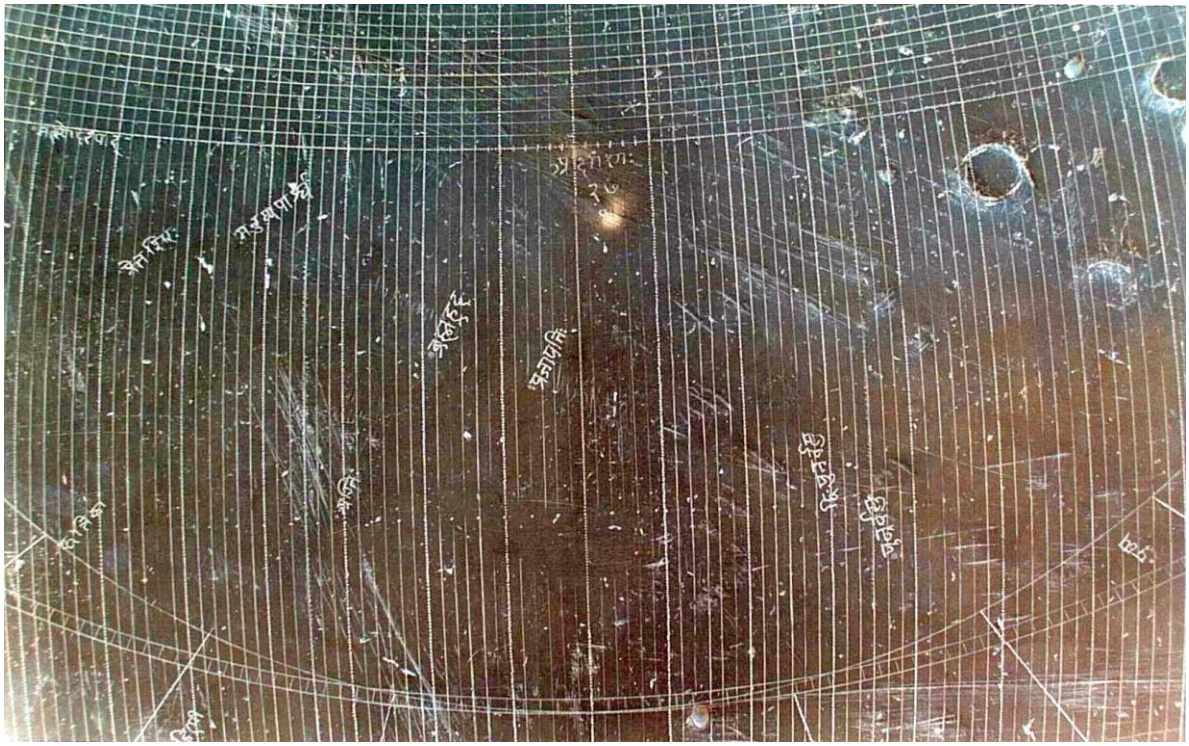


Figure D001.6 – Middle part of the plate; at the top is the line of horizon.
Running parallel to it above are the altitude circles. Vertical lines extending below the horzon are the azimuth arcs. At the bottom can be seen the graduated ecliptic band touching the Tropic of Cancer. Immediately below the horizon line at the centre is engraved *akṣāṃśāḥ 27,* 'degrees of latitude 27'.
(photo by S. R. Sarma)

On the plate are marked the positions of about 56 stars, when the sun's longitude is 0°, and the names are engraved very correctly and neatly on the astrolabe.[827] The star positions are said to be indicated by inlaid silver points, but these are not visible now. The stars marked on this plate are a mixture of the stars known to the Sanskrit astronomical texts and those from Islamic astrolabes, from Mahendra's list as well as directly borrowd from Islamic astrolabes. Of the junction stars of the 28 lunar mansions, 21 are represented here, but the following 7 *nakṣatras* are not: *Jyeṣṭhā, Mūla, Pūrvāṣāḍhā, Uttarāṣāḍhā, Pūrva-bhādrapadā, Uttara-bhādrapadā* and *Revatī.*

Table D001-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti

827 This list is prepared on the basis of notes kindly sent by Professor Virendra Sharma and several close-up photographs taken by Dr Owen Cornwall.

	Star Name as engraved	Full/Correct Form	Identification
2	*Matsyodara*		β Andromedae
3	*Matsyodarapād*		γ Andromedae
4	*Pretaśiraḥ*		β Persei
5	*Manuṣyapārśva*		α Persei
6	*Aśvinī*		β Arietis
7	*Bharaṇī*		41 Arietis
8	*Kṛttikā*		η Tauri
9	*Rohiṇī*		α Tauri
10	*Brahmahṛd*		α Aurigae
11	*Agniḥ*		β Tauri
12	*Prajāpatiḥ*		δ Aurigae
13	*Mithunapāda*	*Mithuna-vāma-pāda*	β Orionis
14	*Mithu.vā.hasta*	*Mithuna-vāma-hasta*	γ Orionis
15	*Āradā Mi.da.hada*[828]	*Ārdrā Mithuna-dakṣiṇa-hasta*	α Orionis
16	*Mithuna da.pāda*	*Mithuna-dakṣiṇa-pāda*	κ Orionis
17	*Mṛgaśiraḥ*		λ Orionis
18	*Lubdhaka*		α Canis Majoris
19	*Luba*	*Lubdhaka-bandhu*	α Canis Minoris

[828] The star α Orionis is known as *Ārdrā* in Sanskrit astronomy. In the Islamic tradition it bears the designation *Yad al-Jawjā' al-Yumnā,* 'the right hand of al-Jawjā'; the same is rendered into Sanskrit as *Mithuna-dakṣiṇa-hasta,* 'the right hand of Gemini'. Both the Sanskrit names are engraved in the present astrolabe.

	Star Name as engraved	Full/Correct Form	Identification
20	*Puṣya*		δ Cancri
21	*Dvi. Purnavasu*	*Dvitīya-punarvasu*	α Geminorum
22	*Punarvasu*		β Geminorum
23	*Aśleṣā*		ζ Cancri
24	*Pharadaśujā*[829]	*Fard al-Shujāʿ*	α Hydrae
25	*Maghā*		α Leonis
26	*Pūrvāphā*	*Pūrvā Phālgunī*	δ Leonis
27	*Utarāphā*	*Uttarā Phālgunī*	β Leonis
28	*Kratu*		α Ursae Majoris
29	*Pulaha*		β Ursae Majoris
30	*Pulasti*	*Pulastya*	γ Ursae Majoris
31	*Atri*		δ Ursae Majoris
32	*Aṃgirā*	*Aṅgirā*	ε Ursae Majoris
33	*Vaśiṣṭha*		ζ Ursae Majoris
34	*Marīci*		η Ursae Majoris
35	*Kākaskandhaḥ*		γ Corvi
36	*Hasta*		δ Corvi
37	*Citrā*		α Virginis
38	*Apāṃvacha*	*Apāṃvatsaḥ*	θ Virginis
39	*Āpaḥ*		δ Virginis
40	*Svātī*	*Svāti*	α Bootis

829 Transliteration of the Arabic name; it is not clear why the Sanskrit name *Mahāpuruṣa* was not used here.

	Star Name as engraved	Full/Correct Form	Identification
41	*Biśāṣā*	*Viśākhā*	α Librae
42	*Anurādhā*		δ Scorpii
43	*Viśākhāmātra.maṃ.*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
44	*Sarpagrīvā*		α Serpentis
45	*Sarpadhārīśiraḥ*		α Ophiuchi
46	*Abhijita*	*Abhijit*	α Lyrae
47	*Śravaṇa*		α Aquilae
48	*Dhaniṣṭhā*		β Delphini
49	*Kukuṭacaṃcu*	*Kukkuṭa-cañcu*	β Cygni
50	*Kukurajānu*[830]	*Kukkuṭa-jānu*	$\omega^{1,2}$ Cygni
51	*Kukuṭapuccha*	*Kukkuṭa-puccha*	α Cygni
52	*Aśvaskandhaḥ*		β Pegasi
53	*Śatabhiṣā*		λ Aquarii
54	*Raṃjitakaraḥ*	*Rañjita-karaḥ*	β Cassiopeiae
55	*Aśvanābhiḥ*		δ Pegasi = α Andromedae
56	*Aśvapakṣaḥ*		γ Pegasi

RETE

The rete is a mere circular ring of the same diameter as the ecliptic circle on the astrolabe plate. A bar runs diagonally across the ring, with a hole for the pin to pass through. The hole is placed at such a distance that the rete can be positioned

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830 This is the only occasion when this star (Arabic: *rukbat al-dajāja*) is marked on Sanskrit astrolabes.

eccentrically. Probably the ecliptic circle is graduated, but the graduations cannot be seen anymore.

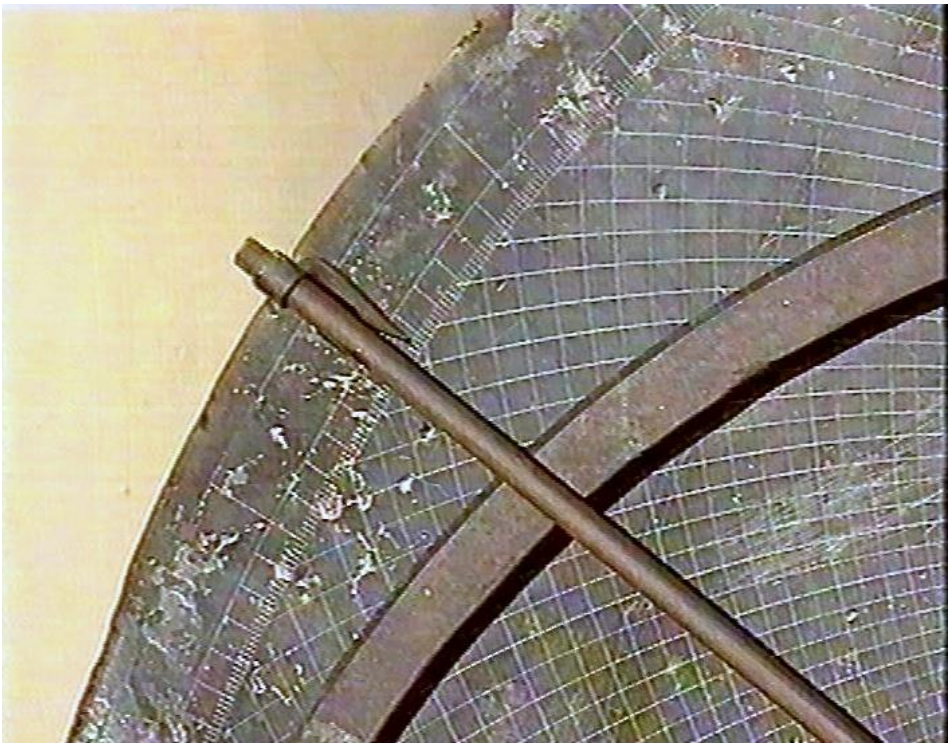


Figure D001.7 – Tip of the sighting tube (photo by S. R. Sarma)

ALIDADE

There a short alidade in the centre of which is a ring with a hole in middle through which the pin passes through. On the alidade is mounted a sighting tube which is slightly longer than the diameter of the astrolabe. At the two ends of the sighting tube, there are hook-like projections which touch the degree scale on the rim of the astrolabe.

BACK

The back of the astrolabe was not not prepared for any engraving; it remains rough and uneven.

BIBLIOGRAPHY

Garrett & Guleri 1902, pp. 49-63.
Kaye 1918, p. 16; figs. 28-29.
Gunther 1932, p. 214, fig. 111.
Sharma 1984.
Sharma 2016, pp. 180-184.

D002 ASTROLABE FOR LATITUDE 27° WITH STAR POSITIONS MARKED ON THE PLATE, NOT SIGNED[831]

1742, Jaipur

Diameter ?

PLU

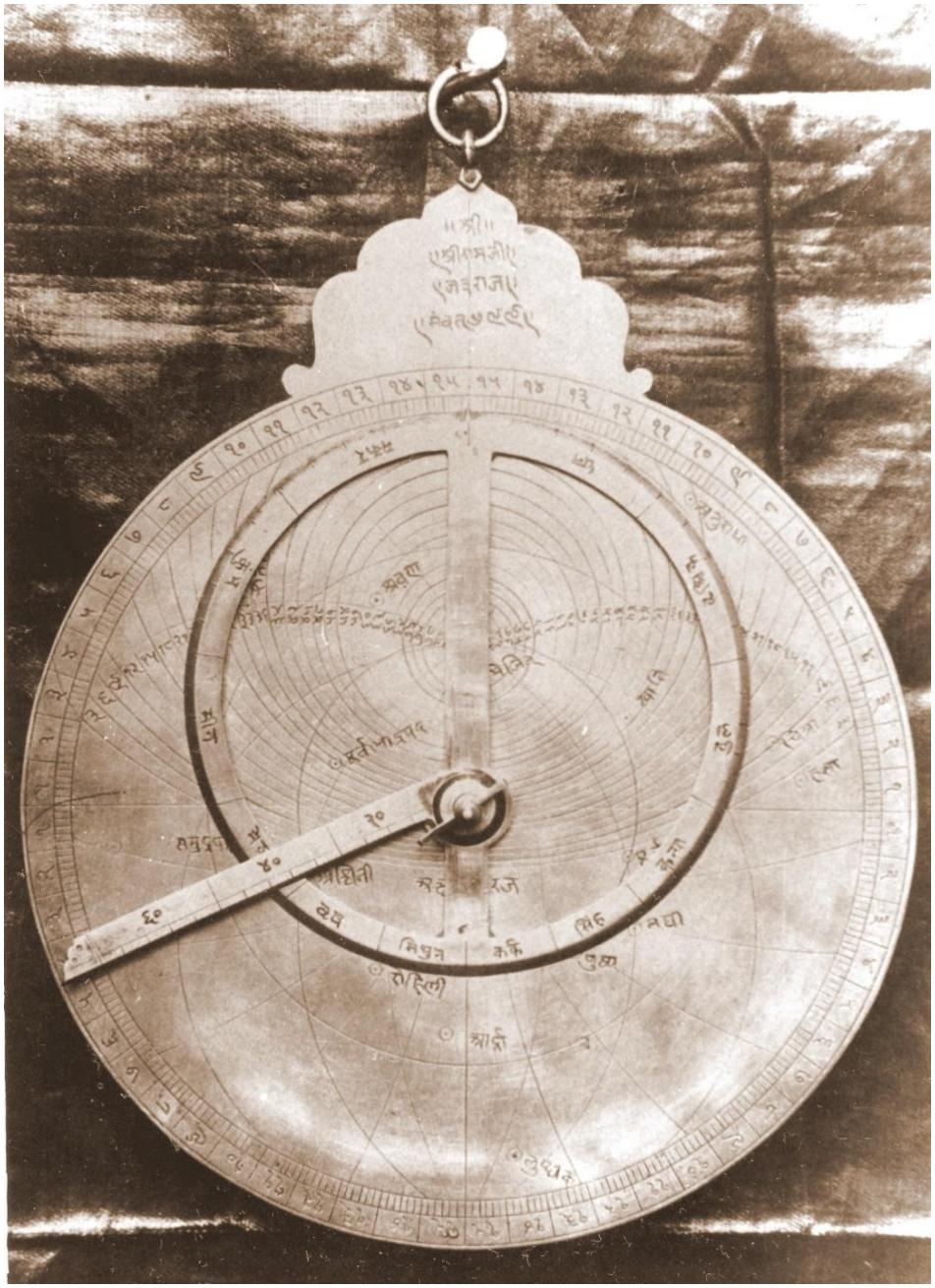


Figure D002.1 – Front of the astrolabe (courtesy Museum of the History of Science, Oxford)

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[831] Entry based on a photo from the 'Kaye Album', preserved in the archives of the Museum of the History of Science, Oxford.

This and the next two astrolabes are smaller versions of the Great Astrolabe (D001) with the ecliptic and star positions marked on the latitude plate. On the crown of the present astrolabe is engraved *Saṃvat* 1799 (= AD 1742-43) as the year of manufacture. Thus it is a very early astrolabe, probably made in the life time of Jai Singh at Jaipur itself. Star pointers are marked on the plate calibrated for latitude 27° and the rete is minimal, consisting just of the ecliptic ring.

COMPONENTS

Plate with crown, shackle and ring, minimal rete, ruler, pin and wedge. No information is available about the alidade; the dimensions are not known.

FRONT

The crown is high and solid; the profiles are made up of an ogees at the base, followed by a lobe and the triangular finial. The shackle is small with a diamond cross section; the ring is fairly large.

The degree scale on the rim is divided in 1° and in 6°. Groups of 6° are numbered serially from 1 to 15, separately in each quadrant, starting at the east and west points and reaching up to the south and north points, as 1—15; 15—1; 1—15; 15—1. Altitude circles are drawn for each 3° and numbered on the left and right. Azimuth arcs are drawn for each 30° above and below the horizon, but not numbered. In the lower half, there are lines for seasonal hours; these too are not numbered. The plate is calibrated for the latitude of 27°.

Below the horizon line at the centre is an inscription which is partly blocked by the supporting bar of the rete: *akṣ--raja.* It must be *akṣabhā araja,* 'midday equinoctial shadow, latitude'. The numerical values 6;6 and 27 appear to have been engraved below, but these too are obscured by the vertical bar of the rete.

On the plate are marked the positions of 16 stars by dots enclosed in small circles. The star names are engraved in correct Sanskrit. These are tabulated below in the order of increasing right ascension:

Table D002-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Aśvinī*		β Arietis
3	*Rohiṇī*		α Tauri
4	*Ārdrā*		α Orionis
5	*Luvdhaka*	*Lubdhaka*	α Canis Majoris
6	*Puṣya*		δ Cancri
7	*Maghā*		α Leonis
8	*Pūr[va-phālgunī]*		δ Leonis
9	*Hasta*		δ Corvi
10	*Citrā*		α Virginis
11	*Svāti*		α Bootis
12	*Anurādhā*		δ Scorpii
13	*Abhijit*		α Lyrae
14	*Śravaṇa*		α Aquilae
15	(not named)	*Śatabhiṣā*	λ Aquarii
16	*Pūrvā Bhādrapada*	*Pūrva-bhādrapadā*	β Pegasi

RETE

The rete consists just of the ecliptic ring with the vertical solstitial bar in which a hole is bored to pivot the rete on the pin at the centre. The solstitial bar runs from the first point Capricorn to the first point of Cancer. At the first point of Capricorn there is a slightly projecting point, called *Makarānana* (Index at the beginning of Capricorn) in Sanskrit. The ecliptic ring is divided into the 12 zodiac signs which are appropriately labelled. The signs are probably divided and subdivided into smaller units on the edge of the ring, but these divisions are not clearly visible in the photo.

RULE

To the front of the astrolabe is attached a rule on which the length of the radius of the astrolabe is divided into 3 parts which are numbered as 20, 40, 60; these parts are further subdivided into 5 units each. The pin is held in position by a wedge which appears to be horse-shaped.

BACK

No photo is available of the back; consequently no information about the alidade as well.

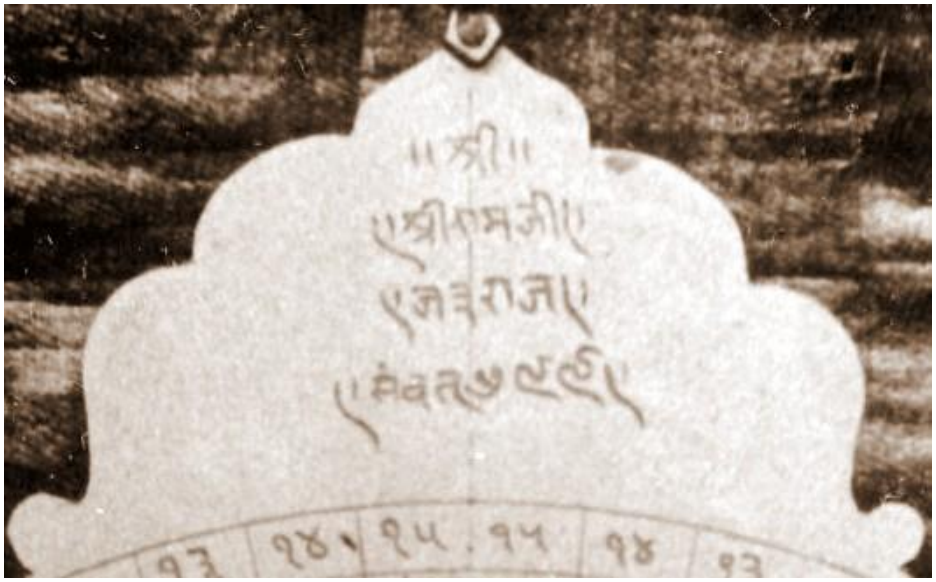


Figure D002.2 – Inscription on the crown (detail of Figure D002.1)

INSCRIPTION

The crown of the astrolabe bears an inscription in four lines. The calligraphy is excellent, but there are errors in the inscription. In the third line the dot above the first syllable is missing; the second syllable *tra* is drawn like the digit 3. In the fourth line, the first two digits (1 and 7) are combined into a strange symbol. After correcting these, the inscription reads: ‖ *śrīḥ* ‖ *śrī-rāma-jī* ‖ *jaṃtrarāja* ‖ *saṃvat 1799*‖ ‘[May it be] auspicious. [May] the illustrious Rāma [be victorious]. [This is] the King of Instruments. [Vikrama] Saṃvat 1799.’ The year translates to AD 1742-43.

PROVENANCE

This sepia-tinted photograph is in what is known as ‘G. R. Kaye album’ in the archives of the Museum of the History of Science, Oxford. In *The Astronomical*

Observatories of Jai Singh, Kaye describes a Sanskrit astrolabe in the following words:[832]

> '24. At Jaipur I was shown a modern Hindu astrolabe or *Yantra Raj,* dated Samvat 1799 (= A. D. 1877) [sic!]. It is a single disc *thulthī* or tripartite instrument for latitude 27° N., with an ecliptic circle and ruler. On the obverse of the disc are engraved azimuth lines for 30°, 60° and 90°, and also the temporal hour lines, and also the names of the following stars […] The ruler is the same type as those employed on the face of certain medieval European instruments.'

Kaye does not describe the reverse side. There is a slight difference between the stars that can be seen in the photo and those listed by Kaye: Kaye does not mention *Aśvinī* and calls the unnamed star as *Śatajīvā*. But in all likelihood, the astrolabe he saw in Jaipur before 1918 and the one depicted in the photo are identical.

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832 Kaye 1918, p. 33.

D003 ASTROLABE FOR LATITUDE 27° WITH STAR POSITIONS MARKED ON THE PLATE, NOT SIGNED, NOT DATED[833]

Ca 1742, Jaipur

Diameter 192 mm

PLU

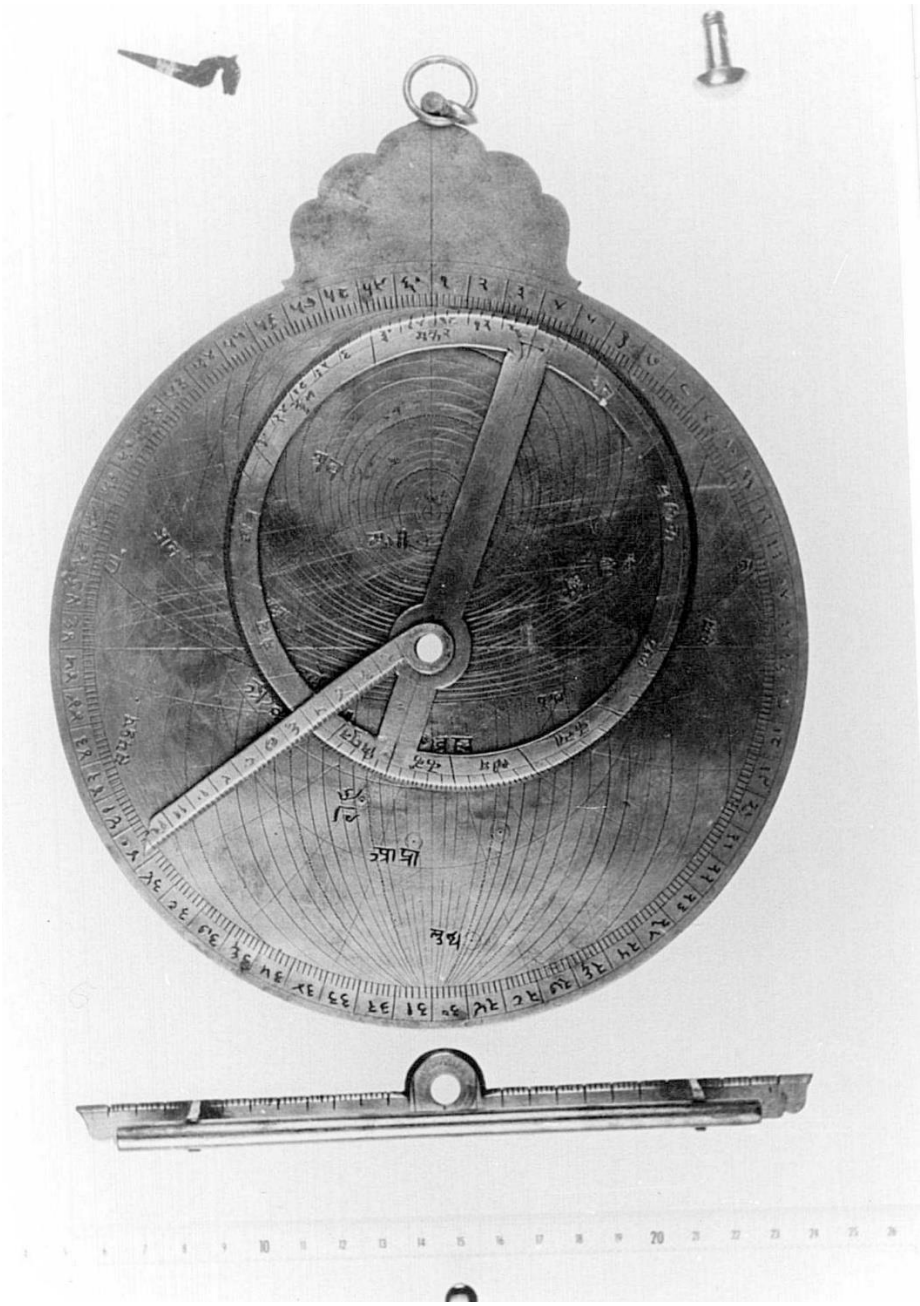


Figure D003.1 – Front of the astrolabe (photo by Alain Brieux)

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[833] Entry based on photos and a short description in French by Alain Brieux, kindly provided by Anthony J. Turner.

This astrolabe closely resembles D002 of 1742 and must have been produced about the same time at Jaipur.

COMPONENTS

Plate with crown (d. 192), shackle and ring, rete, alidade with sighting tube, ruler, pin, horse-shaped wedge.

FRONT

The crown is high with lobed profiles; there is a small shackle and a large ring. The degree scale on the rim is divided in 1° and in 6°; groups of 6° are numbered serially from 1 to 60. Altitude circles are drawn, not very carefully, for each 3°, but not numbered. Azimuth arcs are drawn below the horizon for each 6°. These are not numbered either; nor are the seasonal hour lines. The plate is designed for the latitude of 27° but this fact is not mentioned on the plate.

As in the previous two astrolabes, the positions of certain stars are marked here also on the plate with dots enclosed in small circles. Next to these marks are engraved the names of the stars, often in abbreviated form. Some are difficult to decipher in the photographs.

Table D003-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapa*	*Samudrapakṣī*	β Ceti
2	?		
3	*Aśva*	*Aśvinī*	β Arietis
4	?		
5	*Roha*	*Rohiṇī*	α Tauri
6	*Ādrā*		α Orionis
7	*Brahma*	*Brahmahṛdaya*	α Aurigae
8	*Luvdha*	*Lubdhaka*	α Canis Majoris
9	*Maghā*		α Leonis

	Star Name as engraved	Full/Correct Form	Identification
10	*Puṣya*		δ Cancri
11	*Pū. Phā.*	*Pūrva-phālgunī*	δ Leonis
12	*Hasta*		δ Corvi
13	*Citrā*		α Virginis
14	*Svāti*		α Bootis
15	*Abhī*	*Abhijit*	α Lyrae
16	*Śrava*	*Śravaṇa*	α Aquilae
17	*Śata*	*Śatabhiṣā*	λ Aquarii
18	*Pū.bhā*	*Pūrva-bhādrapadā*	β Pegasi

RETE

The rete consists just of the ecliptic ring with the vertical solstitial bar in which a hole is bored to pivot the rete on the pin at the centre. The solstitial bar runs from the first point Capricorn to the first point of Cancer. At the first point of Capricorn has a slightly projecting point called *makarānana* in Sanskrit. The ecliptic ring is divided into the 12 zodiac signs and labelled with their names. Each signs is divided into 5 parts and each of these parts are subdivided into units of 2°.

RULE

A rule with a pointed tip revolves over the front of the astrolabe. On it the radius of the astrolabe is divided into 12 units which are numbered serially; these parts are further subdivided into 5 parts each.

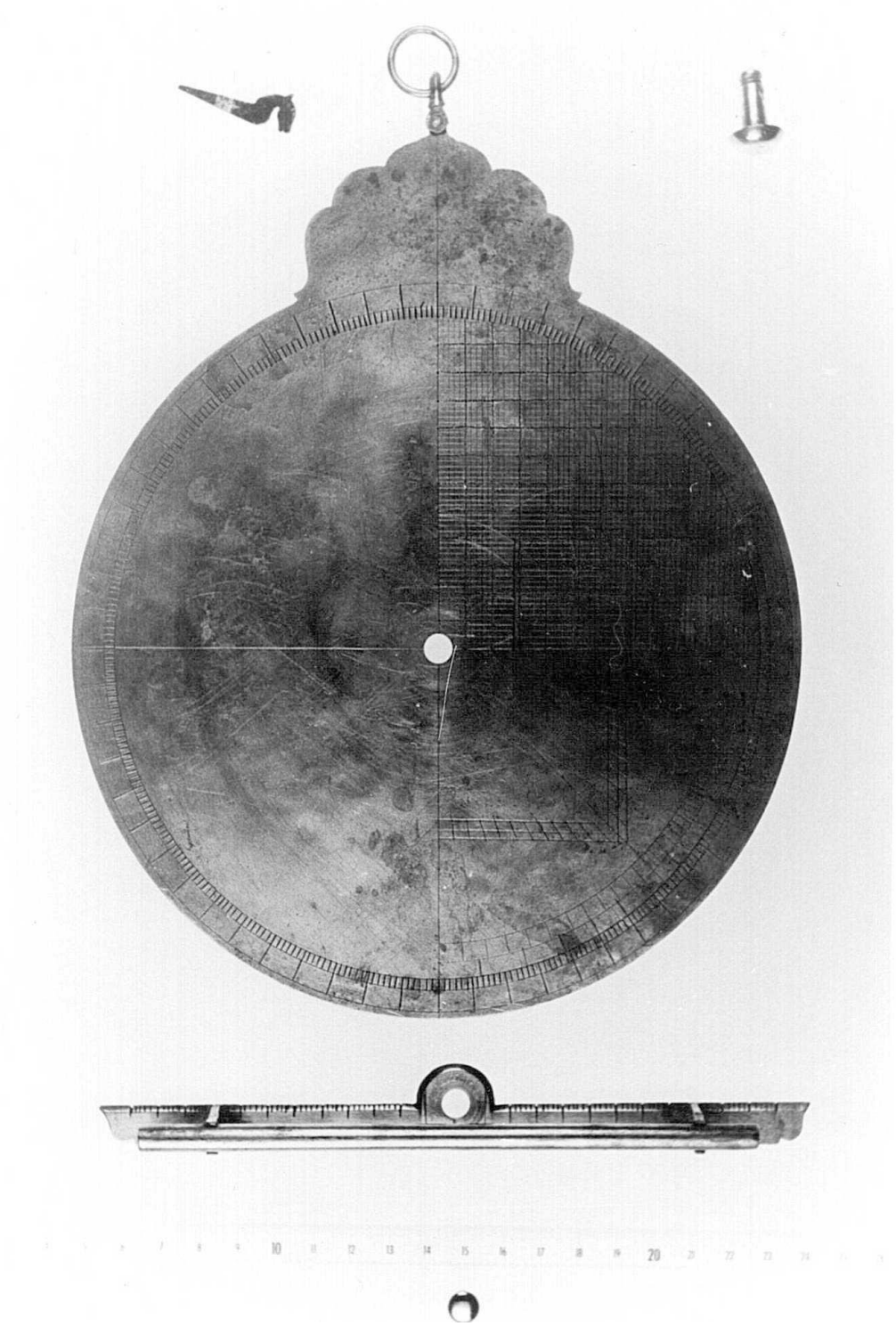


Figure D003.2 – Back of the astrolabe (photo by Alain Brieux)

BACK

A degree scale, divided in 1° and in 6°, but not numbered, covers the entire rim of the back. The upper left quadrant is blank. The upper right quadrant contains a sine-cosine graph with 60 vertical and 60 horizontal parallels, each fifth of which are highlighted. The lower left quadrant is again blank. In the lower right quadrant is

engraved a single shadow quadrant, where the vertical and horizontal scales are divided into 12 parts. Otherwise, the back contains absolutely no numerals or legends.

D004 ASTROLABE FOR LATITUDE 27° WITH STAR POSITIONS MARKED ON THE PLATE, NOT SIGNED, NOT DATED

18th century, Jaipur

Diameter 162 mm

Hastings-on-Hudson, NY, Tesseract



Figure D004.1 – Front of the latitude plate (photo courtesy Dr David Coffeen)

COMPONENTS

Plate with crown (d. 162, h. 186, t. 1), shackle and ring. Other parts are missing.

FRONT

Lobed crown on which God's name is engraved as *śrīhariḥ* (glorius Hari). The limb is graduated for 1˚ and 6˚ but not labelled. Altitude circles are drawn for every 3°; these are numbered partly on both sides of the meridian: 3, 15, 30, 45, 60, 75. The prime vertical and ecliptic are drawn faintly, but these two circles are not deeply engraved. The plate is designed for latitude 27°, but this fact is not recorded on the plate. There are no azimuth arcs or hour lines. 11 star positions are marked with four-petalled flowers, but the star names are carelessly engraved.



Figure D004.2 – Detail showing the star-pointer β Ceti (photo courtesy Dr David Coffeen)

Table D004-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudapaṣī*	*Samudrapakṣī*	β Ceti
2	*Rohiṇī*		α Tauri
3	*Ārdrā*		α Orionis
4	*Luṣa*	*Lubdhka*	α Canis Majoris
5	*Maghā*		α Leonis
6	*Cītrā*	*Citrā*	α Virginis
7	*Suvātī*	*Svāti*	α Bootis
8	(not named)	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
9	*Abhajata*	*Abhijit*	α Lyrae
10	*Saravaṇa*	*Śravaṇa*	α Aquilae
11	*Satabhīvā*	*Śatabhiṣā*	λ Aquarii

BACK

Originally this was intended as the latitude plate and altitude circles were engraved on this side for every 6˚ but not numbered; limb graduated for 1˚ and 6˚, but numbered only in the upper right quadrant. It was abandoned for some unknown reason.



Figure D004.3 – Back of the latitude plate (photo courtesy Dr David Coffeen)

THREE UNUSUAL ASTROLABES FROM JAIPUR

The following three astrolabes (D005, D006 and D007), which carry no signature or date, display close similarity in design and share several unusual features. The crowns with their lobed profiles have roughly the same design. All are equipped with a ruler in front with a graduated longitudinal slit in which there is movable cursor. The most striking feature is the rete consisting of four almost complete rings, representing not only the Tropic of Capricorn, the equator and the ecliptic, but also the Tropic of Cancer, which is not generally represented as a ring in astrolabe retes. The star pointers are shaped like daggers with very sharp ends. Some star pointers are situated inside small heart-shaped incisions made in the main frame. The latitude plates are calibrated for 27°. But this fact is not recorded on any of the three astrolabes, nor are the altitude circles, azimuth arcs and hour lines numbered on any of these.

Another unusual feature common to all the three astrolabes is that on the back there are two pairs of shadow squares, one engraved inside the other.

But the three astrolabes are not exact copies of one another. The sizes are different, so also the workmanship and quality of engraving of the star names. The method of numbering the degree scale on the rim and the tangent and cotangent scales in the shadow squares on the back is different in each astrolabe; likewise the number of star pointers is different.

The workmanship of D006 is far superior to that of the other two. The star names on the rete are engraved very carefully and almost correctly. The two loose ends of the Capricorn ring are nicely shaped like peacocks with their crests erect. These crests are missing in D007, but the beak, the curved neck and the body are delineated very well. In the northern rete of D005, one can just discern the beak and head of a bird. In the southern rete, however, no attempt was made to give any shape to the ends. In D005, the quality of engraving of the star names is very indifferent. There are also differences in the various elements on the back, as will be shown in the individual description of these astrolabes.

But it is certain that these three astrolabes were designed by the same enterprising astronomer who attempted to introduce some unusual variations and it is also certain that they were fabricated by the same artisan. The engraving of the star names on the

rete, however, was done by different assistants. It is quite likely that these astrolabes were made in Jaipur.

The present owner of D006 acquired it from the Libraire Alain Brieux in Paris. In a letter dated 22 December 1976, Alain Brieux informed him that the astrolabe was bought from a scholar of Jaipur who possessed a large library of manuscripts emanating from the collection of Maharaja Jai Singh. Therefore, Brieux assumed, 'avec la plus grand certitude,' that the astrolabe was from the private collection of the Maharaja. Whether it is from the private collection of the Maharaja or not, it is appears quite likely that three astrolabes were produced in the early part of the eighteenth century

But an intriguing feature is that all the three astrolabes are equipped in the front with a ruler in which a cursor moves along a graduated longitudinal slit. Rulers are generally attached to the front of European astrolabes, but not in Islamic or Indo-Persian astrolabes. [834] Even in European astrolabes, such rulers as in these three astrolabes with cusors moving along longitudinal slits are not known.

However, a Sanskrit astrolabe dated 1742 (D002) and another produced about the same time (D003) are equipped with graduated rulers. These astrolabes are also designed for the latitude of 27° at Jaipur. This would show that already in the first half of the eighteenth century astrolabes were produced at Jaipur with graduated rulers attached to the front. Then rulers with cursors may be regaded as a variation developed at Jaipur itself.

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[834] Allāhdād's undated astrolabe (A002) has a ruler in front. This must have been added later and was not an original component of the astrolabe which was produced in the second half of the seventeenth century.

D005 ASTROLABE FOR LATITUDE 27°, WITH NORTHERN & SOUTHERN RETES, NOT SIGNED, NOT DATED

18th century, Jaipur

Diameter 241 mm

Hastings-on-Hudson, Tesseract



Figure D005.1 – Front of the astrolabe (courtesy Professor David Pingree)

This unique astrolabe is equipped with a northern and a southern rete. On the obverse side of the plate is the northern projection for the latitude of 27° and on the reverse side the southern projection for the same latitude 27°. Although Sanskrit texts on the astrolabe speak of northern (*saumya*), southern (*yāmya*) and combined north-south astrolabes (*miśra*),[835] the extant Sanskrit astrolabes are all northern save this one. The same is almost the case with the Indo-Persian astrolabes. Ḍiyā' al-Dīn Muḥammad of the Lahore family produced one north-south astrolabe in 1674 (A090); and there exist two other north-south astrolabes which are not signed, but are attributable to Ḍiyā' (A103 and A104). Of these, A104 is the only which is equipped with two separate retes like the present astrolabe.[836]

COMPONENTS

Plate with crown (d. 241), shackle and ring, northern rete (d. 216) for 35 stars and southern rete (d. 216) for 30 stars, alidade with a sighting tube, pin, wedge, ruler with a longitudinal slit with a movable cursor.

FRONT

The crown is high. Lobes alternate with small triangles in the profiles; at . There are small circular projections at the base of the profiles. The finial is also circular. The shackle has circular bases to match with the circular finial of the crown. The ring is large.

The rim carries the degree scale in three concentric bands; the outer and inner bands are divided in 1° and the middle band in 6°. Groups of 6° are numbered serially from 1 to 60 starting at the east point and proceeding counter-clockwise, which is most unusual. Inside the degree scale, altitude circles are drawn for each 2°. The oblique horizon and every third altitude circle are highlighted with dots. Lines are drawn for seasonal hours and dotted lines for equal hours counted from the western and eastern horizons. There are no azimuth arcs. Neither the altitude circles, nor the hour lines are

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835 Mahendra Sūri, 3.1-24.

836 See Figure A104.2 and Figure A104.3.

numbered. The plate is calibrated for the latitude of 27°, but this fact is not recorded on the plate.



Figure D005.2 – Northern rete (photo courtesy Dr David Coffeen)

THE NORTHERN RETE

Both the northern and southern retes contain three almost complete concentric rings, in addition to the ecliptic ring which is eccentric. In the case of the northern rete, the three rings contain, starting from the outside, the Tropic of Capricorn, the equator and the Tropic of Cancer; the same is the case in the southern rete, but in reverse order. In both retes, the inner ring merges with the zodiac ring where it touches the latter. The four rings are held together by the east-west equinoctial bar and the south-north solstitial bar, both completey represented without any counter change. The upper edge of the equinoctial bar represents the equinoctial colure and the left edge of solstitial bar the

solstitial colure. All the circular rings and the straight bars have about the same width. The star pointers in both retes are fashioned in the same manner.

In the northern rete, the ring of the equator is counterchanged where it intersects the ecliptic ring. The latter is divided into the 12 zodiac signs and labelled with their names, and each sign is divided into 3 units and marked 1, 20, and 30. The sloped edge of the zodiac ring is divided unevenly in 1°.



Figure D005.3 – Detail of the northern rete showing the very sharp dagger-shaped, star pointers (below) and star pointers created by notches in the equinoctial bar (above) (photo courtesy Dr David Coffeen)

There are 35 star pointers, most of which are dagger-shaped with very sharp tips. Some star pointers are placed inside the equinoctial bar, inside the ring of Cancer and inside the ecliptic ring by small slits cut into them. In the case of *Samudrapakṣī* (β Ceti), there is a pointer, but the name is not engraved. In the case of *Mithuna-vāma-pāda* (β Orionis), there is the name but no pointer. In two instances, viz. *Viśākhā-mātṛ-maṇḍala,* (α Coronae Borealis) and *Sarpadhārīśira* (α Ophiuchi), the outlines of the pointers are drawn next to the names, but not cut out of the matrix. The engraving and the orthography of the names is very uneven. Some names are cut deeply, while a few others are scratched on the surface.

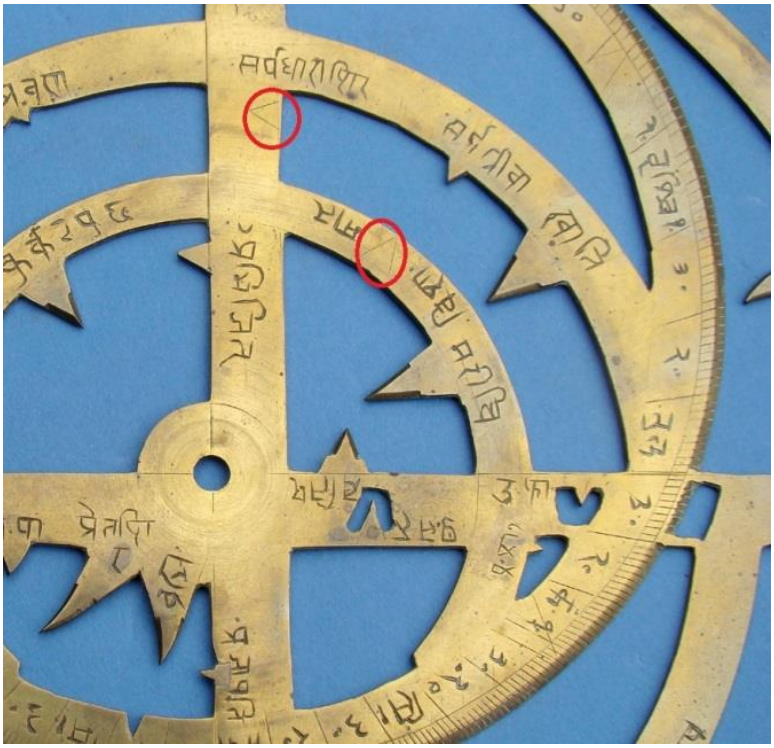


Figure D005.4 – Detail of the Northern rete, detail showing two uncut star pointers (photo courtesy Dr David Coffeen)

Table D005-1 Stars on the Northern Rete

	Star Name as engraved	Full/Correct Form	Identification
1	(not named)	*Samudrapakṣī*	β Ceti
2	*Ma.pā*	*Matsyodara-pāda*	γ Andromedae
3	*Aśvanī*	*Aśvinī*	β Arietis
4	*Pretaśira*	*Pretaśirā*	β Persei
5	*Rohiṇī*		α Tauri
6	*Vrahma*	*Brahma-hṛdaya*	α Aurigae
7	*Mi.vā.hasta*	*Mithuna-vāma-hasta*	γ Orionis
8	*Mi.vā.pāda*[837]	*Mithuna-vāma-pāda*	β Orionis

[837] The name is engraved on the equator ring, but there is no corresponding pointer.

	Star Name as engraved	Full/Correct Form	Identification
9	*Mi.da.pāda*	*Mithuna-dakṣiṇa-pāda*	κ Orionis
10	*Mṛga*	*Mṛgaśirā*	λ Orionis
11	*Prajāpati*		δ Aurigae
12	*Ārdrā*		α Orionis
13	*Lubdhaka*		α Canis Majoris
14	*Lubdhakabandhu*		α Canis Minoris
15	*Aśleṣā*		ζ Cancri
16	*Mahāpuruṣa*		α Hydrae
17	*Pū.phā.*	*Pūrva-phālgunī*	δ Leonis
18	*Pulaha*		β Ursae Majoris
19	*U.phā*	*Uttara-phālgunī*	β Leonis
20	*Hasta*		δ Corvis
21	*Catipa*	*Vasiṣṭha*	ζ Ursae Majoris
22	*Citrā*		α Virginis
23	*Marīci*		η Ursae Majoris
24	*Svāti*		α Bootis
25	*Viśā.matā*[838]	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
26	*Sarpagrīvā*		α Serpentis
27	*Sarpadhārīśira*[839]		α Ophiuchi
28	*Abhijit*		α Lyrae

838 An outline of the pointer is drawn on the ring of Cancer, but not cut out.

839 An outline of the pointer is drawn on the vertical bar, but not cut out.

	Star Name as engraved	Full/Correct Form	Identification
29	*Śravaṇa*		α Aquilae
30	*Dhaniṣṭā*	*Dhaniṣṭhā*	β Delphini
31	*Karkaṭapuccha*	*Kukkuṭapuccha*	α Cygni
32	*Aśvamuṣa*	*Aśvamukha*	ε Pegasi
33	*Śatabhiṣā*		λ Aquarii
34	*Pū-bhā.*	*Pūrva-bhādrapada*	β Pegasi
35	*U.bhā.*	*Uttara-bhādrapada*	γ Pegasi



Figure D005.5 – southern rete (left) and northern rete (right)(photo courtesy Dr David Coffeen)

THE SOUTHERN RETE

As mentioned above, the southern rete also consists of three concentric rings and the ecliptic ring. Here the outer ring represents the Tropic of Cancer and the innermost ring the Tropic of Capricorn. The centre is the South Pole. The ring of the equator is not counterchanged at the equinoxes, as is done in the northern rete. The ecliptic ring is divided into 12 signs of the zodiac and labelled with the names of the signs, starting from the autumnal equinox and proceeding anticlockwise. As in the northern rete, each sign is divided into three units and marked as 10, 20, 30 in anticlockwise direction. Each

of these units is divided into 10 degrees on the rim of the ecliptic ring and also on its edge.



Figure D005.6 – Southern rete (photo courtesy Dr David Coffeen)

There are 30 star pointers, four without names engraved on them. Those situated south of the Tropic of Capricorn should be of particular interest because these are not marked in northern retes. Thus here appears for the first time the southern star *Agasti,* also called *Agastya,* (no. 10, α Carinae). But the other stars are problematic. A cluster of several triangular star pointers is cut out of the inner edge of the Capricorn ring immediately above the equinoctial bar (no. 3) in the sign Aries. This cluster is labelled as *sapta-tārā,* 'seven stars,' a name under which Ursa Majoris is understood in Sanskrit. But this cannot be the intended meaning here. The star pointer next to it is (no. 4) *Maghataka,* the correct form of is likely to be *Nadyantaka* (θ Eridani). If so, it should be to the north of the Capricorn ring and not to south of it. Star no. 19 is named *Aśva-*

jaghana, the hind part of the horse'. Since the star occurs between the Tropic of Capricorn and the South Pole, the 'horse' can only refer to Centaurus; then the star *Aśva-jaghana* is probably *Nayyir badan qanṭūris*, 'the Bright One in the Body of Centaraur', i.e., ζ Centaruri.[840] No. 22 *Vyālī,* 'female serpent', must be σ Hydrae.[841] No. 25 *Vatala* is a corruption; it is not clear which star this is supposed to represent.

Table D005-2 Stars on the Southern Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Aśvapakṣī*	*Aśvapakṣa*	γ Pegasi
2	*Samudrapa*	*Samudrapakṣī*	β Ceti
3	*Saptatārā*	(seven stars)	?
4	*Maghataka*	*Nadyantaka*	θ Eridani
5	*Aśvanā*	*Aśvinī*	β Arietis
6	*Rohiṇī*		α Tauri
7	*Mi.vā.pāda*	*Mithuna-vāma-pāda*	β Orionis
8	*Mṛgaśira*	*Mṛgaśirā*	λ Orionis
9	(not named)		
10	*Agasti*	*Agastya*	α Carinae
11	*Ludhaka*	*Lubdhaka*	α Canis Majoris
12	*Lu.vandhu*	*Lubdhaka-bandhu*	α Canis Minoris
13	(not named)		
14	(not named)		
15	*Maghā*		α Leonis

840 Kunitzsch 1959, p. 128; Kunitzsch & Smart 1986, p. 28.

841 Kunitzsch 1959, p. 183.

	Star Name as engraved	Full/Correct Form	Identification
16	*Uttarāphā*	*Uttarā Phālgunī*	β Leonis
17	*Purvāphā*[842]	*Pūrvā Phālgunī*	δ Leonis
18	*Hasta*		δ Corvi
19	*Aśvajaghana*		ζ Centauri
20	*Anāvatpa*	*Apāṃvatsa*	θ Virginis
21	*Svācāti*	*Svāti*	α Bootis
22	*Vyālī*		σ Hydrae?
23	*Viṣākhā*	*Viśākhā*	α Librae
24	*Sarpaghrība*	*Sarpagrīvā*	α Serpentis
25	*Vatala*		?
26	(not named)	*Jānūpaviṣṭa*	α Herculis
27	*Abhijit*		α Lyrae
28	*Śravaṇa*		α Aquilae
29	*Dhaniṣṭa*	*Dhaniṣṭhā*	β Delphini
30	*Macharuṣa*	*Matsyamukha*	α Piscis Austrini

842 The name is inscribed on the ring, but the star pointer is not cut.



Figure D005.7 – Back of the astrolabe (photo courtesy Dr David Coffeen)

BACK

On the back, the entire rim is enraved with a degree scale which is divided in 1° and 6°. Groups of 6° are numbered from 6 to 90, separately for each quadrant, starting from the east and west points and reaching up to the south and north points as 6—90; 90—6; 6—90; 90—6. Inside the degree scale are drawn the east-west and south-north diameters and the concentric circles of the equator and the Tropic of Cancer. Here

altitude circles are drawn for every 2°, with each third one dotted, for the southern projection of latitude 27°.[843]

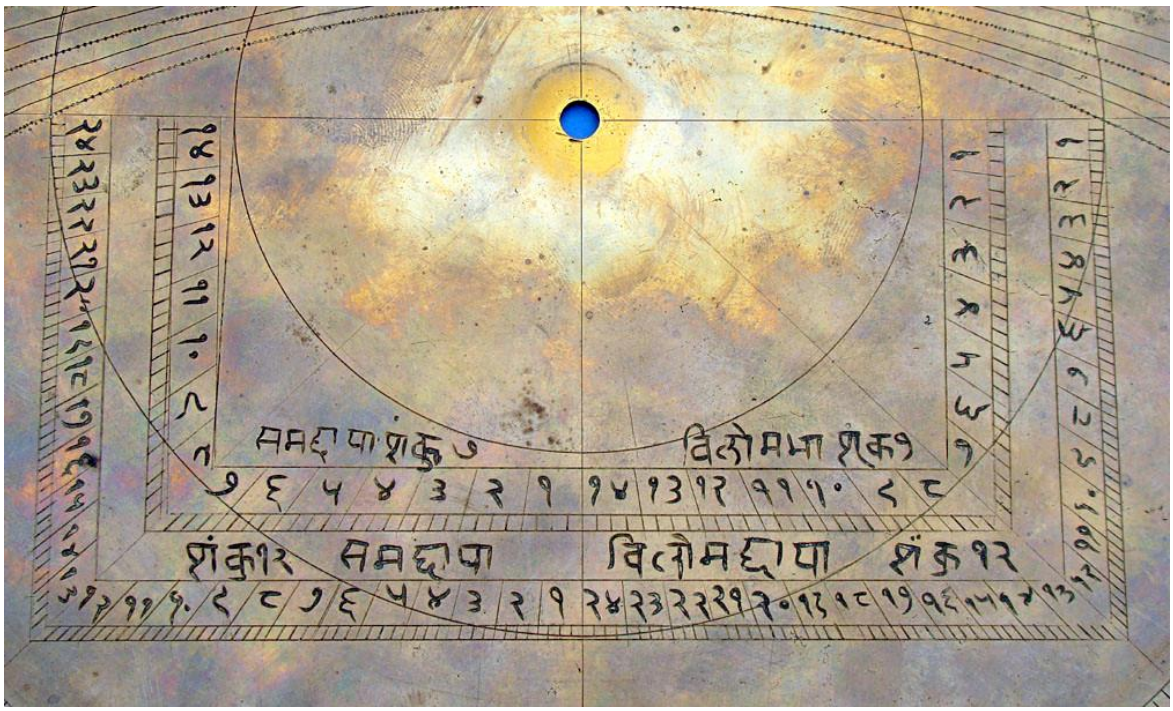


Figure D005.8 – Shadow squares on the back (photo courtesy Dr David Coffeen)

SHADOW SQUARES

In the lower half are drawn the shadow squares which are problematic. As against the normal practice of having one square in which the two halves are devoted for the shadow lengths of two types of gnomons having 12 and 7 digits respectively, here are drawn two set of shadow squares one inside the other. The inner pair is devoted to shadows cast by the gnomon of 7 digits. On the left, the horizontal and vertical scales are divided into 7 units each and numbered from 1 to 14, starting at the centre and proceeding leftwards along the horizontal scale and continuing clockwise along the vertical scale. Each unit is subdivided into 4 parts. Above the horizontal scale is the label *samachāyā śaṃku 7,* 'umbra recta gnomon 7'. Apparently both the horizontal and the vertical scales are treated here as a continuous scale of direct shadows, which is ill-conceived.

On the right also the horizontal and vertical scales are divided into 7 units each and numbered from 1 to 14, starting at the top of the vertical scale and proceeding

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843 Cf. Figure A104.4 which shows the southern projection for 36°.

clockwise downwards along the vertical scale and then continuing leftwards along the horizontal scale up to the centre. Here also each unit is subdivided into 4 parts. Above the horizontal scale is the label *vilomabhā śaṃku 7,* 'umbra versa gnomon 7'. Here also both the vertical and the horizontal scales are erroneously treated as continuous scale of reverse shadows.

The same misconception is repeated in the outer pair of squares which is devoted to the gnomon of 12 digits. On the left, the horizontal and vertical scales are divided into 12 units each and numbered from 1 to 24, starting at the centre and proceeding clockwise leftwards along the horizontal scale and continuing along the vertical scale. Each unit is subdivided into 4 parts. Above the horizontal scale is the label *śaṃku 12 samachāyā,* 'gnomon 12, umbra recta'. On the right also the horizontal and vertical scales are divided into 12 units each and numbered from 1 to 24, starting at the top of the vertical scale and proceeding clockwise downwards along the vertical scale and continuing leftwards along the horizontal scale up to the centre. Here also each unit is subdivided into 4 parts. Above the horizontal scale is the label *vilomachāyā śaṃku 12,* 'umbra versa gnomon 12'.

It is not clear what advantage is sought to be achieved by duplicating the the shadow squares. When the alidade is set for a certain angle marked in either of the altitude scales engraved on the upper rim, it would cross the 7-digit in inner shadow square and the 12-digit in outer shadow square; this could enable the observer to determine the shadow lengths in the 7-digit system as well as in the 12-digit system in one go. But the way the scales are numbered, without making a distinction between the tangent scales and cotangent scales, preclude this minor advantage.[844]

On the back is pivoted an alidade to which a sighting tube is attached. The tube is slightly bent in the middle.

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[844] This can also be done with a single pair of shadow squares; all that the observer has to do is to take readings by placing the alidade at the same angle successively in the eastern and in the western hemispheres.

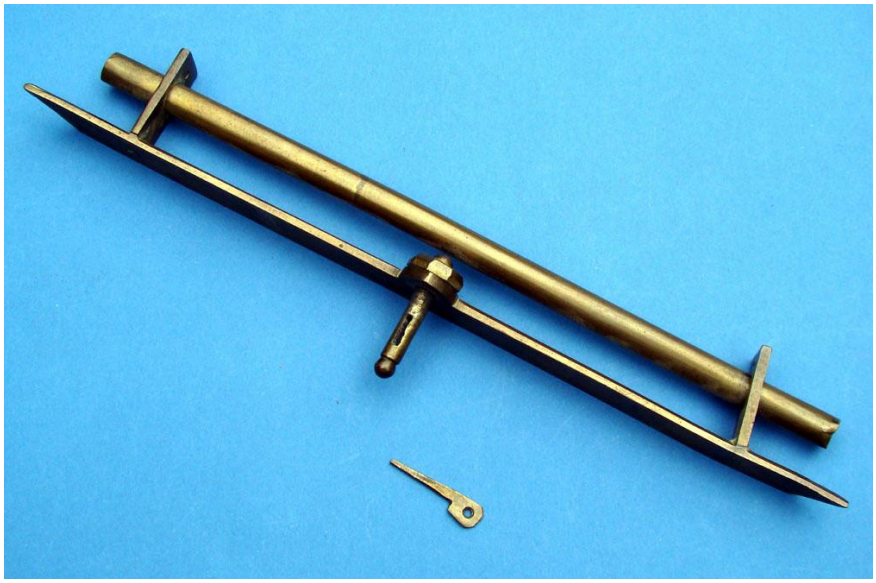


Figure D005.9 – Alidade with the Sighting Tube, Pin and Wedge (photo courtesy Dr David Coffeen)

PROVENANCE

The auction house Skinner, Bolton, received a single plate astrolabe with a northern and a southern rete. Thinking that one of the retes does not belong to the astrolabe, the auction house offered the plate with the southern rete as lot 240 and the northern rete separately as lot 241 in their auction of 13 April 2002. Luckily Dr David Coffeen of Tesseract acquired both the lots and joined the two retes with the astrolabe plate.[845]

BIBLIOGRAPHY

Skinner 2002, lots 240 and 241, p. 38.

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845 Skinner 2002, lot 240, p. 38: 'Brass Single-Plate Indian Astrolabe, with simple shaped throne, the rete with 30 star pointers and zodiacal circle divided into three sections, the mater plate with lines but not indicated, the reverse with shadow box divided into four sections and outer scale divided into four quadrants by 6s, the alidade with sighting tube, and an additional alidade, dia 9 ½ in., (lacking horse)'; lot 241, p. 38: ' Brass Indian Rete, with thirty-five star pointers and Zodiacal ring, dia 8 ½ in. Note: This rete was originally found on lot 240, but does not line up with it. It may have been made by the same student.'

D006 ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED

18th century, Jaipur

Diameter 363 mm

Brussels, PC



Figure D006.1 – Front of the astrolabe (photo by the owner)

This well-preserved astrolabe is almost like the preceding D005 and must have been made by the same instrument maker. The crown is almost the same with tiered

lobes with ogees at the base. The shackle with the circular bases is exactly the same. Both have the same type of ruler with a longitudinal slit in which there is a movable cursor. The retes in both the astrolabes are alike in the arrangement of four circular rings held together by the straight vertical and horizontal bars. The star pointers are also fashioned in the same manner. On the back, both have double shadow squares one inside the other. Finally, alidades with sighting tubes are alike.

However, there are certain differences. The present astrolabe displays better and more elegant workmanship. In the rete, the two ends of the Capricorn ring are fashioned elegantly like peacocks. The quality of engraving and the quality of orthography of the star names is much superior here to that in the previous piece. This astrolabe does not a have a southern rete and its degree scale on the rim is different from the degree scale on in D005. Though both astrolabes have two pairs of shadow squares on the back, the arrangements and the numbering of the scales is different.

COMPONENTS

Plate with crown (d. 363 mm, wt. 3.4 kg), shackle and ring, rete for 33 stars, alidade with a sighting tube, pin, wedge; a ruler in the front with a longitudinal slit and a cursor.

FRONT

The crown is high and lobed. At the base of the crown on each side there are circular projections. The crown terminates in a circular finial to which is attached the shackle with exactly matching circular bases. A large ring passes through the shackle.

The limb carries degree scale in three columns as in D005. The outermost and the innermost columns are graduated in single degrees of the arc, while the middle column is divided in groups of 6˚. But here the numbering of the scale is different. Groups of 6° are numbered from 6 to 90, separately for each quadrant. The numbering commences from the east and the west points respectively and reaches up to the south and north points (6—90; 90—6; 6—90; 90—6). The numbers are neatly engraved.

Altitude circles are drawn for every 2° and each fifth circle is highlighted with dots. Azimuth arcs are drawn below the oblique horizon for each 6°. There are two sets of hour lines, one for unequal hours and another for equal hours counted from the western and eastern horizons. However, none of these four sets of lines is numbered.

Nor is there an inscription mentioning the latitude for which this plate is calibrated. The disposition of the almucantars shows that the astrolabe is calibrated for 27°.

RETE

As in the previous astrolabe, the rete has an unusual configuration of rings. There are three almost complete concentric rings containing the circles of the Tropic of Capricorn, the equator and the tropic of Cancer. There is no counter change in the equator ring. The ring of Cancer merges at the bottom with the zodiac ring. The four rings are held together by the two straight bars placed in the east-west and south-north directions. The lower edge of the east-west bar corresponds to the equinoctial colure and the left edge of the vertical bar to the solstitial colure. The outer ring representing the Tropic of Capricorn terminates at the top in two peacock-like figures. All these circular bands and straight bars have the same width. The band representing the tropic of Capricorn and the equator are joined together below by two slender bars.

The ecliptic is divided into the 12 signs of the zodiac and labelled with their names. Each sign is subdivided into 3 decans and numbered as 10, 20, 30. The name of the sign and the degrees of the first division are written together: thus, e.g., *Meṣa10.* The edge of the ecliptic ring is graduated in single degrees.

On both sides of the ecliptic there are star pointers shaped like daggers or stepped-up daggers. The positions of some stars are marked by heart-shaped slits inside the broad bands.

The Sanskrit star names engraved next to the pointers are sometimes given in full, sometimes in abbreviated form. The vertical pointer for *Rohiṇī* (α Tauri, no. 5) contains another pointer, branching off horizontally from it. This has not been named, but represents γ Orionis (*Mithuna-dakṣiṇa-hasta*, no. 8). As in D001, α Hydrae (no. 15) is called by its Arabic name *Fard al-Shujāʿ* (transcribed here as *Pharadalasujī*) and not by the Sanskrit name *Mahāpuruṣa*.

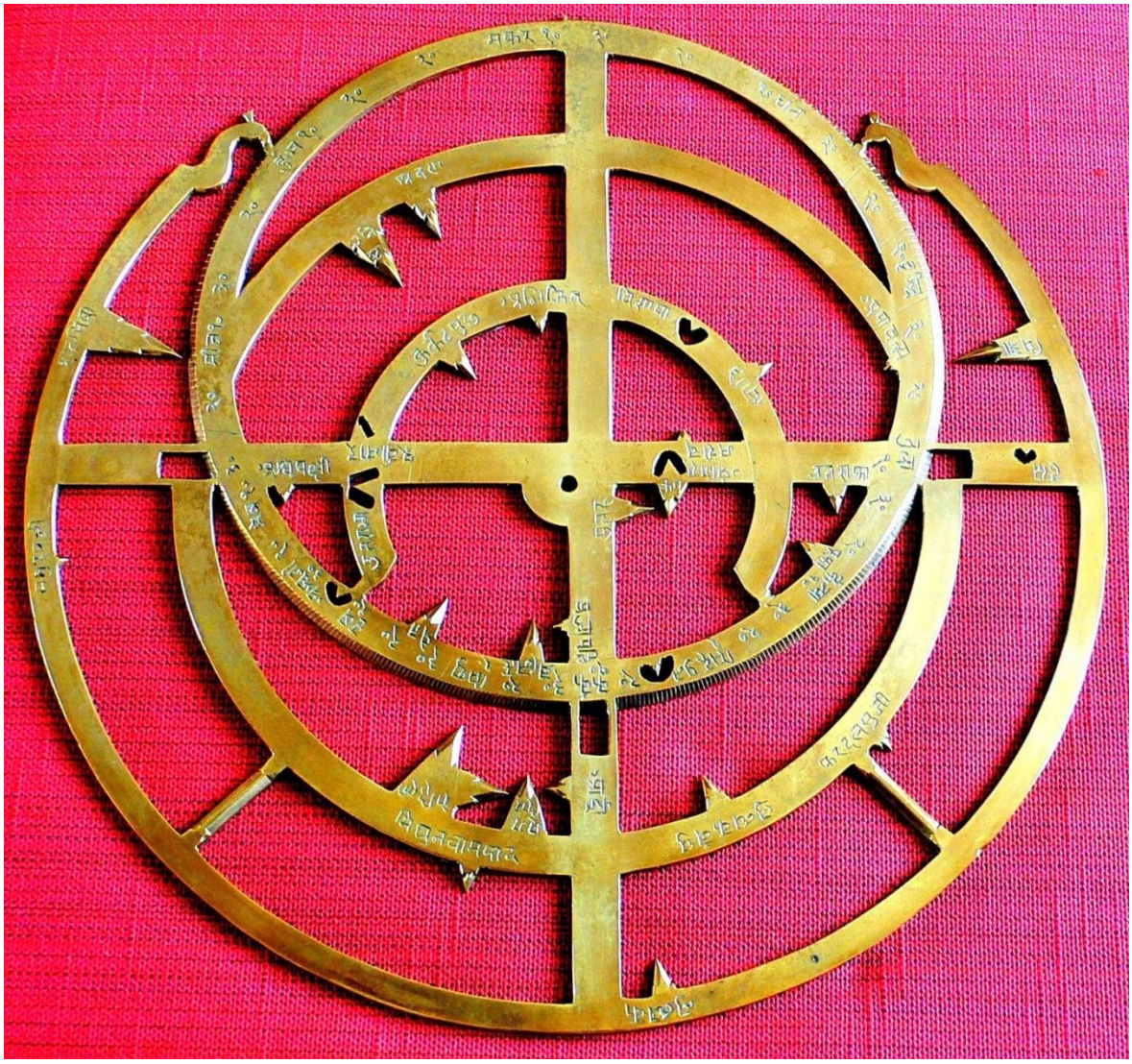


Figure D006.2 – Rete of the astrolabe (photo by the owner)

Table D006-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Aśvapakṣī*	*Aśvapakṣa*	γ Pegasi
2	*Samudrapakṣī*		β Ceti
3	*Aśvanī*	*Aśvinī*	β Arietis
4	*Preta*	*Pretaśira*	β Persei
5	*Rohiṇī*		α Tauri
6	*Brahmahṛ*	*Brahmahṛdaya*	α Aurigae

	Star Name as engraved	Full/Correct Form	Identification
7	*Mithunavāmapāda*		β Orionis
8	(not named)	*Mithuna-dakṣiṇa-hasta*	γ Orionis
9	*Mṛgaśira*	*Mṛgaśirā*	λ Orionis
10	*Prajāpati*		δ Aurigae
11	*Ārdrā*		α Orionis
12	*Lubdhaka*		α Canis Majoris
13	*Lubdhakabaṃdhu*		α Canis Minoris
14	*Puna*	*Punarvasu*	β Geminorum
15	*Pharadalasujī*	*Mahāpuruṣa*	α Hydrae
16	*Pulaha*		β Ursae Majoris
17	*Kratu*		α Ursae Majoris
18	*Pūphā*	*Pūrva-phālgunī*	δ Leonis
19	*Uttaraphā*	*Uttara-phalgunī*	β Leonis
20	*Hasta*		δ Corvi
21	*Aṅgirā*		ε Ursae Majoris
22	*Citrā*		α Virginis
23	*Apāṃvatsa*		θ Virginis
24	*Marīca*	*Marīci*	η Ursae Majoris
25	*Svāti*		α Bootis
26	*Viśāṣā*	*Viśākhā-matṛ-maṇḍala*	α Coronae Borealis
27	*Abhijit*		α Lyrae
28	*Śravaṇa*		α Aquilae
29	*Dhaniṣṭhā*		β Delphini

	Star Name as engraved	Full/Correct Form	Identification
30	*Kurkaṭapucha*	*Kukkuṭa-puccha*	α Cygni
31	*Śatabhiṣā*		λ Aquarii
32	*Pūrvābhā*	*Pūrva-bhādrapadā*	β Pegasi
33	*Uttarābhā*	*Uttara-bhadrapadā*	γ Pegasi

BACK

The rim of the back also has an almost similar degree scale as in the front with three columns, but here the outermost column is blank and not graduated.

The upper left quadrant carries a sine-cosine grid with 30 horizontal parallels and 30 vertical parallels; each fifth line is highlighted. The upper right quadrant is blank.



Figure D006.3 – Back of the Astrolabe (photo by the Owner)

SHADOW SQUARES

In the lower half, there are two pairs of shadow squares, one inside the other as in D005. The arrangement of the scales, however, differs from that in D005, but this arrangement too is erroneous. Here the squares on the left (in the outer scale and inner scale) pertain to the gnomon of 12 digits*;* those on the left to the gnomon of 7 digits. The inner scales are said to be of umbra recta (*sama-bhā*) and the outer scales of umbra versa (*viloma-chāyā*).

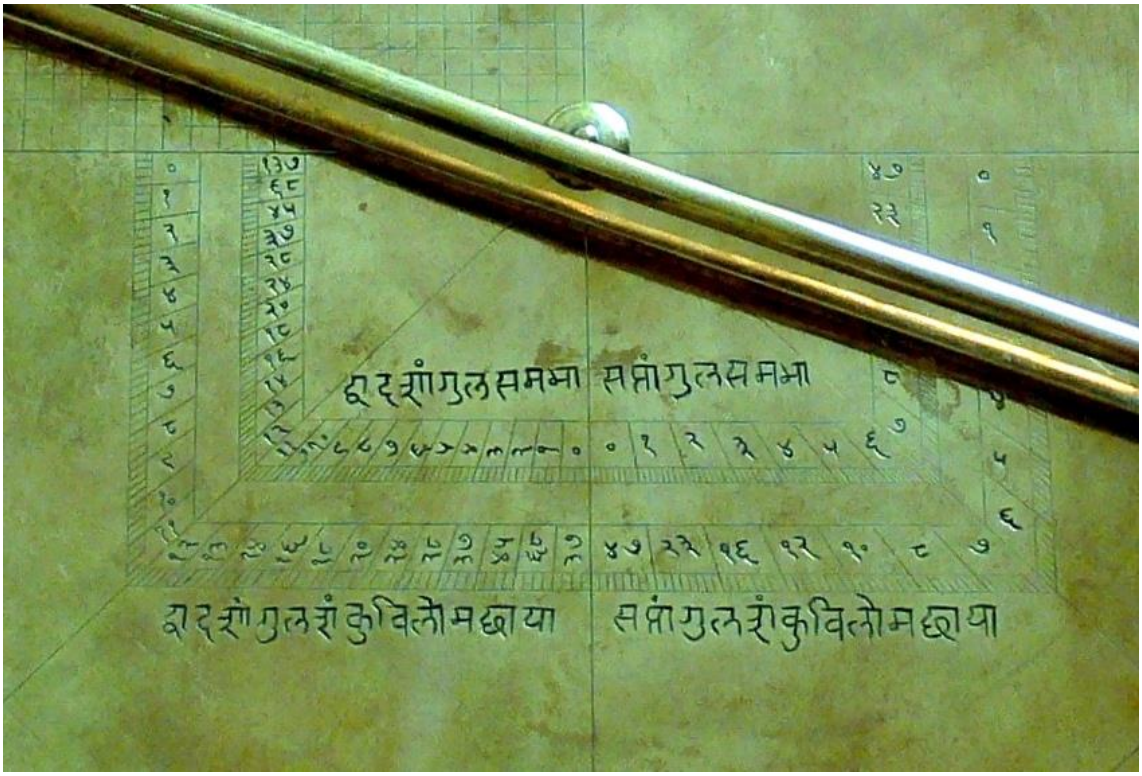


Figure D006.4 – Shadow Squares on the Bank (photo by the owner)

The numbering also is quite idiosyncratic. In the outer squares the numbering starts with 0 at the top of the vertical scale and continues along the horizontal scale up to the meridian. On the left, the 12 divisions on the vertical side are numbered from the top as 0, 1, 2, …, 9, 10, 11. The 12 divisions on the horizontal side are numbered from left to right as 12, 13, 14, 16, 18, 20, 24, 28, 37, 45, 68, 37. Below the horizontal scale is the label: *dvādaśāṃgula-śaṃkuvilomachāyā,* 'umbra versa of the gnomon of 12 digits'.

On the right, the 7 divisions on the vertical side are numbered starting from the top and proceeding downwards as 0, 1, 2, 3, 4, 5, 6. The 7 divisions on the horizontal side are numbered from right to left as 7, 8, 10, 12, 16, 23, 47. Below the horizontal scale is the label: *saptāṃgulaśaṃku-vilomachāyā,* 'umbra versa of the gnomon of 7 digits'.

In the inner squares the numbering starts at the intersection of the horizontal scale and the north-south line, proceeds along the horizontal scale and then continues along the vertical scale up to the top. On the left, the divisions in the horizontal scale are numbered from right to left as 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11. These continue upwards on the vertical scale as 12, 13, 14, 16, 18, 20, 24, 28, 37, 45, 68, 137. Above the

horizontal scale is the label *dvādaśāṃgulasamabhā,* ‘umbra recta [of the gnomon of] 12 digits’.

On the right, the numbers on the horizontal scale are from left to right 0, 1, 2, 3, 4, 5, 6. These continue upwards on the vertical scale as 7, 8, 10, 12, 16, 23, 47. Above the horizontal scale is the label *saptāṃgulasamabhā,* ‘umbra recta [of the gnomon of] 7 digits’.

Alidade and Rule

Pivoted to the centre at the back is an alidade on which a sighting tube is mounted. In the front there is a ruler with a longitudinal slit in which a cursor slides up and down. The cursor bears the mark of two perpendicular straight lines and a triangle pointing along the longitudinal direction. On both sides of the slit is an identical scale, divided into 17 unequal divisions. Many of these divisions are further divided into 6 parts, while some are divided into 4 parts only.

Provenance

This astrolabe belonged originally to a scholar of Jaipur from whom Alain Brieux acquired it; it was listed as no. 8585 in Alain Brieux’s catalogue of 1976. The present owner bought it from Brieux around 1976.

Bibliography

Libraire Alain Brieux, catalogue of 1976, no. 8585.

D007⦿ ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED

18th century, Jaipur

Diameter 304.5 mm

Jaipur, PC



Figure D007.1 – Front of the astrolabe (photo by S. R. Sarma)

This astrolabe is not well preserved and looks rusty; it shares many features with the preceding two specimens and must have been produced by the same person at about the same time in the eighteenth century at Jaipur.

Components

Plate with crown (d. 304.5, h. 380), shackle, ring, rete (d. 280) for 37 stars, alidade with a sighting tube, pin, wedge, and a ruler (length 125).

Front

The shackle and the ring have diamond cross-sections. The high crown has profiles similar to those on D006. On the crown is engraved *yaṃtrarāja*.

The degree scale on the rim is divided in 1° and 6° and labelled in 6s separately for each quadrant as 6—90; 90—6; 6—90; 90—6 as in D006. Altitude circles are drawn for each 2°, every fifth line is highlighted by dotted lines; but only every third is numbered as 6, 12, … 90. Azimuth arcs are drawn below the horizon for every 6° and numbered. In the lower half there are lines for seasonal hours and dotted lines for equal hours counted from the western and eastern horizons. These hours lines are not numbered. The plate is calibrated for the latitude of 27° but not so labelled.

Rete

The rete is exactly like the same in the two previous specimens with its configuration of four rings. The outer ring representing the Tropic of Capricorn terminates at the top in two peacock-like figures.

The ecliptic is divided into the 12 signs, each sign divided into 5 parts of 6° each. In the first part is engraved the name of the sign, other parts carry the labels of their degrees. Thus *Mīna*, 12, 18, 24, 30. The bevelled edge is divided in 1°.

The equator ring and the ring of Cancer also carry double bands of scales, divided in 1° and 6° respectively, which is unusual. However, these scales are not numbered.

There are 37 star pointers, but four of these are not named.

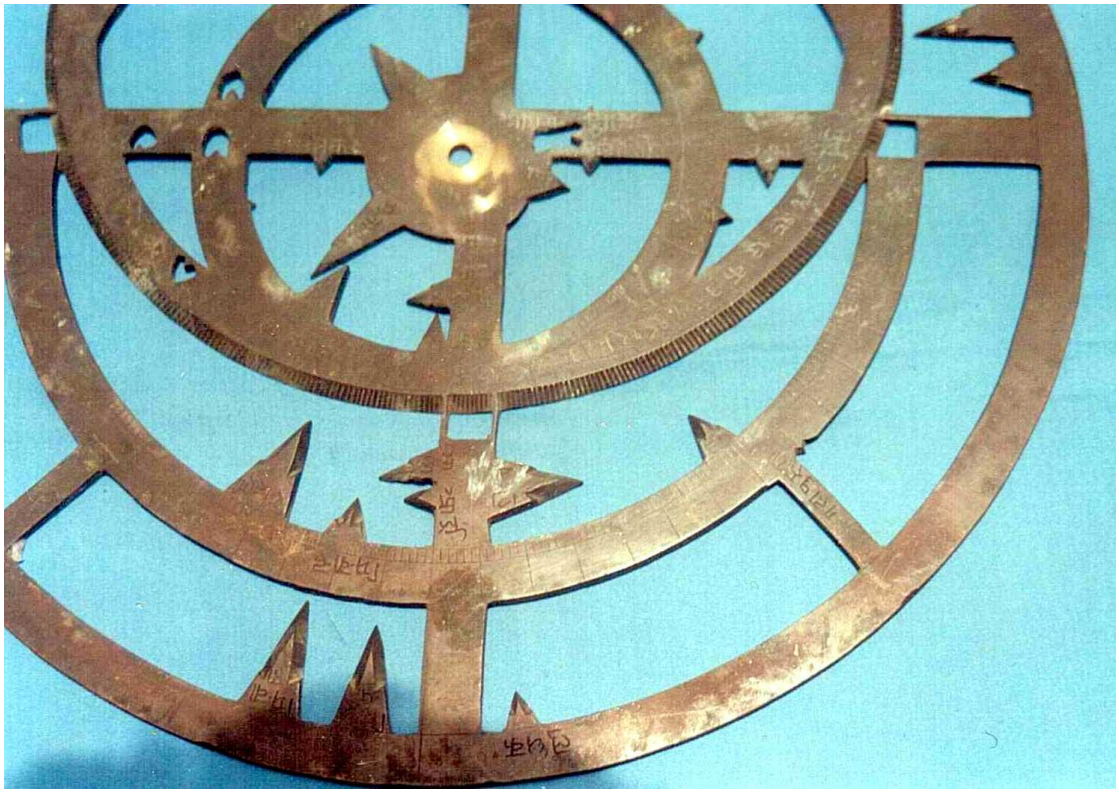


Figure D007.2 – Rete of the astrolabe, detail (photo by S. R. Sarma)

Table D007-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Matsyodara*		β Andromedae
2	(not named)		
3	*Pretaśira*		β Persei
4	*Manu. pā.*	*Manuṣya-pārśva*	α Persei
5	*Rohiṇī*		α Tauri
6	*Brahmahṛdaya*		α Aurigae
7	*Mi. vā. pā.*	*Mithuna-vāma-pāda*	β Orionis
8	*Mi. vā. ha.*	*Mithuna-vāma-hasta*	γ Orionis
9	*Ma. tra. śi.* ?		?
10	*Mi. da. pā.*	*Mithuna-dakṣiṇa-pāda*	κ Orionis

	Star Name as engraved	Full/Correct Form	Identification
11	*Ārdrā*		α Orionis
12	*Prajāpa*	*Prajāpati*	δ Aurigae
13	*Lubdhaka*		α Canis Majoris
14	*Lu. baṃ.*	*Lubdhaka-bandhu*	α Canis Minoris
15	*Aśleṣā*		ζ Cancri
16	*Mahāpuruṣa*		α Hydrae
17	*Kratu*		α Ursae Majoris
18	*Pū. phā.*	*Pūrva-phālgunī*	δ Leonis
19	*Pulaha rata*	*Pulaha*	β Ursae Majoris
20	*U. phā.*	*Uttara-phālgunī*	β Leonis
21	(not named)		
22	*Citrā*		α Virginis
23	*Marīci*		η Ursae Majoris
24	(name rubbed off)		
25	*Viśākhā*		α Librae
26	*Sarpaśrī*	*Svāti*	α Bootis
27	*Vi.mā.*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
28	*Sarpadhārīśira*		α Ophiuchi
29	*Abhijit*		α Lyrae
30	*Ku.ca.*	*Kukkuṭa-cañcu*	β Cygni
31	*Śravaṇa*		α Aquilae
32	*Dhaniṣṭhā*		β Delphini
33	*Kukkuṭa mu.*	*Kukkuṭa-puccha*	α Cygni

	Star Name as engraved	Full/Correct Form	Identification
34	(not named)		
35	*Aśva*	*Aśvamukha*	ε Pegasi
36	*Aśvanābha*	*Aśvanābhi*	δ Pegasi = α Andromedae
37	*Raṃjitakara*		β Cassiopeiae

BACK

The entire rim is covered by the degree scale as in the front. In the upper left quadrant is engraved a sine-cosine grid with 30 vertical and 30 horizontal parallels. A quarter circle is drawn to represent the obliquity. Unusually enough, there are several labels here, as they would be in a sine quadrant. At the top of the vertical radius of the quadrant is engraved *khamadhya* (zenith), at the centre *kendra* (centre), at the end of the horizontal radius *kṣitija* (horizon), next to the circle of obliquity *krāntivṛtta* (circle of declination), below the quadrant along the horizontal parallels *jyā* (sine) and next to the vertical parallels *utkrama-jyā* (versed sine). The upper right quadrant is empty.

SHADOW SQUARES

As in the previous two astrolabes, two sets of shadow squares are engraved on the back of this astrolabe. However, the labels and numbers in the scales differ from the other two: the arrangement of the scales is as in D005, i.e., the shadows of the 7-digit gnomon in the inner squares and those of the 12-digit gnomon in the outer squares, but the numbering of the divisions follows the same in D006.

First the larger scale for the gnomon of 12 digits. Here, below the horizontal scale on the left is written, *dvādaśāṃgulaśaṃkoḥ samachāyā* (umbra recta of the gnomon of 12 digits). The horizontal scale is divided into 12 parts and labelled, starting from the centre as 0, 1, 2 … 11. The vertical scale is divided into 12 parts and these are labelled as 12, 13, 14, 16, 18, 20, 24, 28, 37, 45, 68, [1]37. On the right, below the horizontal scale, is written *dvādaśāṃgulaśaṃkoḥ viṣamachāyā* (umbra versa of the gnomon of 12 digits). Here the vertical scale is divided into 12 parts and labelled as 0, 1, 2, … 11; the

horizontal part is divided into 12 parts and labelled as 12, 13, 14, 16, 18, 20, 24, 28, 37, 45, 68, [1]37. Each of these divisions is further subdivided into parts.

In the inner squares devoted to the 7-digit gnomon, on the left, below the horizontal scale is written *saptāṃgulaśaṃkoḥ samachāya* (umbra recta of the gnomon of 7 digits). Here the horizontal part is divided into 6 parts and labelled, starting from the centre, as 1, 2, 3, 4, 5, 6. (It should have been divided in 7 parts and labelled as 0, 1, … 6). The vertical part is divided into 7 parts and labelled as 7, 8, 10, 12, 16, 23, 47. On the right, below the horizontal scale is written *saptāṃgulaśaṃkoḥ viṣamachāyā* (umbra versa of the gnomon of 7 digits). Here the vertical scale is divided into 6 parts and labelled as 1, 2, 3, 4, 5, 6. (It should have been divided in 7 parts and labelled as 0, 1, … 6). The horizontal scale is divided into seven parts and labelled as 7, 8, 10, 12, 16, 23, 47.

ALIDADE AND RULE

The alidade has ornate terminals and an ornate centre piece. To this alidade is attached a sighting tube. One end of the sighting tube is broken. There is a pin with a broad head, and a wedge which terminates in a bird’s head.

In the front is a ruler of 125 mm length with a longitudinal slit in the middle. On both sides there are 16 divisions gradually increasing in size. These divisions are further subdivided into 6 parts in an adjacent scale. But the curser is missing.

STANDARD ASTROLABES FOR LATITUDE 27° MADE AT JAIPUR

Leaving aside the seven unusual specimens described above, there are extant several standard astrolabes made for latitude 27°. In most cases, these are unostentatious pieces having simple retes with dagger-shaped star pointers. All these must have been produced at Jaipur, either in Jai Singh's palace workshop or outside for individual astronomers. Just one astrolabe (D008) is dated, but it is difficult to extract the precise date from the symbolic notation. Nevertheless, it is an extraordinary piece with the intricately carved throne and with silver inlay in the inscriptions. Worthy of note are also the ornithomorphic motifs on the rete of D018 and in the throne of D026.

The last traditional astrolabe to be made at Jaipur is D027. It was made ca. 1951 at the behest of Madanamohana Śarmā as a companion piece to his Hindi rendering of Mahendra Sūri's *Yantrarāja.*

D008⊙ ASTROLABE FOR LATITUDE 27°, COMMISSIONED BY MANNĀLĀLA, MADE BY ŚIVADATTA

Mid 19th century, Jaipur

Diameter 344.5 mm

London, Science Museum (# 1986-1190)



Figure D008.1 – Front of the astrolabe (© Science Museum / Science & Society Picture Library)

This large and fabulously crafted brass astrolabe is a superb example of metal craft in Jaipur. According to the inscription on the back, this astrolabe was commissioned by Mannālāla, who was the officer in charge of justice at the court of Sawai Ram Singh of Jaipur (r. 1835-1879).[846] It was fabricated by Syudatta; his correct name must be Śivadattta which was compressed for the sake of meter. The year of manufacture is expressed in the so-called *Bhūtasaṃkhyā* notation, where the numbers are denoted by certain symbolic words.[847] Again for the same of metre, the expression denoting the year of manufacture is so clumsily phrased that it it difficult to extract the year from it. In the same inscription Mannālāla is referred to as the 'Darogah' which position was bestowed on him in 1851. Therefore, the astrolabe must have been produced after 1851 and before the death of Ram Singh in 1879.

In this astrolabe all the inscriptions are inlaid in silver. In the rete, the two ends of the open ring of the Tropic of Capricorn are shaped like elephants, their trunks holding lotus flowers, as if paying homage to the artistic creator of this masterpiece of metal work. The high open work crown is intricately carved, playfully incorporating elephant heads and trunks. A careful examination would reveal at least ten such motifs. In the rete, the three large rings are joined by foliate tracery with fern-like leaf-fronds. The instrument maker playfully placed parrots here and there on the rings. On the ecliptic circle, there is a parrot/dove-like bird to the right of the rule; there is another bird immediately to the right of the rule perched upon the equator ring. There is one more on the equator ring on the right between two fronds of fern. On the Capricorn ring, the two ends of a creeper which are touching the ring are being nibbled at by a bird each.

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846 Sarma 2010, s.v. Mannālāla. About Mannālāla, Sri Gopal Narayan Bahura of the Maharaja Mansingh II Museum and Library, Jaipur, wrote to me on 13.11.1993 thus:
'About Mannalal Sanghi I know only so much that he was Saraogi by caste and had become Bakhshi (Superintendent of armed forces) during the prime ministership of his relative Jhuntalal Sanghi in the minority period of S. Ram Singh and regency of Maji Chandravatiji (1835-1851). By favour of the political agent and the A.G.G. he rose to the high post of Fauz Musahab in 1835 (military member).
'He had become a favourite of Maharaja Sawai Ram Singh and also functioned as a trusted Daroga (Supdt.) under him (1851-1880 A.D.). He acted against the rebel jagirdars at Sawai Madhopur and subdued them in 1830. He led a campaign against the robbers in Shekhawati in 1831. He was active in 1857 also in suppressing the mutineers in Shekhawati by leading a force of 200 cavalry and 1000 Nagas.'

847 On this notation, see SarmaKV 2003.

Aside from the playful artistry, this astrolabe is an excellently crafted scientific instrument with all the scales and the projections of circles and lines carefully executed. The rete incorporates a very large number of star pointers like the large wheel astrolabe produced at the time of Sawai Jai Singh (C021).

Components

Plate with crown (d. 344.5, h. 446, t. 4), shackle and ring, rete (d. 295) for 47 stars, alidade with a sighting tube, pin, ruler, wedge in the form of a parrot.

Front

The high crown is intricately carved and worked *à jour.* The finial of the crown is formed like a lotus to which the shackle with the circular bases is attached. The ring has a peculiar shape. It is not completely circular; the lower part tapers down and is loosely screwed to the top of the small shackle. The degree scale on the rim is divided in ½ °, 1° and in 6° and numbered separately for each quadrant in 6s as 6—90; 90—6; 6—90; 90—6. In the outer band the lines separating the groups of 6° are inlaid in silver; so too the numbers there. In the middle band the division marks of single degrees are inlaid in silver. In the inner band, the divisions of ½ degrees are marked with black enamel.

On the plate altitude circles are drawn for each 2° with every third line emphasized with dots. Azimuth arcs are drawn for each 6° above the horizon and for each 2° below the horizon. There are lines for the seasonal hours. The lines are filled with black enamel. Below the horizon line, on either side of the meridian, there are labels inlaid silver, which read *akṣabhā 6|6 ,* ‘midday equinoctial shadow 6;6’, and *akṣāṃśa 27,* ‘latitude degrees 27’.

Rete

The three rings of the Tropic of Capricorn, equator and ecliptic are held together by the east-west equinoctial bar without counter change and a series of foliate tracery. The two ends of the ring of the Tropic of Capricorn terminate into heads of elephants, holding lotuses in their trunks; the almost complete equator ring is counterchanged at its intersection with the ecliptic ring. The ecliptic circle is divided in 12 zodiac signs, and the names of the signs are inlaid in silver. Each sign is divided into groups of 6° and numbered in 6s. These numbers are inlaid in silver and the division marks filled with black enamel.

From the foliate tracery arise the various star pointers which are formed like ferns. The names of the stars are not engraved on the fern-shaped star pointers, but on the equinoctial bar and on the central disc from which the ferns arise. The names are also inlaid in silver.

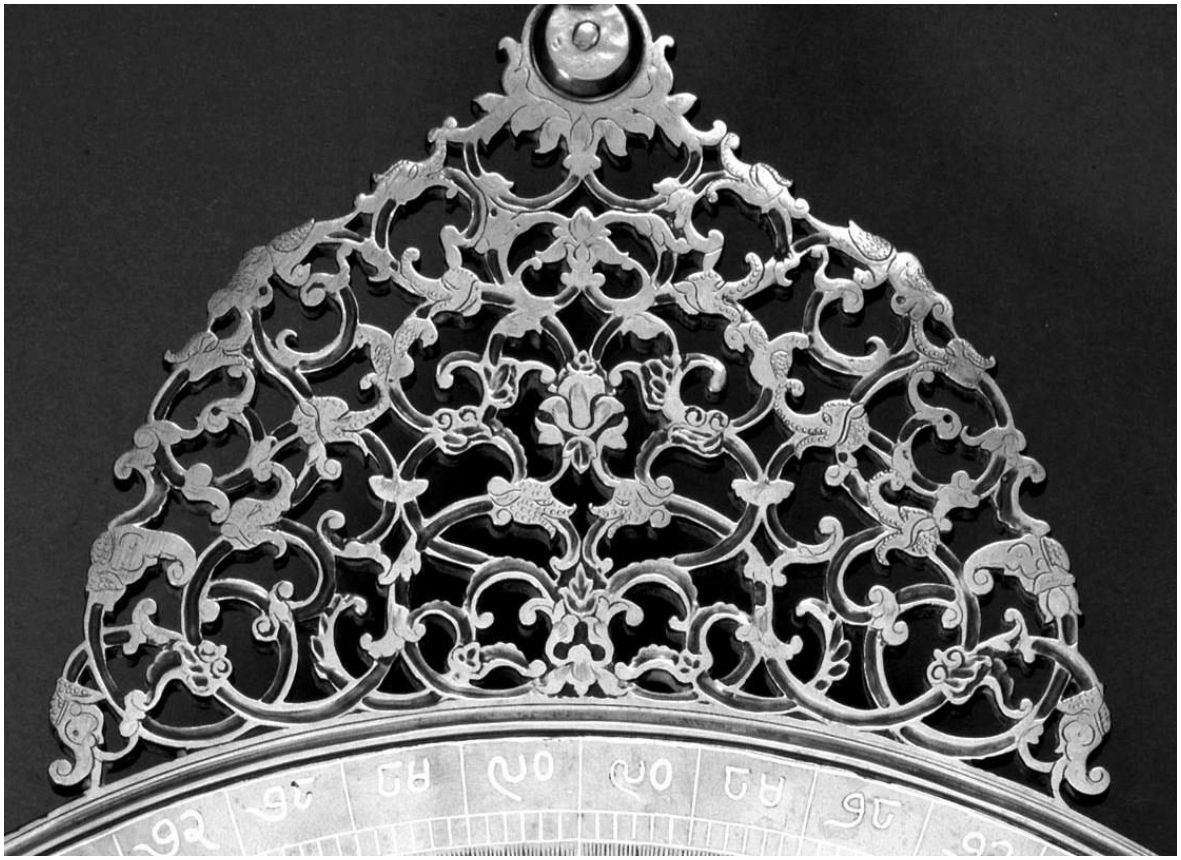


Figure D008.2 – Detail of Figure D001.1, showing the elephant motif in the crown

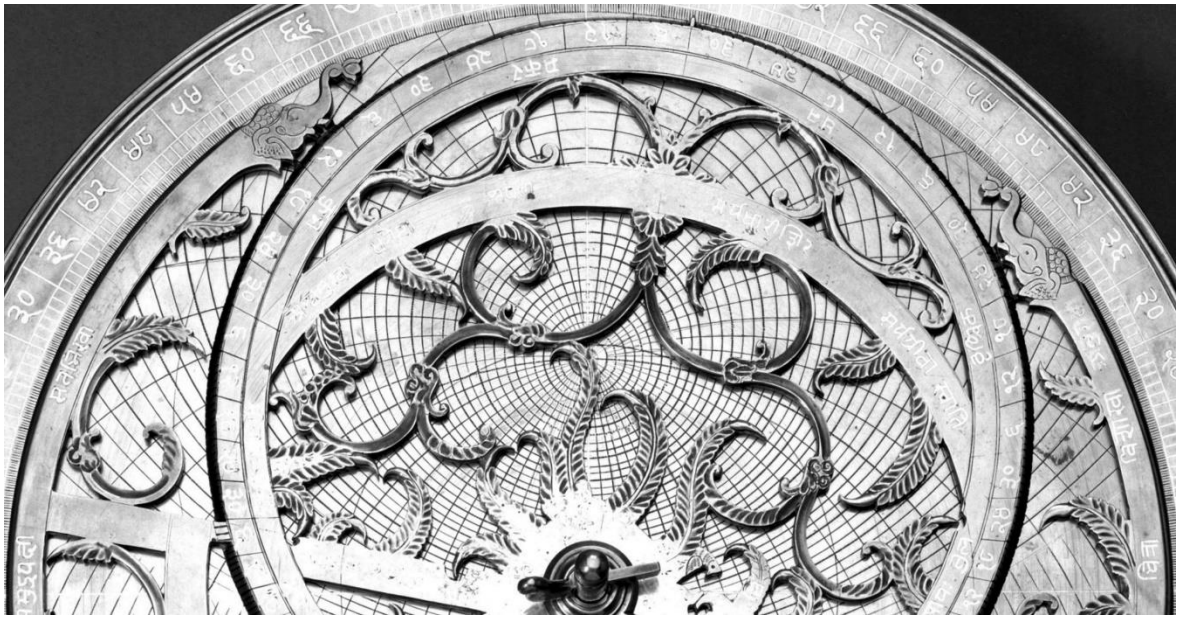


Figure D008.3 – Detail of Figure D001.1, showing the upper half of the rete. Note the elephant heads at the two terminals of the Capricorn ring.

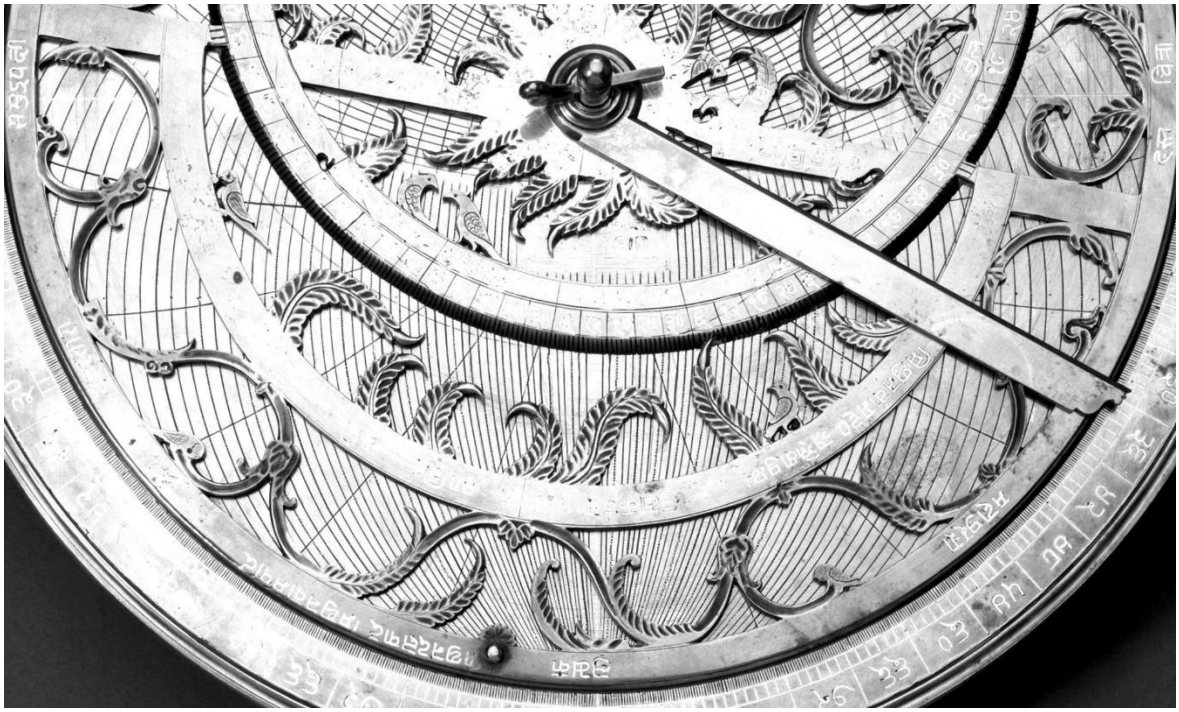


Figure D008.4 – Detail of Figure D001.1, showing the birds on the three tings.

There are about 47 star names on the rete, but some of them are problematic. In three cases, two synonyms of a star name are treated as two independent stars. Thus no. 10 *Mithuna-dakṣiṇa-pāda* and no. 11 *Ārdrā,* both representing α Orionis, are treated as two separate stars. Likewise no. 18 *Maghā* and 19. *Siṃha-hṛdaya,* both names of α Leonis, become two different stars. Finally no. 38 *Pūrva-bhādrapadā* and no. 39 *Aśva-skandha,* both names of β Pegasi, become two separate stars in this astrolabe.

The second problem with the star names is that there are 7 abbreviated names which are difficult to identify. These are placed at the end of the list.

Table D008-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Matso*	*Matsyodara*	β Andromedae
3	*Matso.pā.*	*Matsyodarapāda*	γ Andromedae
4	*Naharatārā*		γ Eridani
5	*Rohiṇī*		α Tauri
6	*Agni*		β Tauri

	Star Name as engraved	Full/Correct Form	Identification
7	*Bra.ha.*	*Brahma-hṛdaya*	α Aurigae
8	*Mithuna-vāma-pāda*		β Orionis
9	*Mithuna-vāma-hasta*		γ Orionis
10	*Mithuna-dakṣa-pāda*	*Mithuna-dakṣiṇa-pāda*	α Orionis
11	*Ārdrā*		α Orionis
12	*Lubdhaka*		α Canis Majoris
13	*Lubdhakabaṃdhu*		α Canis Minoris
14	*Mṛgaśirā*		λ Orionis
15	*Aśleṣā*		ζ Cancri
16	*Puṣya*		δ Cancri
17	*Mahāpuraśa*	*Mahāpuruṣa*	α Hydrae
18	*Maghā*		α Leonis
19	*Siṃ.ha.*	*Siṃha-hṛdaya*	?
20	*U.phā.*	*Uttara-phālgunī*	β Leonis
21	*Hasta*		δ Corvi
22	*Atri*		δ Ursae Majoris
23	*Vaśiṣṭha*		ζ Ursae Majoris
24	*Citrā*		α Virginis
25	*Svātī*	*Svāti*	α Bootis
26	*Āpaḥ*		δ Virginis
27	*Viśākhā*		α Librae
28	*Anurādhā*		δ Scorpii

	Star Name as engraved	Full/Correct Form	Identification
29	*Sarpagrīvā*		α Serpentis
30	*Sarpadhārīśira*		α Ophiuchi
31	*A.ji.*	*Abhijit*	α Lyrae
32	*Ku.da.ja*	*Kukkuṭa-cañcu*	β Cygni
33	*Śravaṇa*	α Aquilae	
34	*Ku.ṭa.puṃ.*	*Kukkuṭa-puccha*	α Cygni
35	*Dhaneṣṭā*	*Dhaniṣṭhā*	β Delphini
36	*Aśvamukha*		ε Pegasi
37	*Śatabhikhā*	*Śatabhiṣā*	λ Aquarii
38	*Pu.bhā*	*Pūrva-bhādrapadā*	β Pegasi
39	*Aśvaskaṃda*	*Aśvaskandha*	?
40	*Aśvana*	*Aśvanābhi*	δ Pegasi = α Andromedae
41	*ka*	?	
42	*kraṃ.ti.ma*	?	
43	*kṛ.ndu.*	?	
44	*ma.li.*	?	
45	*mi.ā.ma.*	?	
46	*ma.yya.gaku*	?	
47	*pra.ṇa.*	?	

BACK

The degree scale on the rim is divided ½°, 1° and in 6° and numbered in 6s separately for each quadrant as 6—90; 90—6; 6—90; 90—6. As in the front, the division marks of 6° and the numbers are inlaid in silver in the outer band; the division

marks of single degrees are inlaid in silver in the middle band and the divisions of ½ degrees are marked with black enamel in the inner band.

The upper left quadrant contains the sine-cosine grid with 60 horizontal and 60 vertical parallels with each sixth line emphasized by dots. The upper quadrant on the right contains 30 declination arcs, five for each zodiac sign, i.e. one for each 6° of solar longitude. The names of the signs are written along the two radii with inlaid silver.

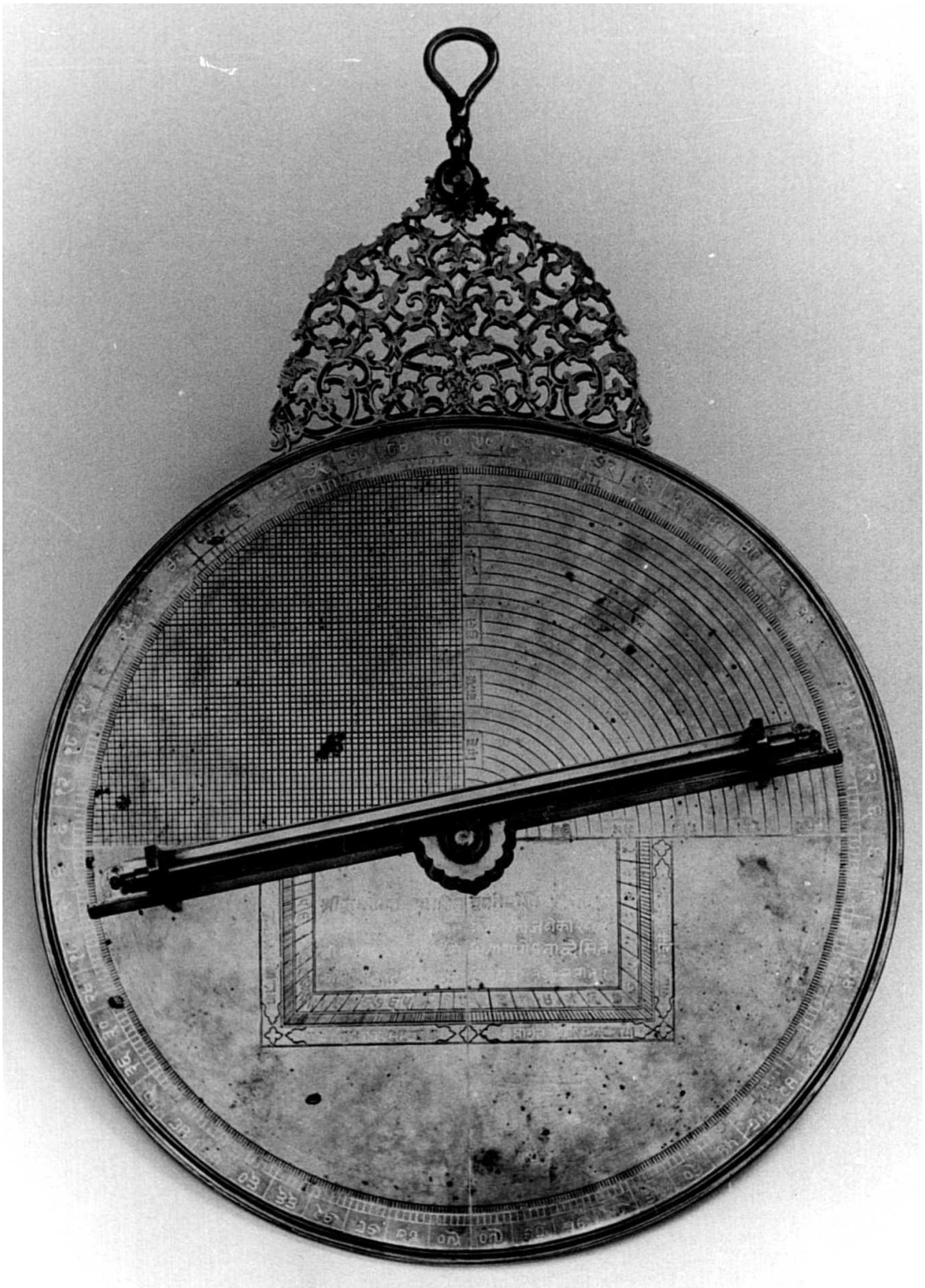


Figure D008.5 – Back of the astrolabe (courtesy Anthony J. Turner)

In the lower half are shadow squares, on the left for a gnomon of 12 digits and on the left for a gnomon of 7 digits. The vertical and horizontal scales on the left and right are appropriately divided into 12 and 7 parts respectively and each part further divided into six units each. The engraved marks of division are filled with black enamel. The

labels are again inlaid in silver inside cartouches, below the horizontal scales and to the left and right of the vertical scales. These read as follows:
dvādaśāṃgulaśaṃkoḥ samachāyā (umbra recta of the gnomon of 12 digits)
dvādaśāṃgulaśaṃkoḥ vilomachāyā, (umbra versa of the gnomon of 12 digits)
saptāṃgulaśaṃkoḥ samachāyā, (umbra recta of the gnomon of 7 digits)
saptāṃgulaśaṃkoḥ vilomachāyā (umbra versa of the gnomon of 7 digits).

The alidade has very ornate terminals and a matching ornate central piece. At the ends of the alidade are two ornate sighting plates containing two pinholes each. Between these pinholes isa large hole through which passes the sighting tube.



Figure D008.6 – The inscription inlaid with silver (photo by S. R. Sarma)

INSCRIPTION

The inscription, silver inlaid on brass inside the shadow squares, reads thus in Śārdūlavikrīḍita metre:

> *śrīkūrmānvayi-rāmasiṃha-nṛpater dārogya-dharmadhvajo*
> *mannālāla-budhaḥ prasiddhanagare nāmnā jaye 'kārayat* |
> *śrīsomeśvara īśa-netra-nidhi-tānāgendranābde site*
> *śrāvaṇye 'kṣitithau śyudattaracitaṃ yaṃtraṃ ca tad bhrājatāt* ||
>
> 'The learned Mannālāla, the Dārogah and the banner of justice of King Rāmasiṃha of the Kūrma (i.e. Kachchwaha) dynasty, caused this [astrolabe] to be made in the famous city named Jaya (i.e. Jaipur). May this instrument, made by Śyudatta (= Śivadatta), on the second (*akṣi* = 2) lunar day of the bright half of Śrāvaṇa month, in the year …., flourish.'

The year of manufacture is mentioned in the third line of the verse. Here the first word *śrī-someśvara* is in nominative, vocative or locative case; it is clearly not a part of the compound which follows. The compound ends in *abde* (in the year); the remaining

part *īśa-netra-nidhi-tānāgendranā* should indicate the year. For a four-digit number, there are too many symbolic words here: their numerical values are as follows: *īśa* = 11, *netra* = 2, *nidhi* = 9, or *īśa-netra* 3, *nidhi* = 9. The last part is problematic: either it is *tāna-aga-indra-na-abde* where *tāna* = 49, *aga* = 7 and *indra* = 14, but *na* makes no sense, or it is *tā-nāgendra-na-abde* where *nāgendra* is 8, but *tā* and *na* make no sense.

The auction catalogue of 1983 renders the verse thus: '*Dans la sixiè année du règne de Râma Sinhade familie de la tortue, le savant Mâla lâla a commandé cet astrolabe dans la célèbre cite nommée Victoire (Jairpur). Sari Somesvarî l'a fabriqué en 1842 de l'ère chrétienne.*' The year 1842 is indeed the sixth regnal year of Sawai Ram Singh; its equivalent in the Vikrama era would be 1898 or 1899. I do not see how this number can be derived from the compound mention above. But as mentioned at the beginning of this entry, Mannālāla became the Dārogarh in 1851 and the astrolabe was thereafter. Moreover, the person who commissioned the astrolabe is not Māla lāla, but Mannālāla and the man who made it is certainly not Sari Somesvarī!

BIBLIOGRAPHY

Adar Picard Tahan, Paris, *Instruments Scienifiques Anciens,* auction catalogue, 23 March 1983, no. 47, p. 26 (photos of front and back).

D009⊙ ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED

18th century, Jaipur

Diameter 185 mm

Jaipur, Jai Singh's Observatory

CCA 95

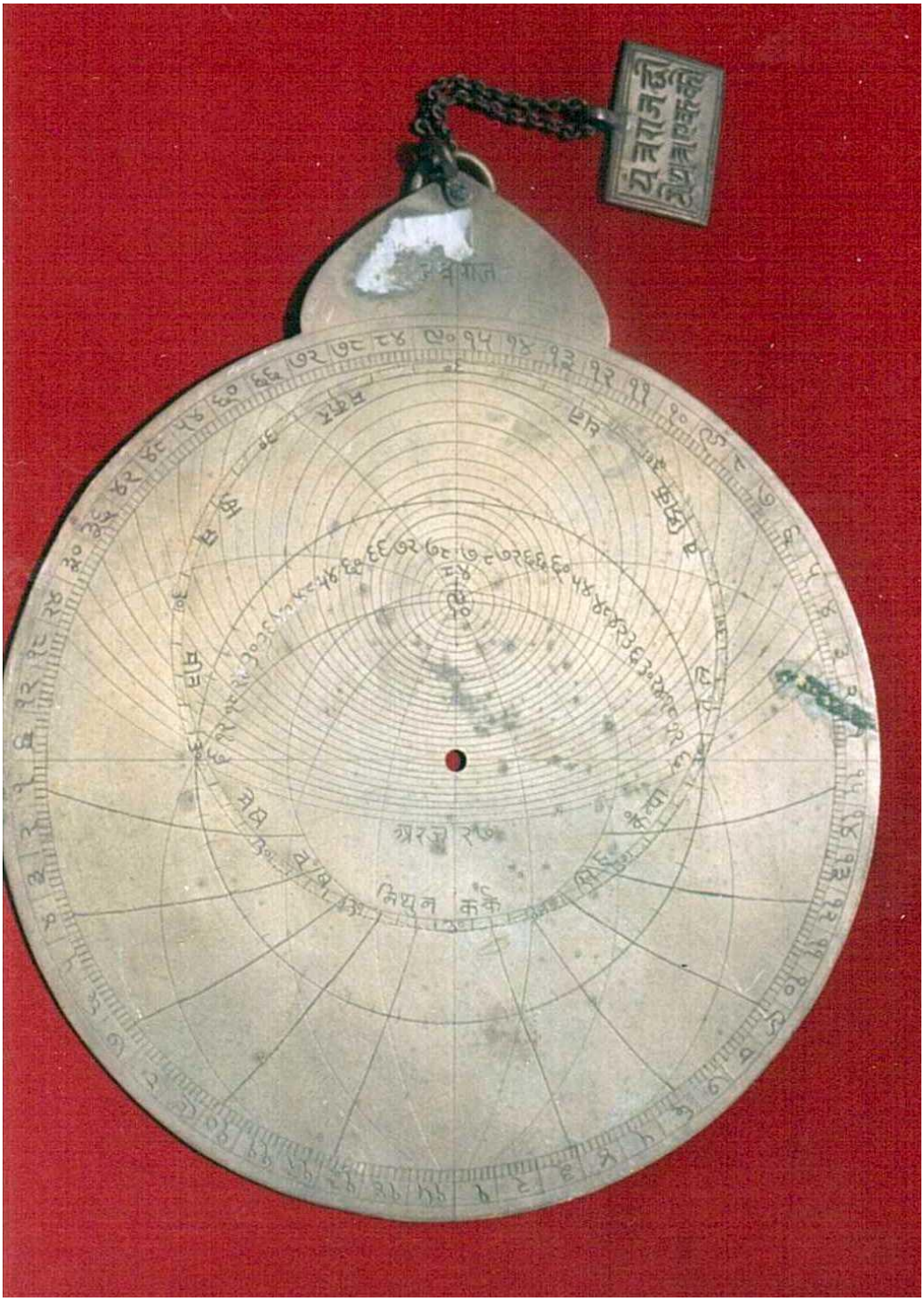


Figure D009.1 – Front of the astrolabe (photo by S. R. Sarma)

This is a well-crafted astrolabe with an elegant rete. But the obverse side of the plate is quite empty. On the crown is engraved *ja[ṃ]trarāja,* a phonetic variation of *yantrarāja,* 'king of instruments'. Gunther 1932, no. 95, misread the word as *Janna* and named the astrolabe as 'Saphea inscribed Janna'.[848]

COMPONENTS

Plate (d. 185, h. 216), with crown, shackle and ring, rete (d. 176) for 19 stars; the alidade, pin and wedge are missing.

FRONT

The crown is shaped like a triangle, slighly rounded at the base; the small shackle and ring have diamond cross section. The rim carries the degree scale divided in 1° and 6°. Groups of 6° are numbered separately for each quadrant, but not in a consistent system. In the upper left quadrant, the groups 6° are numbered from 6 to 90 starting from the east point and reaching up to the south point in a clockwise direction, in the other quadrants the numbering proceeds counter-clockwise from the east point onwards, counting the groups of 6° in each quadrant serially from 1 to 15.

Altitude circles are drawn for each 3° and every tenth line is dotted. Each second line is labelled as 6, 12, 18 … 90, on both the sides, in the form of rounded M. Azimuth arcs are drawn for every 30° above and below the horizon, but not numbered. In the lower half there are lines for unequal hours. Below the line of the local horizon, on either side of the meridian, is engraved *araja 27,* from the Arabic *arḍ,* meaning 'latitude'.

Upon these projections for the latitude 27°, there is also drawn the zodiac ring, which is unusual. It is divided into the 12 signs and labelled correctly with their names. Each sign is subdivided into 5 units, only the last part is labelled as 30 but not the others. Each part is again subdivided into 3 parts (i.e. 2°) by simple dots at the bottom of the line.

The lines are drawn neatly and the orthography of letters and numerals is excellent.

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848 Gunther 1932, no. 95, p. 224, pl. LI.

RETE

At present, the rete of this astrolabe is wrongly assembled with another astrolabe. But it can be seen correctly assembled with this plate in a photograph taken for G. R. Kaye ca. 1918 and reproduced in Gunther 1932, pl. LI. On this rete, Gunther remarks that it 'suggests the influence of a modern art school.' What he considers the influence of a modern art school is, in fact, the 'bird in the cage' motif which occurs in the bilingual astrolabe of 1616 (B002) and is repated in several Sanskrit astrolabes as well.[849]

The instrument maker made his mark in fashioning the elegant terminals for the two ends of the Capricorn ring. The ecliptic ring is divided into 12 signs of the zodiac and labelled with the first syllables of their names. The edge of the ecliptic ring is graduated in 1°; groups of 3° are marked there but not labelled. There are 19 star pointers.

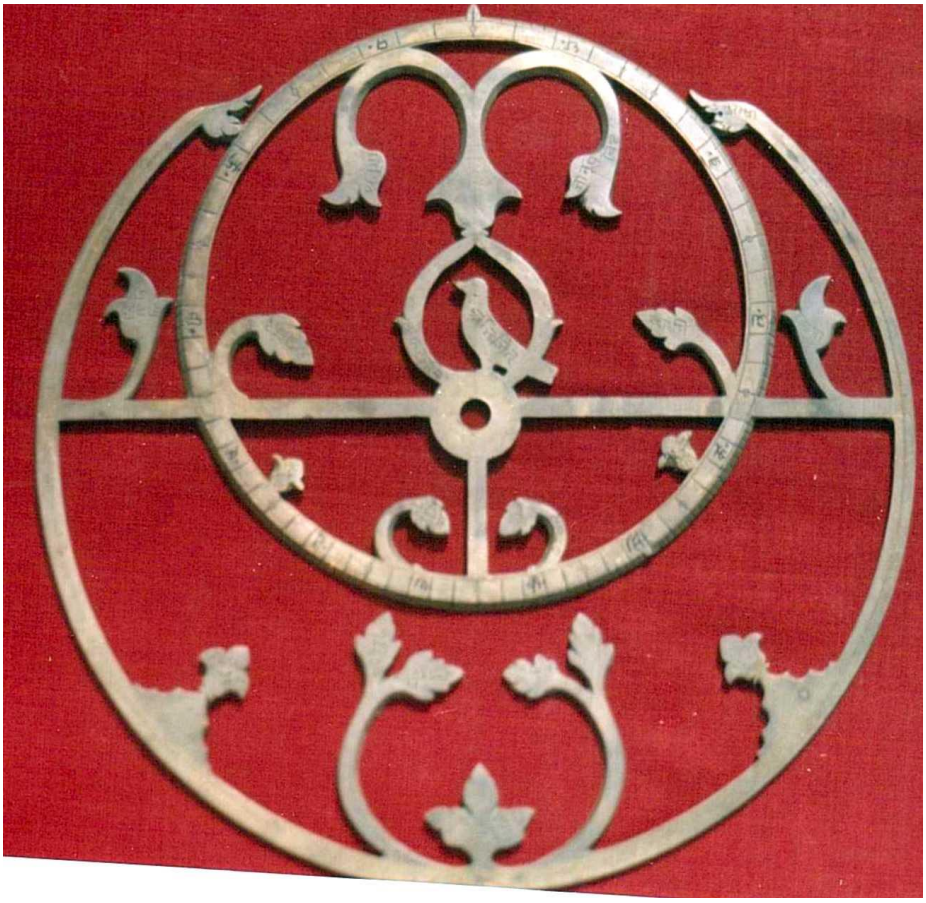


Figure D009.2 – Rete of the Astrolabe (photo by S. R. Sarma)

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849 Sarma 2011, esp. pp. 108-110 and Figure 8.

Table D009-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Aśvi*	*Aśvinī*	β Arietis
2	*Manuṣyapārśva*		α Persei
3	*Brahmahṛda*	*Brahmahṛdaya*	α Aurigae
4	*Rohiṇī*		α Tauri
5	*Ārdrā*		α Orionis
6	*Lubdhaka*		α Canis Maoiris
7	*Lubdhakabandhu*		α Canis Minoris
8	*Vanavejī* ?		
9	*Mahāpuruṣa*		α Hydrae
10	*Pū. phā*	*Pūrva-phālgunī*	δ Leonis
11	*Citrā*		α Virginis
12	*Svātī Svāti*		α Bootis
13	*Anurādhā*		δ Scorpii
14	*Jānūpatiṣṭhā*	*Jānūpaviṣṭha*	α Herculis
15	*Abhijit*		α Lyrae
16	*Kukkuṭajāna*[850]	*Kukkuṭa-puccha*	α Cygni
17	*Śravaṇa*		α Aquilae
18	*Aśvaskaṃdha*		β Pegasi
19	*Śatabhiṣā*		λ Aquarii

[850] The first part of this strange name, viz., *kukkuṭa,* is Sanskrit and signifies ‘cock’. The second part is borrowed from the Arabic *janāḥ,* ‘wing’. The Arabic name of the star is *Dhanab al-Dajājah,* ‘the tail of the hen’.

Back

The Back is divided into four quadrants which are, however, quite empty.

A small plaque is attached with a chain to the suspension ring; on this plate is inscribed in Rajasthani: *yaṃtrarāj choṭo. patra ek ko,* ‘astrolabe small; [with] one plate.’ This is too misread by Gunther.

Bibliography

Gunther 1932, no. 95, p. 224, pl. LI.

D010⊙ ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED

19th century, Jaipur

Diameter 180 mm

New York, Columbia University, Butler Library, D. E. Smith Collection (# 27-257A); CCA 98

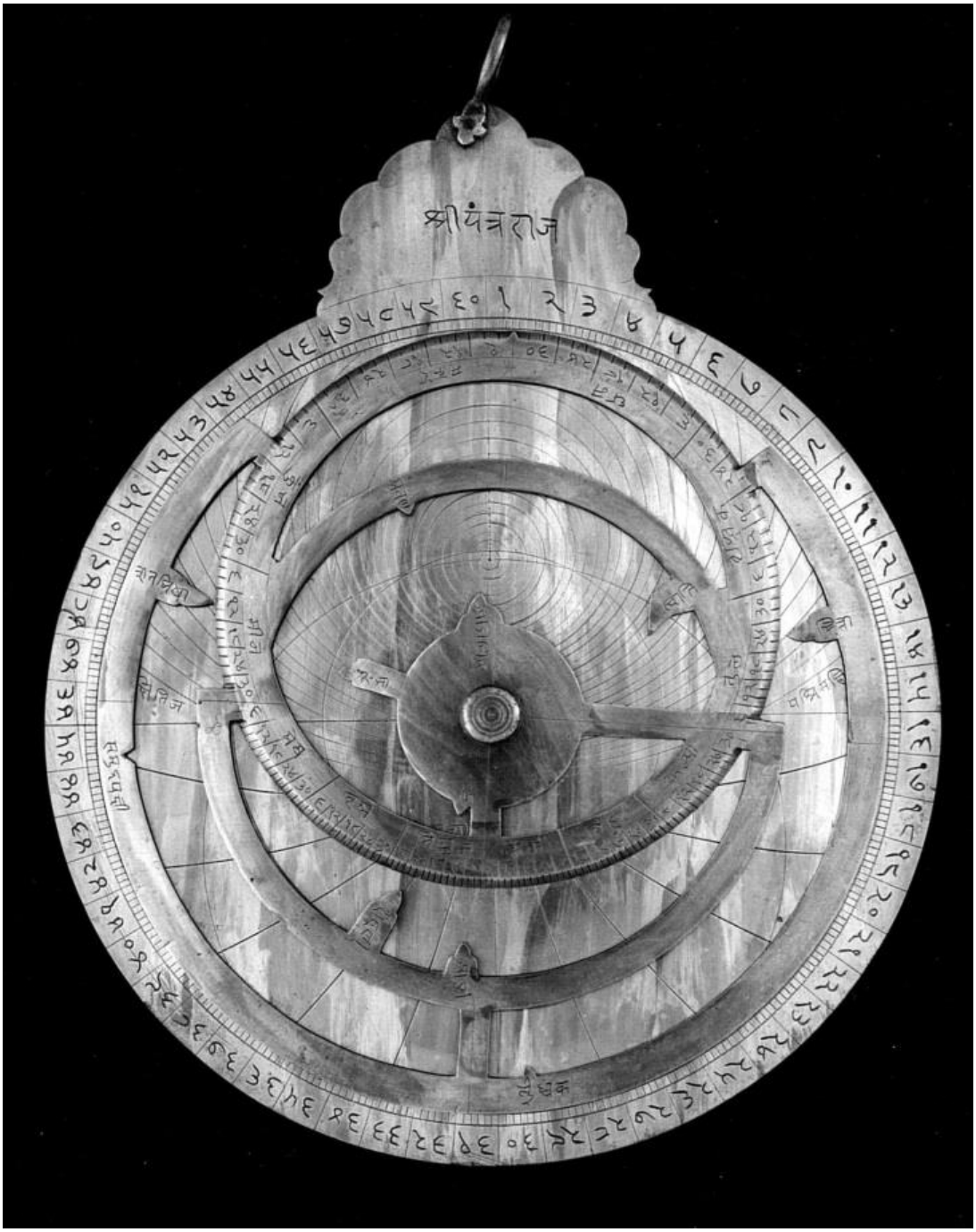


Figure D010.1 – Front of the astrolabe (courtesy Butler Library, Columbia University)

COMPONENTS

Plate (d. 180, h. 215) with crown, shackle, rete (d. 155) for 11 stars, alidade; the ring and the original pin and wedge are missing.

FRONT

The shackle is large with trefoil-shaped bases. The crown is high and solid. The profiles consist of ogres at the two two bases and five lobes. On the front of the crown is engraved *śrīyaṃtrarāja,* 'the glorious king of instruments'. The degree scale on the rim is divided in 1° and in 6° and groups of 6° are numbered serially from 1 to 60. Altitude circles are traced for each 3° and every third line is highlighted, not with dots as is generally the case, but with fine 'dashes' engraved somewhat deeper than the other lines. There are no azimuth arcs. In the lower half, lines are drawn for the seasonal hours. None of these lines is numbered. Below the horizon line on the east is engraved *pūrva-kṣitija,* 'eastern horizon', on the west *paścima-kṣitija,* 'western horizon,' and in the middle *akṣāṃśa* 27, 'latitude 27'.

RETE

The three rings of the Tropic of Capricorn, equator and ecliptic are joined by segments of the equinoctial and solstitial bars. The ecliptic circle is divided into the 12 zodiac signs and labelled; each sign is subdivided into 5 parts and numbered. Each part is further subdivided into single degrees on the sloped edge of the ecliptic ring. There are the following 11 dagger-shaped star pointers.

Table D010-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Rohaṇī*	*Rohiṇī*	α Tauri
3	*Bra*	*Brahmahṛdaya*	α Aurigae
4	*Ādrā*	*Ārdrā*	α Orionis
5	*Ludhvaka*	*Lubdhaka*	α Canis Majoris
6	*Citrā*		α Virginis

	Star Name as engraved	Full/Correct Form	Identification
7	*Svāti*		α Bootis
8	*Abhi*	*Abhijit*	α Lyrae
9	*Śravaṇa*		α Aquilae
10	*Śatabhiṣā*		λ Aquarii
11	*Pūbhā*	*Pūrva-bhādrapada*	β Pegasi

BACK

The rim of the back carries a degree scale divided in 1° and 6°; but it is numbered only in the two upper quadrants as 6—90; 90—6. In the upper left quadrant is drawn a trigonometric graph with 30 equidistant horizontal parallels. The other three quadrants are blank.

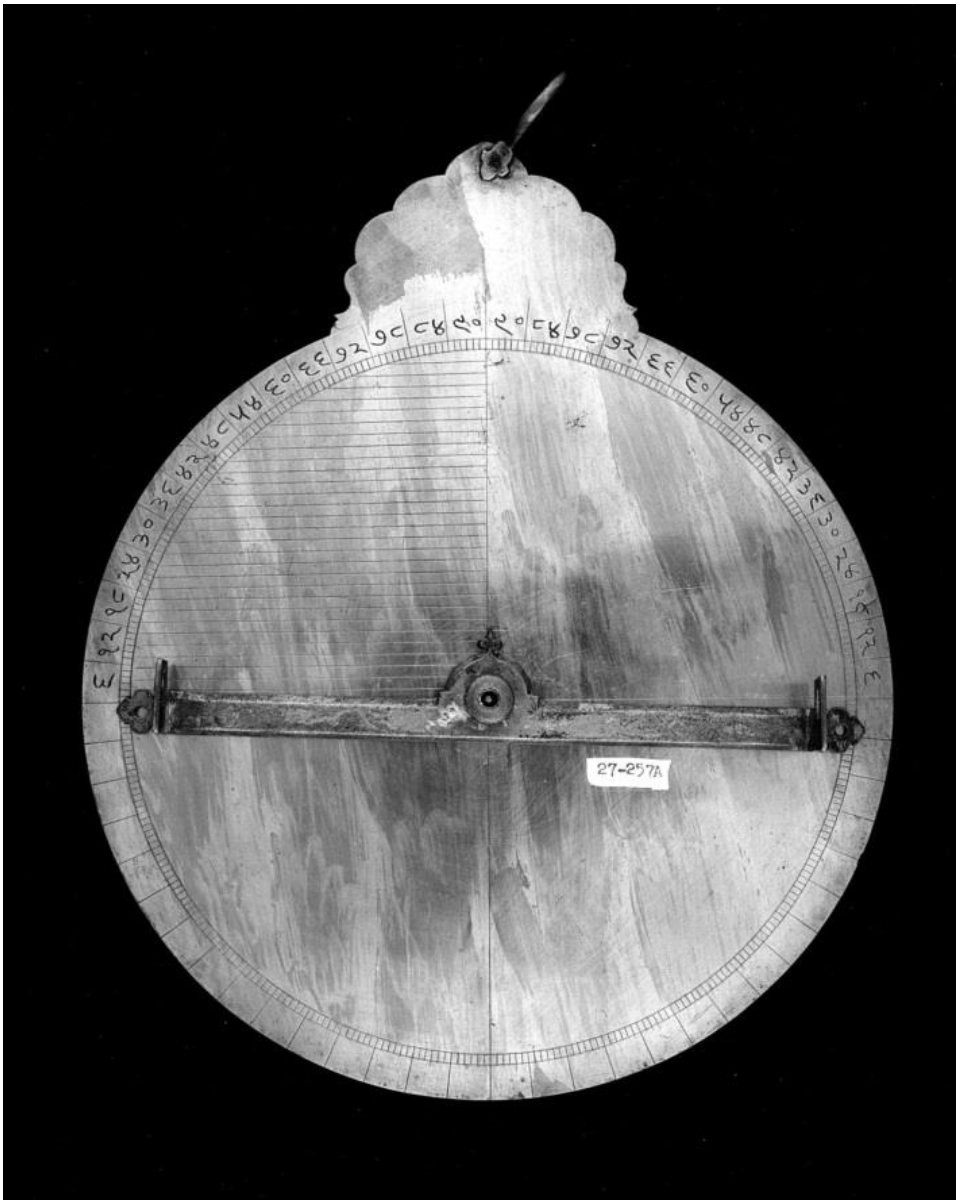


Figure D010.2 – Back of the astrolabe (photo courtesy Butler Library, Columbia University)

ALIDADE

The alidade is straight bar alidade without any divisions, but with trefoil-shaped ends and a similar centre piece. The sighting plates are larger than the width of the alidade and project beyond the fiducial line. According to the illustration in Gunther 1932 (Fig. 115, p. 227), the pin had an ornate head formed like an eight-petalled flower. But it is missing when I saw the astrolabe in 1993 and in the photos provided to me in 1993; it was replaced by a nut and bolt.

PROVENANCE

This astrolabe is described and illustrated in Gunther 1932, no. 98, under the heading 'Mr Plimton's Sanskrit Astrolabe'.[851] There are some errors in the decipherment of star names. George Arthur Plimpton (1855-1936) was senior partner of the firm Ginn & Co and benefactor to the Columbia University and Bernard College. He collected many books and MSS on arithmetic which are now in the Low Memorial Library, Columbia University. His collections were catalogued by D. E. Smith in Rara Arithmetica and Addenda to Rara Mathematica.

BIBLIOGRAPHY

Gunther 1932, no. 98, pp. 226-228.

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851 Professor F. W. Thomas, a well-known Sanskrit scholar, deciphered and translated the Sanskrit labels for Gunther. Some of these translations are too literal and miss the actual purport: *pūrva-kṣitija* (eastern horizon) is rendered as 'sprung from the eastern Earth, *paścima-kṣitija* (western horizon) as 'sprung from the western Earth and *akṣāṃśa 27* (latitude 27 degrees) 'parts of the axle 27'!

D011⦿ ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED

19th century, Jaipur, Rajasthan

Diameter 257 mm

London, Science Museum (#1980-1191)



Figure D011.1 – Front of the astrolabe (photo by S. R. Sarma)

This is an elegantly crafted astrolabe with excellent calligraphy; all the Sanskrit labels are correctly engraved which is quite rare.

COMPONENTS

Plate with crown (d. 257, h. 298), shackle and a large ring, rete (d. 228) for 36 stars, alidade with a sighting tube, pin with washer, wedge in the form of an aigrette.

FRONT

The lobed crown is of medium height. As in D005, the ring has a peculiar shape. It is not completely circular; the lower part tapers down and is loosely screwed to the top of the small shackle. The degree scale on the rim is divided in 1° and in 6°. Groups of 6° are numbered from 6 to 90, separately for each quadrant, from the east point on as 6—90; 90—6; 6—90; 90-6.

On the circular plate are drawn the vertical and horizontal diameters and circles of the equator and the two tropics. Altitude circles are drawn for each 3°, every 6° highlighted with dots; azimuth arcs for each 6° above the horizon and for each 3° below the horizon; there are lines fot the seasonal hours. But none of these are numbered. The plate is calibrated for the latitude of 27°, but this too is not recorded on the plate.

RETE

In the rete, the three almost complete rings of the Tropic of Capricorn, equator and ecliptic are held together by the equinoctial bar without any counter change. A segment of the solstitial bar joins the equinoctial bar with the ecliptic ring below. Groups of 3° are marked on the equatorial ring, which is unusual. The ecliptic ring is divided in 12 signs and labelled with their names. Each sign is divided in groups of 6° and labelled accordingly. The beveled edge of the ecliptic ring is divided into 1°. The star pointers are leaf-shaped. A few star pointers are formed by incisions in the equinoctial bar and in the ecliptic ring. In two cases (12 *Lubdhaka* and 13 *Lubdhaka-bandhu*), the star positions have been corrected by inserting small nails to the brass pointers. Following are the names of the 36 stars, arranged here in the order of increasing right ascension.



Figure D011.2 – Rete of the Astrolabe (photo by S. R. Sarma)

Table D011-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Matsyodara*		β Andromedae
3	*Aśvi*[852]	*Aśvinī*	β Arietis
4	*Naharatārā*		γ Eridani
5	*Nahāna*	*Matsyodara-pāda*?	γ Andromeadae?

[852] The star pointer is marked by a slit in the ecliptic ring; the slit is drawn but not cut out.

	Star Name as engraved	Full/Correct Form	Identification
6	*Pre.śi.*	*Pretaśira*	β Persei
7	*Rohiṇī*		α Tauri
8	*Bra.hṛda.*	*Brahmahṛdaya*	α Aurigae
9	*Mithunavāmapāda*[853]		β Orionis
10	*Ārdrā*		α Orionis
11	*Prajāpa*	*Prajāpati*	δ Aurigae
12	*Lubdhaka*		α Canis Majoris
13	*Sapu*	*Punarvasu* ?	β Geminorum
14	*Lubdhakavadhu*	*Lubdhaka-bandhu*	α Canis Minoris
15	*Mahāpuruṣa*		α Hydrae
16	*Maghā*		α Leonis
17	*Pū.phā.*	*Pūrva-phālgunī*	δ Leonis
18	*U.phā.*	*Uttara-phālgunī*	β Leonis
19	*Siṃhahṛdaya*[854]		?
20	*Vasiṣṭa*		ζ Ursae Majoris
21	*Citrā*		α Virginis
22	*Marīciḥ*		η Ursae Majoris
23	*Svāti*		α Bootis
24	*Viṣākhā-mātṛ-maṃḍala*		α Coronae Borealis
25	*Anurādhā*		δ Scorpii

853 The correct sequence is *Prajāpati, Mithuna-vāma-pāda* and *Ārdrā,* but the star pointers do not follow this sequence.

854 As in D008, *Siṃhahṛdaya* and *Maghā* are treated as two different stars.

	Star Name as engraved	Full/Correct Form	Identification
26	*Sarpadhāriśiraḥ*		α Ophiuchi
27	*Abhijit*		α Lyrae
28	*Kukkuṭacaṃcu*		β Cygni
29	*Śravaṇa*		α Aquilae
30	*Kukkuṭapuccha*		α Cygni
31	*Aśvamukha*		ε Pegasi
32	*Śatabhiṣā*		λ Aquarii
33	*Pūrvābhādrapada*	*Pūrva-bhādrapadā*	β Pegasi
34	*U.bhā.*	*Uttara-bhādrapadā*	γ Pegasi
35	*Aśvapakṣa*		α Pegasi
36	*Rajitakara*	*Rañjitakara*	β Cassiopeiae

BACK

The rim on the upper half carries altitude scales which are divided in 1° and 6°and numbered in 6s as 6—90; 90—6. The rim on the lower half is divided in 2° and 6° but not labelled.

In the upper left is the trigonometric quadrant with 30 vertical and 30 horizontal parallels, with each third line highlighted with dots. At 12 units from the centre, the circle of obliquity is drawn. In the upper right quadrant are drawn 30 declination arcs, as continuations of the 30 horizontal parallels on the left.

On the vertical radius are engraved the names of the signs from summer solstice to winter solstice, starting from the centre (*Karka, Siṃha, Kanyā, Tulā, Vṛśi[ka], Dhana*). On the horizontal radius are engraved the names of the signs from the winter to the summer solstice, from the periphery to the centre (*Makara, Kumbha, Mīna, Meṣa, Vṛṣabha, Mithuna*).



Figure D011.3 – Back of the astrolabe (photo by S. R. Sarma)

In the lower half, there are shadow squares, on the left for a base of 12 and the right for for a base of 7, with the following labels:

Vertical scale on the left: *dvādaśāṃgulaśaṃkor vilomacchāyā* (umbra versa of the gnomon of 12 digits),

Horizontal scale on the left: *dvādaśāṃgulaśaṃkoḥ samacchāyā* (umbra recta of the gnomon of 12 digits),

Horizontal scale on the right: *saptāṃgulaśaṃkoḥ samacchāyā* (umbra recta of the gnomon of 7 digits).

Vertical scale on the right vertical: *saptāṃgulaśaṃkor vilomacchāyā* (umbra versa of the gnomon of 7 digits).

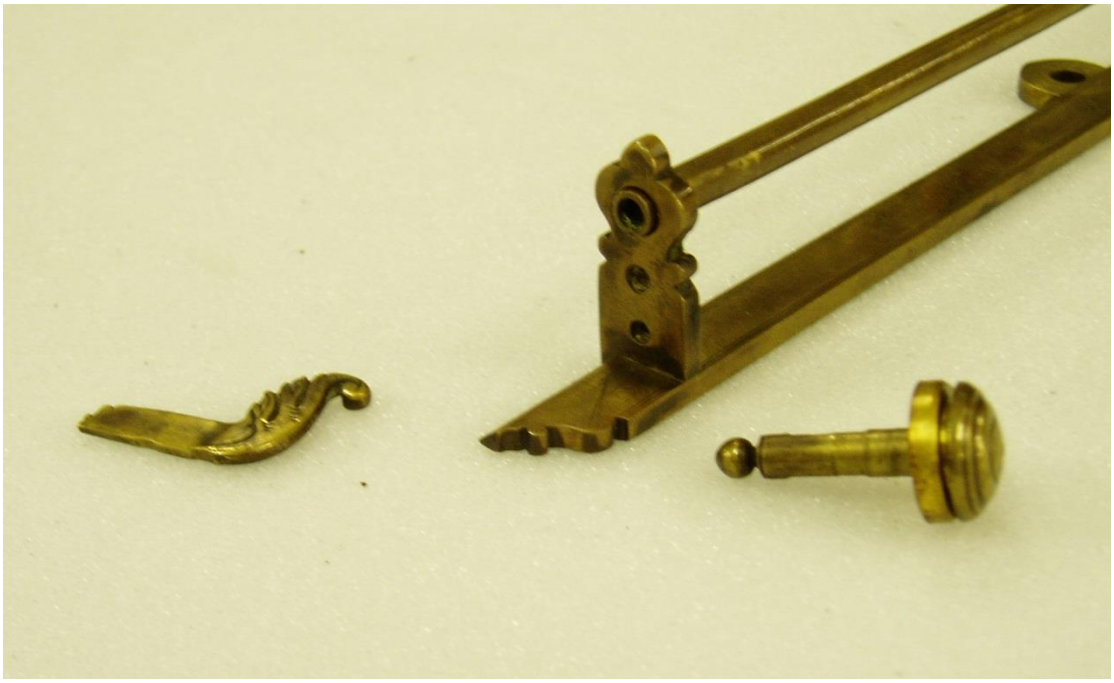


Figure D011.4 – Alidade, pin and wedge (photo by S. R. Sarma)

Alidade

The un-inscribed straight bar alidade has ornate terminals; the same design is repeated in the upright sighting plates also. The sighting plates contain three pinholes, the sighting tube passing through the uppermost pinholes. The pin has a heavy circular head and the other end is formed like a tiny ball. The wedge is beautifully styled as an ornate leaf or aigrette.

BIBLIOGRAPHY

Harriet Wynter, *A Miscellany of Instruments,* Auction Catalogue, October 1974, London, pp. 2-3.

Wynter & Turner 1975, p. 22, fig. 15.

Sotheby's, London, catalogue, 31 June 1980, lot 45, p. 14.

Anderson 1982, no. 129, p. 35.

D012⊙ ASTROLABE FOR LATITUDE 26;56°, NOT SIGNED, NOT DATED

19th century, Jaipur

Diameter 509 mm

London, Ahuan Art Gallery



Figure D012.1 – Front of the astrolabe (photo by S. R. Sarma)

Even though it is very large, this astrolabe is well executed; all the lines are carefully drawn and legends and numbers exhibit good calligraphy. Lines are filled with some white stuff.

COMPONENTS

Plate with crown (d. 509, h. 613, t. 3), shackle and ring, rete (d. 466, t. 2.6) for 17 stars, alidade (l. 471, width 18) with a sighting tube (l. 503, d. 15), pin and a bird-shaped wedge.

FRONT

A very high and plain crown with 8 lobes on each side, to which is attached a small shackle with a circular base and a small ring. On the front of the crown is inscribed *akṣaśa* (! read *akṣāṃśa*) 26/56 *palabhā* 6/6, meaning 'latitude 26;56°, midday equinoctial shadow of the gnomon of 12 units is 6;6'. Thus this astrolabe is made for the use at Jaipur (26;55° N, 75;49° E).

The rim is graduated in single degrees; groups of 6° are labelled from 6 to 90, separately for each quadrant, starting at the east and west points and proceeding towards the north and south points. Altitude circles are drawn for each 3°; azimuth arcs above the horizon for each 4° and below the horizon for each 2°; there are and lines for unequal hours. But none of these lines is numbered.

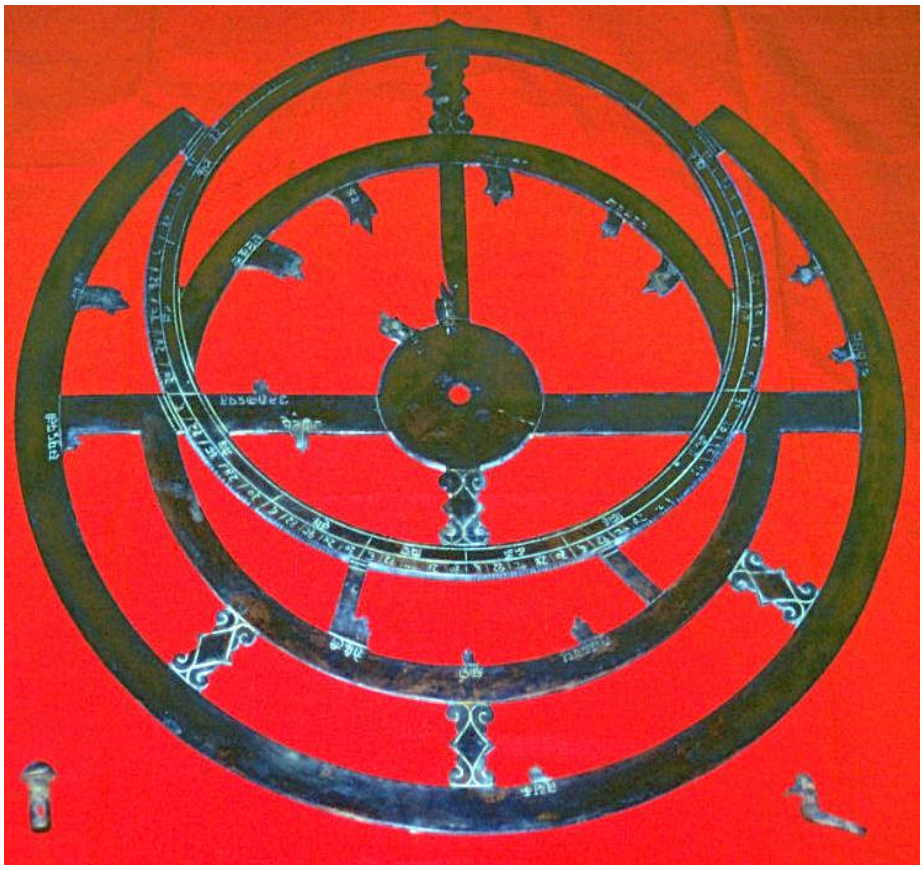


Figure D012.2 – Rete of the astrolabe (photo by S. R. Sarma)

RETE

The rete consists of the three almost complete rings of the Tropic of Capricorn (which is very wide), the celestial equator and ecliptic. In the lower half the equatorial ring and the ring of the Tropic of Capricorn are joined by three ornate struts. The middle strut coincides with the solstitial bar. The ecliptic ring and the equatorial ring are joined by two plain struts; the central disc is joined to the ecliptic ring by an ornate strut which coincides with the solstitial bar.

The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names. Each sign is divided into groups of 6° and numbered as 6, 12, 18, 25, 30. The edge of the ecliptic ring is divided into single degrees. There are 17 dagger-shaped star pointers with engraved star names; 9 inside the ecliptic and 8 without.

Table D012-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Pretaśirā*	*Pretaśira*	β Persei
3	*Rohiṇī*		α Tauri
4	*Ārdrā*		α Orionis
5	*Ludhaka*	*Lubdhaka*	α Canis Majoris
6	*Ludhakabaṃdhu*	*Lubdhakabandhu*	α Canis Minoris
7	*Mahāpuruṣa*		α Hydrae
8	*Citrā*		α Virginis
9	*Svātī*	*Svāti*	α Bootis
10	*Mātṛmaṇḍala*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
11	*Sarpadhārīśiri*	*Sarpadhārīśira*	α Ophiuchi
12	*Abhijit*		α Lyrae
13	*Śravaṇa*		α Aquilae
14	*Ku[k]kuṭapuccha*		α Cygni

	Star Name as engraved	Full/Correct Form	Identification
15	*Aśramukha*	*Aśvamukha*	ε Pegasi
16	*Śatabhiṣā*		λ Aquarii
17	*Uttarābhādrapat*	*Uttarabhādrapadā*	γ Pegasi

BACK

The entire rim carries a degree scale which is divided in 1° and in 6°, but numbered in the upper half only as 6—90; 90— 6. In the upper left is the trigonometric quadrant with 28 (!) horizontal parallels. The same 28 lines are extended as declination circles in the solar quadrant on the upper right. On the vertical and horizontal radii which enclose this quadrant, the names of the respective signs are engraved. On the vertical radius, starting from the centre: *Karka* (Cancer), *Siṃha* (Leo), *Kanyā* (Virgo), *Tulā* (Libra), *Vṛści[ka]* (Scorpio), *Dhanu* (Aquarius), i.e., from summer solstice to winter solstice; on the horizontal radius, starting from the periphery *Makara* (Capricorn), *Kuṃbha* (Aquarius), *Mīna* (Pisces), *Meṣa* (Aries), *Vṛṣa* (Taurus), *Mitha* (for *Mithuna* Gemini), i.e, from winter solstice to summer solstice.

In the lower half there are shadow squares; on the left for a gnomon of 7 digits and on the right for a gnomon of 12 digits. The vertical and horizontal scales are divided and numbered accordingly. The vertical scale on the left carries the label *saptāṃgula-śankor vilomachāyā* (umbra versa of the gnomon of 7 divisions) and the horizontal scale *saptāṃgula-śankoḥ samachāyā* (umbra recta of the gnomon of 7 divisions). Likewise the horizontal scale on the right has the label *dvādaśāṃgula-śankoḥ samachāyā* (umbra recta of the gnomon of 12 divisions). By mistake the same label is engraved along the vertical scale instead of the label *dvādaśāṃgula-śankor vilomachāyā* (umbra versa of the gnomon of 12 divisions).

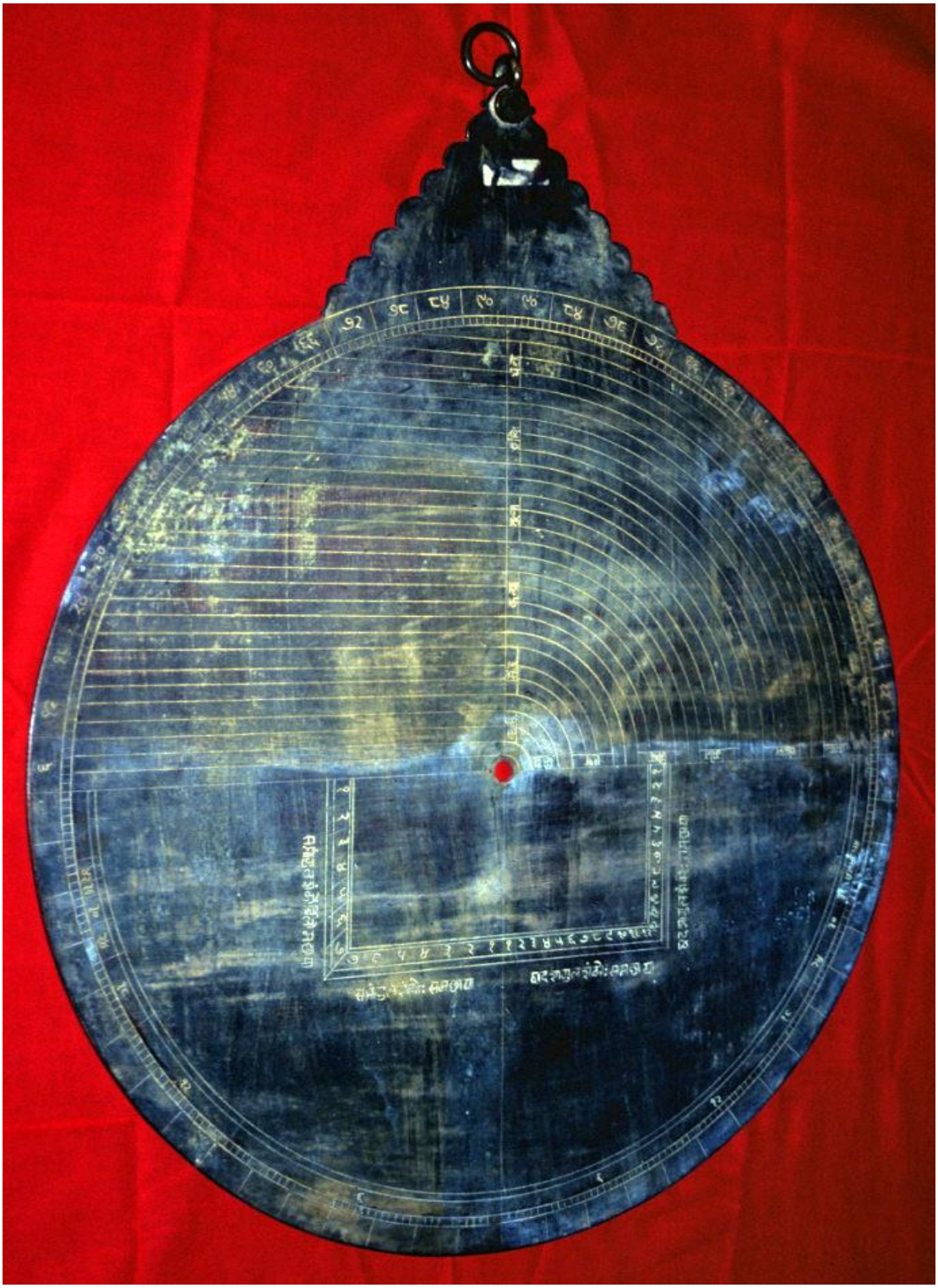


Figure D012.3 – Back of the astrolabe (photo by S. R. Sarma)

PROVENANCE

I saw and studied this astrolabe at the Libraire Brieux in Paris in September-October 1994. Subsequently it was acquired by a private collector at Milan. Around 2010 this private collection was said to have been acquired by Ahuan Art Gallery, London.

D013⊙ ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED

19th century, Jaipur

Diameter 552 mm

Oxford, Museum of the History of Science (# 30402)



Figure D013.1 – Front of the astrolabe (from Christie's catalogue 1998)

A massive single plate astrolabe calibrated for 27°. The numerals and legends are neatly engraved. The retes in this and in the following three astrolabes are designed nearly in the same style with the complete ring of the equator and dagger-shaped star pointrs.

COMPONENTS

Plate with crown (d. 552, h. 625, t. 1), shackle, ring and a hook, rete (d. 527, t. 1.5) for 36 stars, alidade with a sighting tube, pin and wedge.

FRONT

This huge astrolabe capped with a very small lobed crown whose sides rise almost vertically. The shackle through which passes a ring is also small. A hook is attached to the ring for suspension. On the crown is engraved *śrīyantrarāja,* 'the glorious king of instruments.'

The degree scale on the rim is divided in ¼°, 1°, 6°; group of 6° are labelled serially from 1 to 60. Altitude circles are drawn for each 1°and labelled on both sides of the meridian, the labels forming a large arc of a circle. Azimuth arcs are drawn for each 3° above and below the horizon and numbered along the horizon. In the lower half, lines for unequal hours are drawn which are counted from the western horizon from 1 to 12.

Below the oblique horizon, a label at the middle informs the latitude for which the plate is calibrated: *akṣāṃśā[ḥ] 27,* 'degrees of latitude 27'. Under the horizon, on the east is engraved *pūrvakṣitija,* 'eastern horizon', and on the west *[pa]ścimakṣitija,* 'western horizon'. The prime vertical is dotted and labelled as *samamaṃḍala.* The equator circle is dotted above the horizon; it carries the label *viṣuvadvṛtta.*

RETE

The rete is cut from a thicker sheet of metal than the plate; it consists of the three almost complete rings of the Tropic of Capricorn, the celestial equator and the ecliptic. These and the disc at the centre are held together by the east-west equinoctial bar which has one counter change at the centre. In the south a segment of the solstitial bar joins the ecliptic ring with the equatorial ring. Another segment of the solstitial bar joins the central disc with the ecliptic ring below. In the lower half the equatorial ring and the

ring of the Tropic of Capricorn are joined by two plain struts which are situated at equal distances from the meridian.

The ecliptic circle is divided into the 12 zodiac signs and labelled with the initial syllables of their names. Each sign is divided into five units and numbered as 6, 12, 18, 24, 30. Each of these units is subdivided into single degrees on the edge of the ecliptic ring.

There are 35 dagger-shaped star pointers. One more star name (17) is engraved without a corresponding pointer. In most cases, the star names are correctly inscribed. No. 29 (α Herculis) has an unusual name: *Nṛtya-kālī-śira,* 'the head of the dancing [goddess] Kālī'.[855]

Table D013-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Matsyodara*		β Andromedae
3	*Aśvinī*		β Arietis
4	*Matsyodarapāda*		γ Andromedae
5	*Pretaśira*		β Persei
6	*Manuṣyapārśva*		α Persei
7	*Rohiṇī*		α Tauri
8	*Brahmahṛdaya*		α Aurigae

855 In its transmission from Greek Antiquity to the Islamic world and thence to India, the constellation Hercules retained the same iconography but underwent changes in the designation. Already Ptolemy does not identify the constellation figure as that of the mythological hero Hercules, but names it merely as 'he who is on his knees'. Accordingly celestial globe makers in the Islamic world called the figure *al-Jāthī,* 'the kneeling man.' This name is rendered into Sanskrit as *Jānūpaviṣṭa,* lit. 'sitting on the knee'.
But, when some people made a Sanskrit celestial globe at Jaipur in the early eighteenth century (H001), in imitation of some Islamic celestial globe, they thought that the figure of Hercules on the Islamic globe, wearing a skirt in the Greek fashion, must be a dancing female goddess and therefore named the figure on the Sanskrit globe as *Nṛtyakālī,* 'the dancing [goddess] Kālī'. The present astrolabe was apparently made in the same milieu at Jaipur and so the star α Herculis on the astrolabe was given the designation *Nṛtya-kālī-śira,* 'the head of the dancing [goddess] Kālī'.

	Star Name as engraved	Full/Correct Form	Identification
9	*Mi.vā.pāda*	*Mithuna-vāma-pāda*	β Orionis
10	*Mi.da.pāda*	*Mithuna-dakṣiṇa-pāda*	κ Orionis
11	*Ārdrā*		α Orionis
12	*Lubdhaka*		α Ursae Majoris
13	*Lubdhakabaṃdhu*		α Ursae Minoris
14	*Punarvasu*		β Geminorum
15	*Aśleṣā*		ζ Cancri
16	*Mahāpuruṣa*		α Hydrae
17	*Maghā*		α Leonis
18	*Pulaha*		β Ursae Majoris
19	*Pū. phā.*	*Pūrva-phālgunī*	δ Leonis
20	*U.phā.*	*Uttara-phālgunī*	β Leonis
21	*Kākapakṣī*	*Kāka-pakṣa*	γ Corvi
22	*Hasta*		δ Corvi
23	*Citrā*		α Virginis
24	*Baśiṣṭa*	*Vaśiṣṭha*	ζ Ursae Majoris
25	*Marīca*	*Marīci*	η Ursae Majoris
26	*Svāti*		α Bootis
27	*viśāṣā*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
28	*Sarpagrīvā*		α Serpentis
29	*Nṛtyakālīśira*		α Herculis
30	*Sarpadhārīśira*		α Ophiuchi

	Star Name as engraved	Full/Correct Form	Identification
31	*Abhijit*		α Lyrae
32	*Śravaṇa*		α Aquilae
33	*Kukkuṭa-puccha*		α Cygni
34	*Aśvamuṣa*	*Aśvamukha*	ε Pegasi
35	*Śatabhiṣā*		λ Aquarii
36	*Prabābhādrapada Pūrvabhādrapadā*	β Pegasi	

BACK

On the back, the rim is divided in ¼°, 1° and in 6°. Groups of 6° are labelled from 6 to 90 only in the upper two quadrants, starting from the east or west points and reaching up to the south point. The numerals here are slightly different from those in the front. The upper left quadrant bears a "nonagesimal" sine-cosine graph, the upper right quadrant is blank. In the two lower quadrants, there are shadow squares, on the left for a base of 12 and on the right for a base of 7. The scales are divided and numbered accordingly. The four scales are labelled as follows:



Figure D013.2 – Back of the astrolabe (photo from Christie's Catalogue 1998)

Vertical scale on the left: *dvādaśāṃgula-vilomachāyā* (umbra versa [of the gnomon of] 12 digits),

Horizontal scale on the left: *dvādaśāṃgula-sulomachāyā* (! read, *-sama-chāyā*) (umbra recta [of the gnomon of] 12 digits),

Horizontal scale on the right: *saptāṃgula-sulomachāyā* (! read, *-sama-chāyā*) (umbra recta [of the gnomon of] 7 digits),

Vertical scale on the right: *saptāṃgula-vilomachāyā* (umbra versa [of the gnomon of] 7 digits.

In the four labels, the word *śaṃku* is missing. While *vilomachāyā* is the correct rendering of umbra versa, the opposite umbra recta is not *sulomachāyā* but *samachāyā.*

PROVENANCE

Formerly of the collection of Alain Brieux, then acquired by the Time Museum, Rockford, Illinois, and described in Turner 1985. Subsequently, this astrolabe and several other instruments of this museum were sold off in a special auction by Christie's on 14 April 1988, when it was acquired by the Museum of the History of Science.

BIBLIOGRAPHY

Turner 1985, No.12, pp. 112-113;

Christie's, London, *Time-Measuring Instruments from the Time Museum,* auction catalogue, 14 April 1988, lot 149, pp. 86-87.

D014 ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED[856]

19th century, Jaipur, Rajasthan

Diameter ?

PLU

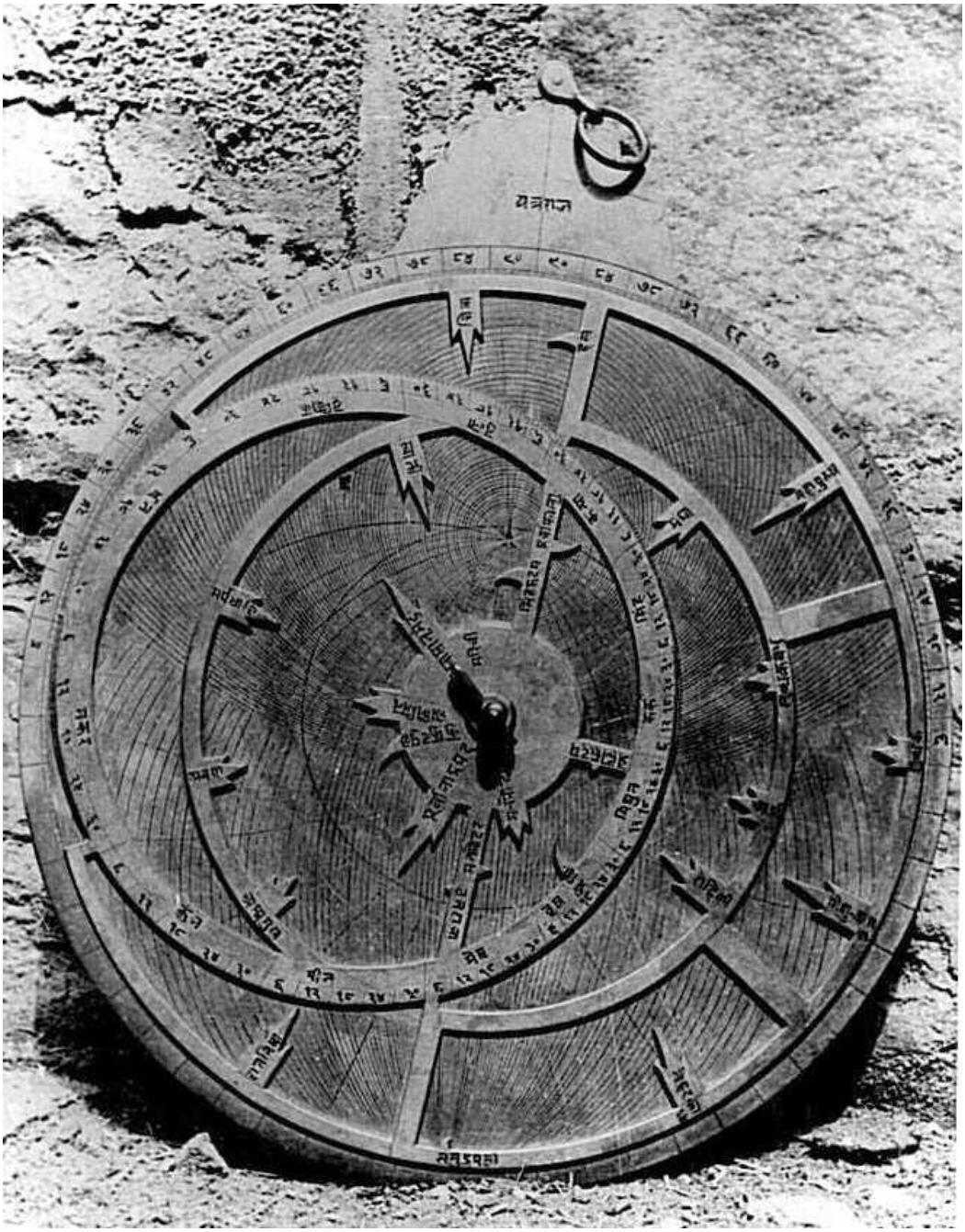


Figure D014.1 – Front of the astrolabe (courtesy Museum of the History of Science, Oxford)

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[856] Entry based on photos in the archives of the Museum of the History of Science, Oxford.

The photos were taken, apparently in India, in the open against a wall with peeling plaster. With altitude circles for every 1°, it must be a fairly large astrolabe. The labels and numbers are engraved neatly and in correct Sanskrit. This and the next two specimens (D012 and D013) are constructed in the same fashion, probably by the same artisan.

COMPONENTS

Plate with crown, shackle and ring, rete for 27 stars, alidade with a sighting tube, pin and wedge.

FRONT

A high lobed crown on which is engraved *yaṃtrarāja,* 'the king of instruments' in the front. The scale on the rim is divided in 1° and in 6°, but numbered only in the upper half, as 6—90; 90—6. Altitude circles are drawn for every 1°, azimuth arcs for every 2° and lines for unequal hours. None of these are numbered. The plate is calibrated for ca. 27 latitude.

RETE

The rete consists of the three almost complete rings of the Tropic of Capricorn, the equator and the ecliptic. These and the disc around the central hole are held together by the equinoctial bar which has no counter change. The disc at the centre is joined to the ecliptic ring by a segment of the solstitial bar. The ring of the equator is joined to that of the Tropic of Capricorn below by broader straight bars which are situated on either side at equal distances from the meridian. The ecliptic ring is divided into the 12 zodiac signs and labelled with their names. Each sign is divided into units of 6° each and numbered accordingly. The edge of the ecliptic ring is divided in 1°.

There are 27 dagger-shaped star pointers.

Table D014-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Matsyodara*		β Andromedae

	Star Name as engraved	Full/Correct Form	Identification
3	*Natsyoda*	*Matsyodara-pāda*	γ Andromedae
4	*Pre.śi.*	*Pretaśira*	β Persei
5	*Rohiṇī*		α Tauri
6	*Vrahmahṛdaya*	*Brahma-hṛdaya*	α Aurigae
7	*Mithu.vā.pāda*	*Mithuna-vāma-pāda*	β Orionis
8	*Ārdrā*		α Orionis
9	*Lubdhaka*		α Canis Majoris
10	*Lubdhakabaṃdhu*		α Canis Minoris
11	*Mahāpuruṣa*		α Hydrae
12	*Maghā*		α Leonis
13	*Pūrvāphālgu*	*Pūrva-phālgunī*	δ Leonis
14	*Hasta*		δ Corvi
15	*Siṃhahṛdaya*		?
16	*Citrā*		α Virginis
17	*Marīcī*	*Marīci*	η Ursae Majoris
18	*Svātī*	*Svāti*	α Bootis
19	*Viśākhāmātṛmaṃḍa*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
20	*Sarpadhāśi*	*Sarpadhārī-śira*	α Ophiuchi
21	*Abhijit*		α Lyrae
22	*Śravaṇa*		α Aquilae
23	*Kukkuṭa-puccha*		α Cygni
24	*Aśvamukha*		ε Pegasi
25	*Śatabhiṣā*		λ Aquarii

	Star Name as engraved	Full/Correct Form	Identification
26	*Pūrvā Bhādrapadā*		β Pegasi
27	*Uttarābhā*	*Uttarahbādrapadā*	γ Pegasi

BACK

The scale on the rim of the back is divided and numbered as in the front. In the upper left is a trigonometric quadrant with a sexagesimal sine-cosine graph, with 60 horizontal and 60 vertical parallels. Each alternate horizontal line is extended neatly into the upper right quadrant and formed into a declination circle there. Thus a solar quadrant is formed in the upper right with a quarter circle each for 6° solar longitude. In the vertical axis are engraved, from the centre onwards, the names of the signs from summer solstice to winter solstice (*Karka, Siṃha, Kanyā, Tulā, Vṛścika, Dhana*) [*Dhanuḥ*]) and in the horizontal axis, from the periphery towards the centre, the names of the signs from winter solstice to summer solstice (*Makara, Kuṃbha, Mīna, Meṣa, Vṛṣa, Mithuna*).

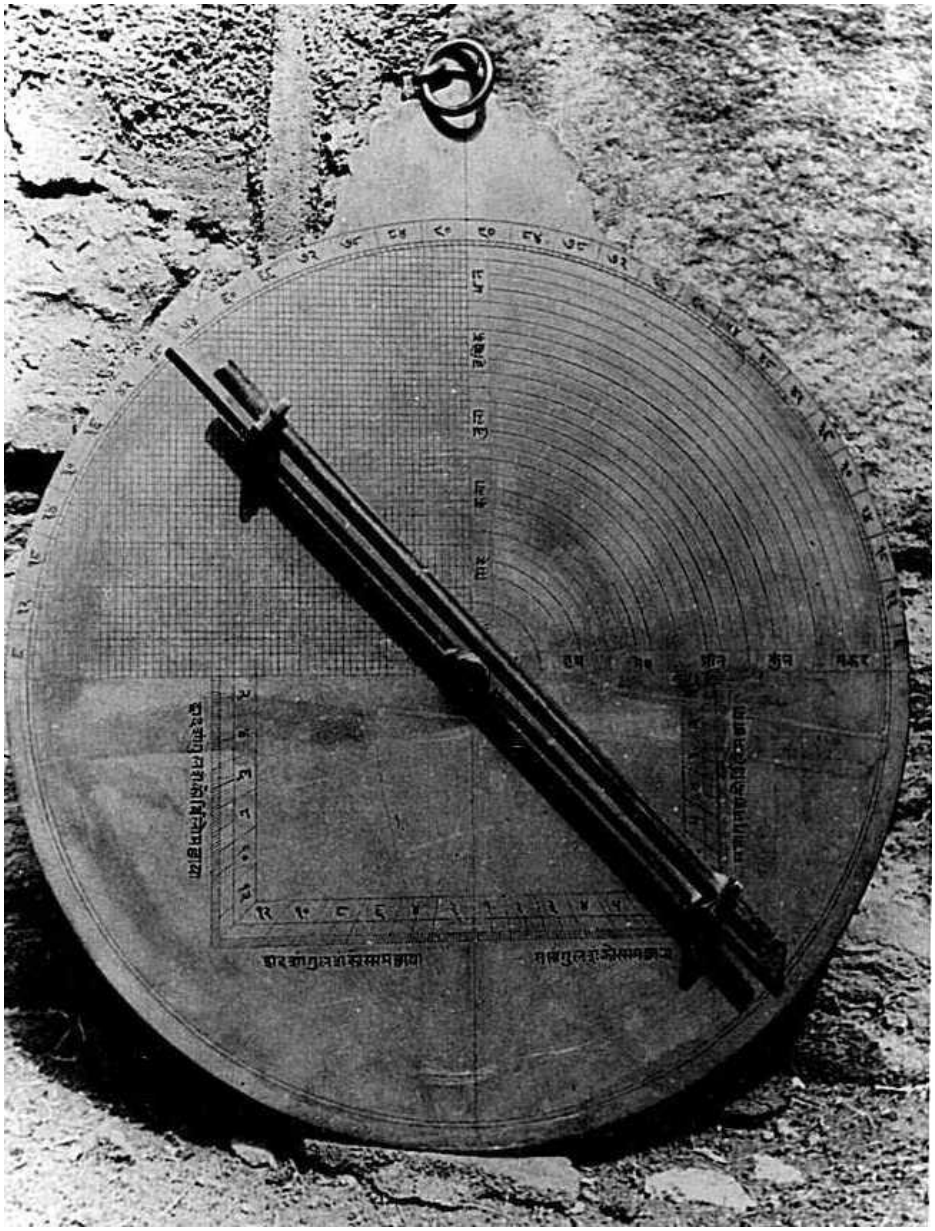


Figure D014.2 – Back of the astrolabe (courtesy Museum of the History of Science, Oxford)

In the lower half are drawn shadow squares, on the left for the gnomon of 12 digits and on the right for the gnomon of 7 digits. The vertical and horizontal scales on the left are divided into 12 units, each unit halved, and each half divided into 6 parts. Each 2 units are numbered as 2, 4, 6, … 12. The vertical scale on the left carries the label *dvādaśāṃgulaśaṃkor vilomachāyā* (umbra versa of the gnomon of 12 digits) and the horizontal scale *dvādaśāṃgulaśaṃkos samachāyā* (umbra recta of the gnomon of 12 digits). On the right, the vertical and horizontal scales are divided into 7 units, each unit halved, and each half divided into 6 parts. The units are numbered from 1 to 7. The vertical scale here has the label *saptāṃgulaśaṃkor vilomachāyā* (umbra versa of the

gnomon of 7 digits) and the horizontal scale *saptāṃgulaśaṃkos samachāyā* (umbra recta of the gnomon of 7 digits).

The alidade is equipped with a sighting tube.

D015 ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED[857]

19th century, Jaipur

Diameter 269 mm

PLU, ex-Paris, Alain Brieux

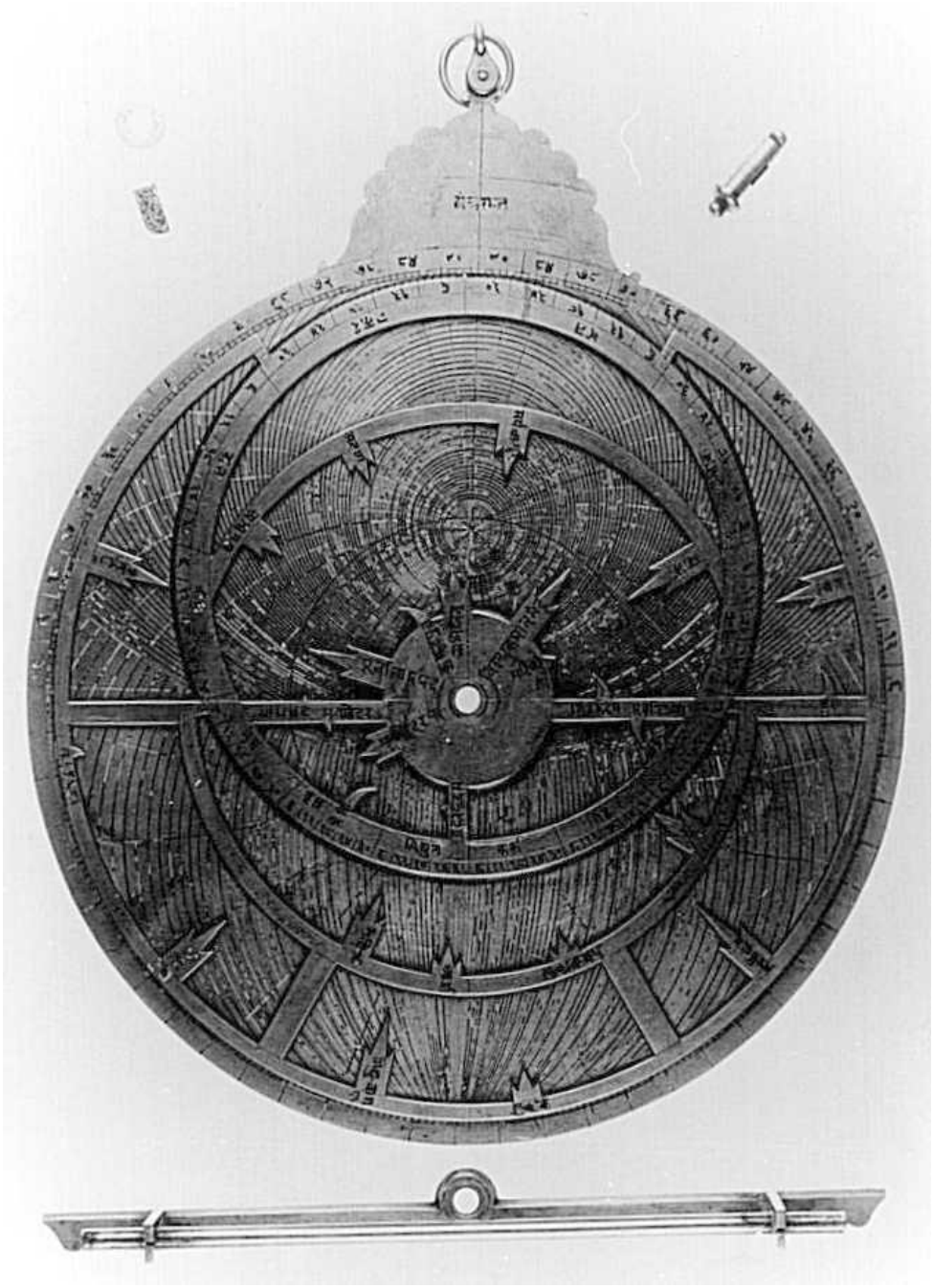


Figure D015.1 – Front of the astrolabe (photo by Alain Brieux)

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[857] Entry based three photos kindly given by Anthony J, Turner along with a brief description in French. Apparently the photos and the description are by Alain Brieux.

COMPONENTS

Plate with crown, shackle, ring, rete for 28 stars, alidade with the sighting tube, washer, pin and wedge.

FRONT

The high crown is lobed, the lowermost lobe curving like an *S,* the shackle with large tear-drop shaped bases. On the crown is engraved *yaṃtrarāja,* 'the king of instruments'.

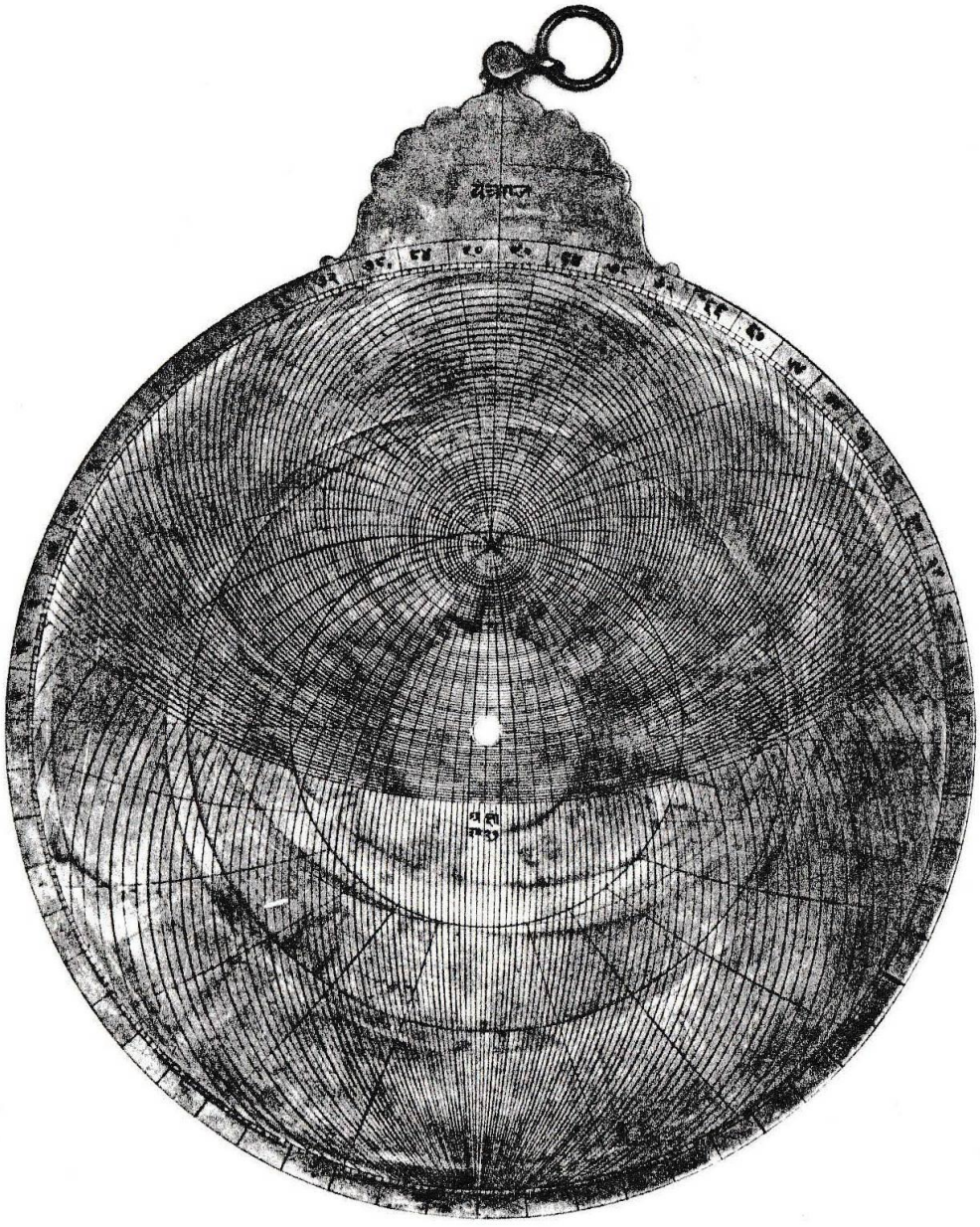


Figure D015.2 – Front of the astrolabe without the rete (photo by Alain Brieux)

The scale on the rim is divided in 1° and in 6° and numbered in 6s only in the two upper quadrants, as 6—90; 90—6. Altitude circles are drawn for each 1° and azimuth arcs for each 2° below the horizon and for each 6° above the horizon; these drawn for 6° are highlighted. There are lines for seasonal hours. But none of the three sets is numbered. Below the horizon, on either side of the meridian, is engraved *akṣāṃśa 27,* 'degrees of latitude 27'.

RETE

The rete consists of the three rings of the Tropic of Capricorn, the equator and the ecliptic; these three rings and the disc around the hole at the centre are held together by the equinoctial bar which has no counter change. A segment of the solstitial bar joins the central disc to the ring of ecliptic below. The equatorial ring and the ring of the Tropic of Capricorn are joined by two bars placed at equal distances symmetrically on either side of the meridian.

The ring of the ecliptic is divided into the 12 signs of the zodiac and labelled. Each sign is divided into groups of 6° and numbered accordingly.

There are 28 dagger-shaped star pointers which are listed below.

Table D015-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Matsyodara*		β Andromedae
3	*Matsyodarapā.*	*Matsyodara-pāda*	γ Andromedae
4	*Nahara*		γ Eridani
5	*Pre.śi.*	*Pretaśira*	β Persei
6	*Rohiṇī*		α Tauri
7	*Mithu.vāma.pā.*	*Mithuna-vāma-pāda*	β Orionis
8	*Vrahmahṛdaya*	*Brahmahṛdaya*	α Aurigae
9	*Ārdrā*		α Orionis

	Star Name as engraved	Full/Correct Form	Identification
10	*Lubdhaka*		α Canis Majoris
11	*Lubdhakabaṃdhu*		α Canis Minoris
12	*Mahāpuruṣa*		α Hydrae
13	*Maghā*		α Leonis
14	*Pūrvā Phālgunī*		δ Leonis
15	*Hasta*		δ Corvi
16	*Siṃhahṛdaya*		?
17	*Citrā*		α Virginis
18	*Marīcī*		η Ursae Majoris
19	*Svāta*	*Svāti*	α Bootis
20	*Viśākhāmātṛmaṃḍa*	*Viśākhā-mātṛ-maṃḍala*	α Coronae Borealis
21	*Sarpa*	*Sarpadhārīśira*	α Ophiuchi
22	*Abhijit*		α Lyrae
23	*Śravaṇa*		α Aquilae
24	*Kukkuṭapuccha*		α Cygni
25	*Aśvamukha*		ε Pegasi
26	*Śatabhiṣā*		λ Aquarii
27	*Pūrvābhādrapada*	*Pūrva-bhādrapadā*	β Pegasi
28	*Uttarābhā.*	*Uttara-bhādrapadā*	γ Pegasi

BACK

The scale on the rim is divided and numbered as in the front, that is to say, as 6—90; 90—6.

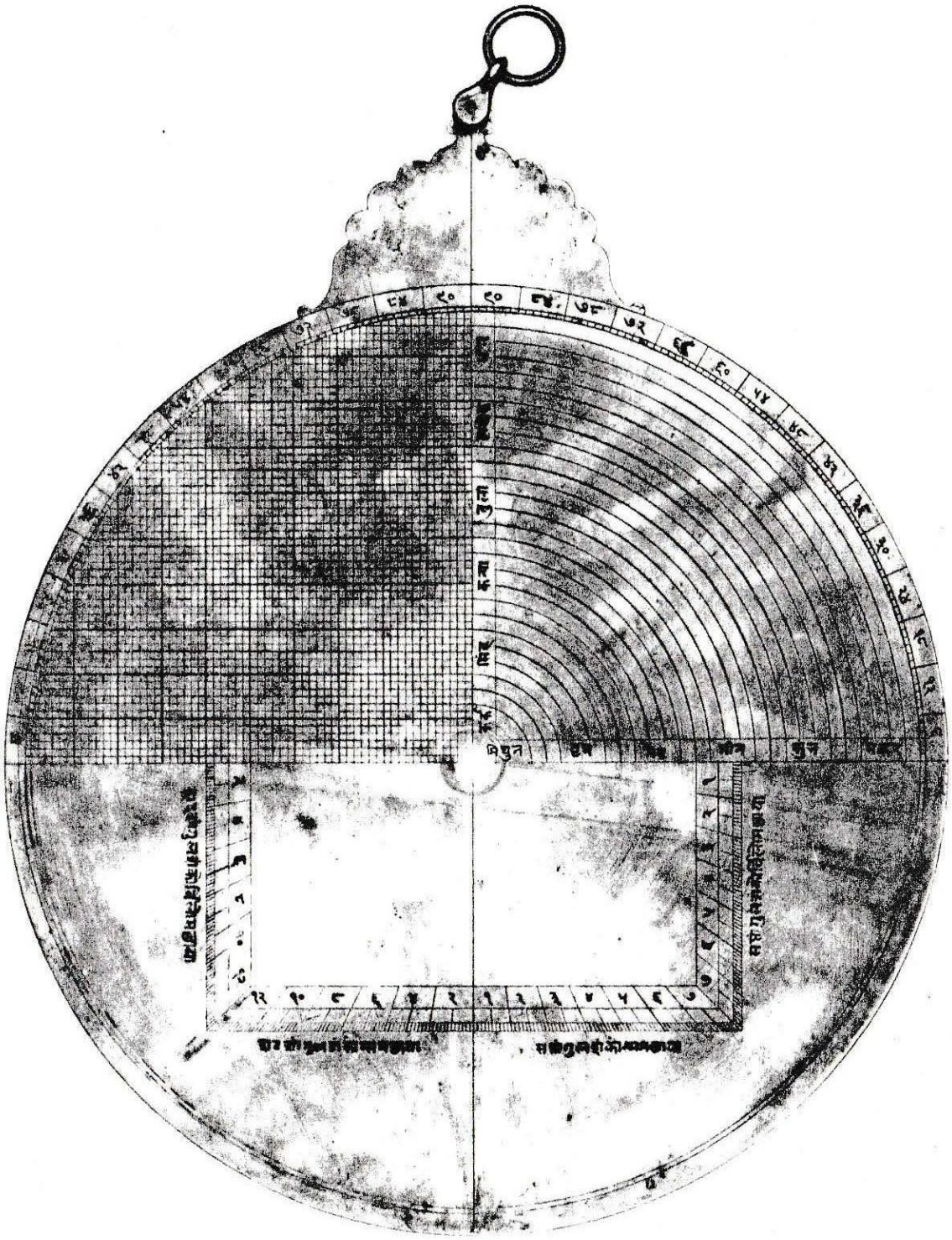


Figure D015.3 – Back of the astrolabe (photo Alain Brieux)

In the upper right quadrant is the sexagesimal sine-cosign graph with 60 horizontal and 60 vertical parallels, where each sixth line is highlighted with dots. Each second horizontal line is extended to form a declination circle in the solar quadrant in the upper right. Thus there are 30 declination circles in this quadrant, each representing 6° solar longitude. Starting from the centre, the signs are marked on the vertical axis from the

summer solstice to winter solstice. On the horizontal axis these are marked from winter solstice to summer solstice, starting from the periphery and reaching up to the centre.

In the lower half there are shadow squares, on the left for thre gnomon of 12 digits and the right for the gnomon of 7 digits. The vertical and horizontal scales on the left are divided in 6 parts and numbered in 2's, each part is halved, each half is divided into 6 parts. The vertical scale carries the label *dvādaśāṃgulaśaṃkor vilomachāyā* (umbra recta of the gnomon of 12 digits) and the horizontal scale *dvādaśāṃgulaśaṃkos samachāyā* (umbra versa of the gnomon of 12 digits). On the right, the vertical and horizontal scales are divided in 7 units and numbered, each unit is halved, each half is divided into 3 parts. The vertical scale carries the label *saptāṃgulaśaṃkor vilomachāyā* (umbra versa of the gnomon of 7 digits) and the horizontal scale *saptāṃgulaśaṃkos samachāyā* (umbra recta of the gnomon of 7 digits).

The alidade is equipped with a sighting tube. The pin is original; the lost wedge is replaced by a small metal piece.

D016 ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED[858]

19th century, Jaipur, Rajasthan

Diameter ?

PLU

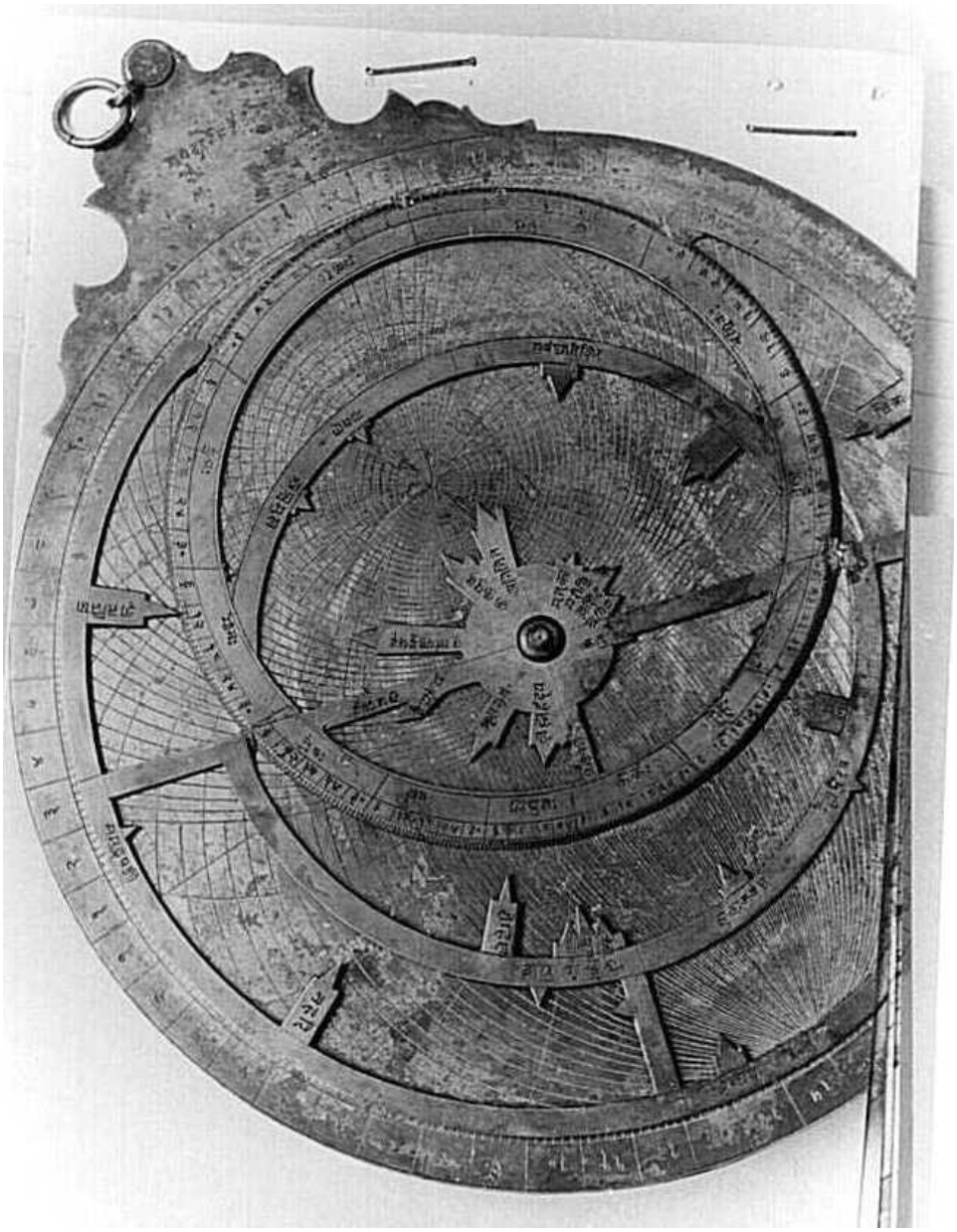


Figure D016.1 – Front of the astrolabe (courtesy Museum of the History of Science, Oxford)

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858 Entry based on three photos in the archives of the Museum of the History of Science, Oxford. These are actually photos of other photos which were pasted in an album. Some person is holding the leaves of the album apart; his thumb can be seen in the photos.

This appears to be fairly large astrolabe. The legends and numbers are neatly engraved. The equinoctial bar was broken at its intersection with the ecliptic ring and the equatorial ring in the west and was welded together.

COMPONENTS

Plate with crown, shackle and ring, rete for 32 stars, alidade, pin, washer and wedge.

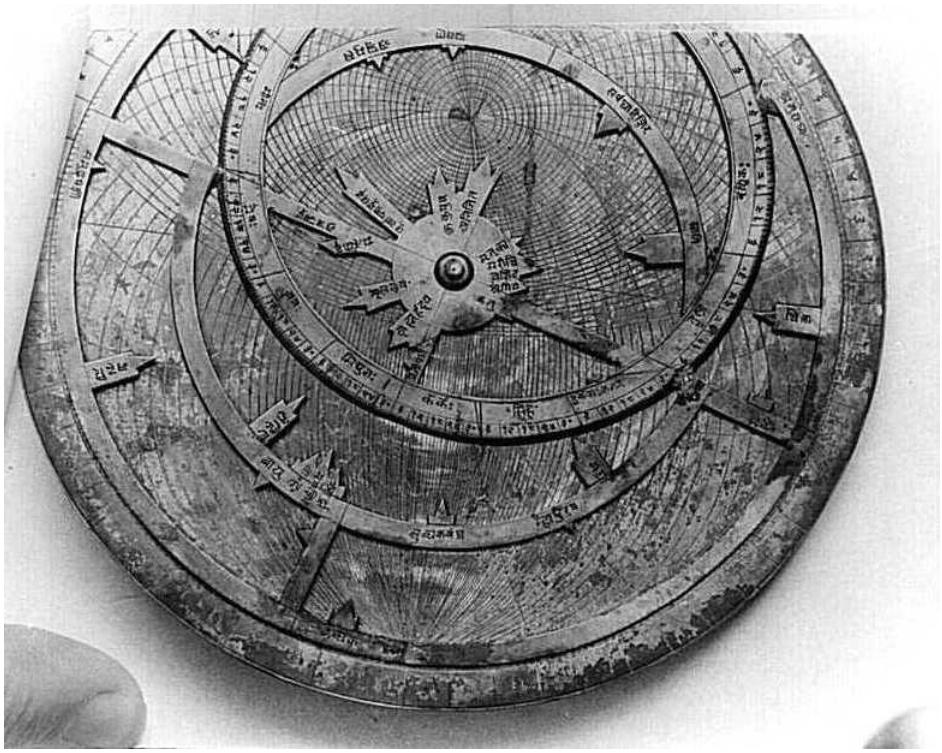


Figure D016.2 – Another front view of the astrolabe
(courtesy Museum of the History of Science, Oxford)

FRONT

A highly ornate crown, its profiles lobed and scalloped, with a deeply cut scallop on either side. On the front of the crown is engraved *jaya durage sāhāya* [?]; it should read *jaya durge sahāya,* 'be victorious, O [goddess] Durgā, [I seek your] help'. The shackle has large circular bases which cover the entire circular finial of the crown.

The scale on the rim is divided in 1° and 6° and numbered in 6s serially from 1 to 15 separately in each quadrant, starting from the east point, thus: 1—15; 15—1; 1—15; 15—1.

Altitude circles are drawn for every 2°, azimuths arcs also for every 2° and there are lines for seasonal hours. None of these sets is numbered. The plate is calibrated for ca. 27° of latitude.

RETE

The rete consists of the three almost complete rings of the Tropic of Capricorn, the equator and the ecliptic; these and the disc around the central hole are these held together by the equinoctial bar which has no counter change. The disc at the centre is joined to the ecliptic ring by a segment of the solstitial bar. Another segment of the solstial bar joins the ring of the equator to the ring of Capricorn below. The ecliptic ring is divided into the 12 zodiac signs and labelled with their names. Each sign is divided into units of 6° each and numbered accordingly. The edge of the ecliptic ring is divided in 1°.

There are 32 dagger-shaped star pointers.

Table D016-1 Stars on the Rete

	Star Names as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Matsyoda*	*Matsyodara*	β Andromedae
3	*Nahari*		γ Eridani
4	*Śṛkhalavaṃ.*	*Śṛṅkhalābaddhā[pāda]*[859]	γ Andromedae
5	*Rohiṇī*		α Tauri
6	*Brahmahardya*	*Brahma-hṛdaya*	α Aurigae
7	*Vāyu* ?		?
8	*Vā.ha.*	*Mithuna-vāma-hasta*	γ Orionis
9	*Mṛgaśira*	*Mṛgaśirā*	λ Orionis
10	*Prajāpati*		δ Aurigae
11	*Ārdrā*		α Orionis
12	*Lubdhaka*		α Canis Majoris

[859] The constellation is called *al-marʿah al-musalsalah* (the chained woman), cf. Savage-Smith 1985, p.160. The star is called *rijl al-musalsala* (foot of the chained woman); this is the first time that an attempt is made to render the Arabic name literally into Sanskrit.

	Star Names as engraved	Full/Correct Form	Identification
13	*Lubdhakabaṃdha*	*Lubdhaka-bandhu*	α Canis Minoris
14	*Mahāpuruṣa*		α Hydrae
15	*Maghā*		α Leonis
16	*Pūrvāphā*	*Pūrva-phālgunī*	δ Leonis
17	*Kratu*		α Ursae Majoris
18	*Hasta*		δ Corvi
19	*Śraṃgiya*	*Siṃha-hṛdaya*?	
20	*Citrā*		α Virginis
21	*Vaśiṭa*	*Vasiṣṭha*	ζ Ursae Majoris
22	*Marīci*		η Ursae Majoris
23	*Svātī*	*Svāti*	α Bootis
24	*Matṛkā*	*viśākhā-mātṛ-maṃḍala*	α Coronae Borealis
25	*Sarpadhāriśira*		α Ophiuchi
26	*Abhijita*	*Abhijit*	α Lyrae
27	*Śravaṇa*		α Aquilae
28	*Kvakupucha*	*Kukkuṭa-puccha*	α Cygni
29	*Aśvamukha*		ε Pegasi
30	*Śatabhiṣā*		λ Aquarii
31	*pūrvābhādrapada*	*Pūrva-bhādrapadā*	β Pegasi
32	*Utrarabhādra*	*Uttara-bhādrapadā*	γ Pegasi

BACK

The scale on the rim of the back is divided in 1° and in 6°. Groups of 6° are numbered only in the two upper quadrants, thus: 6—90; 90—6. In the upper left is a

trigonometric quadrant with 30 horizontal and 30 vertical parallels. Each horizontal line is extended neatly into the upper right quadrant to form there a declination circle. Thus a solar quadrant is formed in the upper right with a quarter circle for each 6° solar longitude. Along the vertical and horizontal radii, there are columns with the names of signs, but these cannot be deciphered in the photo.

In the lower half are the shadow squares, on the left for the gnomon of 12 digits and on the right for the gnomon of 7 digits. The vertical and horizontal scales on the left are divided into 12 parts and numbered in 2's, each part is divided into 6 units. The vertical scale has the label *dvādaśāṃgulabilomachāyā* (umbra versa of 12 digits) and the horizontal scale *dvādaśāṃgulasamachāyā* (umbra recta of 12 digits).

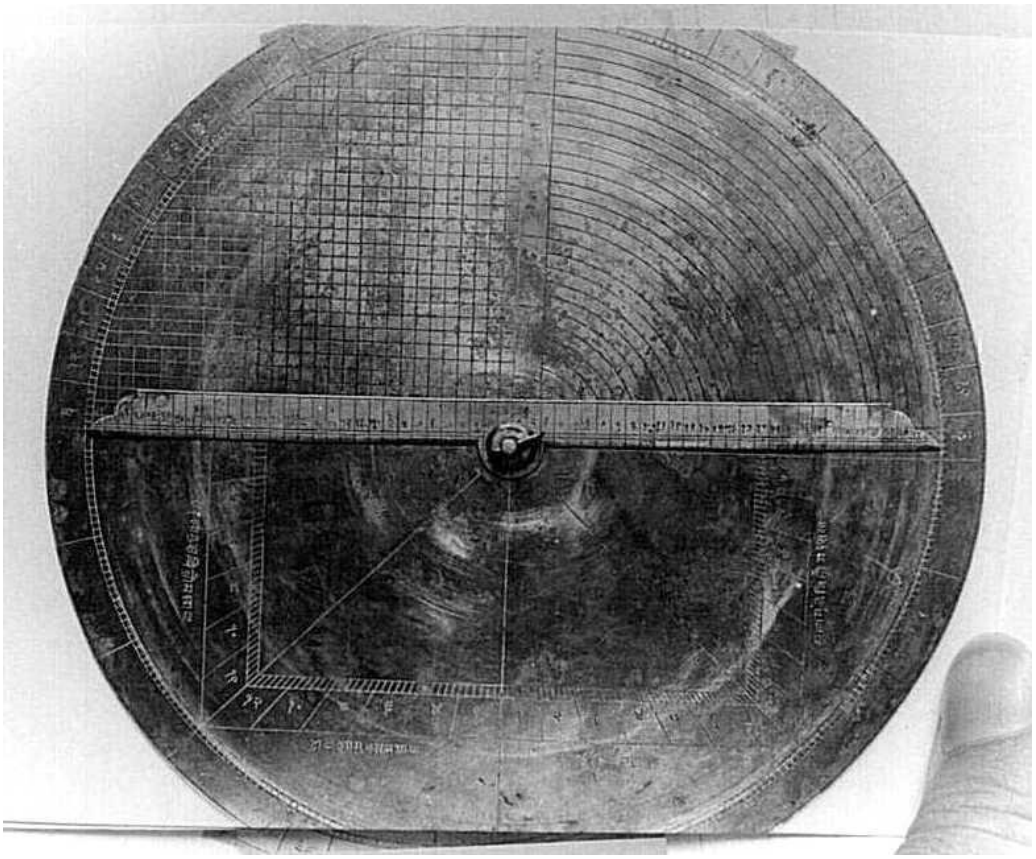


Figure D016.3 – Back of the astrolabe (courtesy Museum of the History of Science, Oxford)

On the right, the vertical and horizontal scales are divided into 7 units and numbered. Each unit is divided into 6 parts. The vertical scale here has the label *saptāṃgulavilomachāyā* (umbra versa of 7 digits); the label along the horizontal scale cannot de deciphered, but it would be *saptāṃgulasamachāyā* (umbra recta of 7 digits).

ALIDADE

There is a graduated alidade, which is rare in Sanskrit astrolabes. The left and right halves are divided into 30 parts each and numbered, starting from the centre and proceeding towards the tips, from 1 to 30. But no sighting plates are attached to the astrolabe.

D017⊙ ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED

19th century, Jaipur, Rajasthan

Diameter 217 mm

Jaipur, PC



Figure D017.1 – Front of the astrolabe (photo by S. R. Sarma)

This is a neatly made astrolabe with good calligraphy.

COMPONENTS

Plate with crown (d. 217, h. 258), shackle and ring, rete (d. 195) for 16 stars, alidade with a sighting tube, broad-headed pin. Wedge is missing. The parts are now held together with a hair pin.



Figure D017.2 – Crown of the Astrolabe (photo by S. R. Sarma)

FRONT

The crown is lobed and scalloped on both sides. The shackle has a trifoliate form with plain bases; the ring is of copper. The rim of the plate carries the degree scale, divided in 1° and 6° and numbered in 6s in deeply engraved ornate Devanagari numerals from 1 to 60. On the plate, altitude circles are drawn for each 3° and labelled on both sides as 3, 6, … 90. Azimuth arcs are drawn for each 6° above and below the horizon and labelled. Unequal hour lines are numbered from the western horizon from 1 to 12. The plate is calibrated for the latitude of 27° but not so marked.

RETE

The rings of the Tropic of Capricorn, equator and ecliptic are held together by the equinoctial bar with one counter change. The ring of the equator is counterchanged where it intersects with the ring of the ecliptic. The ecliptic ring is divided into the 12 signs and labelled with their names. Each sign is divided into 5 parts and labelled as 6, 12, 18, 24, 30. The edge of the ecliptic ring is graduated for groups of 3°. There are 16 star-pointers, 8 outside the ecliptic and 8 inside.

Table D017-1 Stars on the Rete

	Star Name as engraved	Correct/Full Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Mahodara*	*Matsyodara*	β Andromedae
3	*Rohiṇī*		α Tauri
4	*Ārdrā*		α Orionis
5	*Lubdhaka*		α Canis Majoris
6	*Lubdhakabandha*	*Lubdhaka-bandhu*	α Canis Minoris
7	*Pūrvā Phālguṇī*		δ Leonis
8	*Hasta*		δ Corvi
9	*Cītrā*	*Citrā*	α Virginis
10	*Svāti*		α Bootis
11	*Arapadhārī*	*Sarpadhārīśira*	α Ophiuchi
12	*Abhāva*	*Abhijit*	α Lyrae
13	*Śraravaṇa*	*Śravaṇa*	α Aquilae
14	*Aśvamuṣa*	*Aśvamukha*	ε Pegasi
15	*Śatabhiṣā*	*Śatabhiṣā*	λ Aquarii
16	*Pūrvabhādrapada*		β Pegasi

BACK

The rim of the upper half carries altitude scales, divided in 1° and 6° and numbered in 6s, from the east point onwards as 6—90; 90—6. The rim of the lower half is blank.

In the upper right is the trigonometric quadrant with 30 vertical and 30 horizontal parallels. In the upper left quadrant, there is an astrological table of 2 rows and 12 columns, which is reproduced below:

Table D017-2 Planets governing the twelve Hours of the Day

ra	*caṃ*	*maṃ*	*bu*	*vṛ*	*śu*	*śa*	*ra*	*caṃ*	*maṃ*	*bu*	*vṛ*
u	*amṛ*	*ro*	*lā*	*śu*	*ca*	*ka*	*u*	*amṛ*	*ro*	*lā*	*śu*

The first row contains the names of the seven planets (Sun to Saturn), five of them repeated again and the second row their influence. The table seems be to related to the so-called *chau-ghaḍiya* system where planetary regents are assigned to each 4 *ghaṭīs* of the day and of the night.[860] Thus in this system, the day is divided into 8 units of 4 *ghaṭīs* (= 96 minutes) each. In the present table, this system is applied to the day of 12 hours (and probably also to the night of 12 hours). The abbreviations are expanded and translated in the following table.

Table D017-3 Planets and their influence on the twelve Hours of the Day

Ra[vi]	Sun	*u[gra]*	fierce
Can[dra]	Moon	*amṛ[ta]*	immortality
Maṅ[gala]	Mars	*ro[ga]*	disease
Bu[dha]	Mercury	*lā[bha]*	profit
Bṛ[haspati]	Jupiter	*śu[bha]*	auspicious
Śu[kra]	Venus	*ca[ra]*	fickle
Śa[ni]	Saturn	*kā[la]*	death
Ra[vi]	Sun	*u[gra]*	fierce
Can[dra]	Moon	*a[mṛta]*	immortality
Maṅ[gala]	Mars	*ro[ga]*	disease
Bu[dha]	Mercury	*lā[bha]*	profit
Bṛ[haspati]	Jupiter	*śu[bha]*	auspicious

This table occurs in D050 also. There, the effect of the Sun is stated as *na[raka],* hell'.

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860 I did not find any reference to this system in Sanskrit texts, but one gets innumerable hits in Google. It is probably some aspect of popular astrology prevalent in northern India.

In the lower half, there is a double shadow square, on the left for the gnomon of 12 digits, labelled as *12 aṃgulachāyā* (shadow of 12 digits), and on the right for a gnomon of 7 digits, labelled as *7 aṃgulachāyā* (shadow of 7 digits), with the scales appropriately divided.

The alidade is fitted with a sighting tube which is now slightly bent.



Figure D017.3 – Back of the astrolabe (photo by S. R. Sarma)

D018⦿ ASTROLABE FOR LATITUDE 27° WITH AN ORNITHOMORPHIC RETE, NOT SIGNED, UNDATRED

19th century, Jaipur, Rajasthan

Diameter 251 mm

Jaipur, PC



Figure D018.1 – Front of the astrolabe (photo by S. R. Sarma)

This is an elegant astrolabe with a delightful ornithomorphic rete as in C019 with good calligraphy. Lines and circles are well drawn. The numeral 4 is written in two different styles in the same scale.

COMPONENTS

Plate with crown (d. 251, h. 272), shackle, rete (d. 225) for 38 stars, alidade with a sighting tube, pin, wedge; the ring is missing.

FRONT

Very low crown formed like an arc of the circle without any decorations. The shakle is plain; the ring is missing. The rim carries the degree scale divided in 1° and 6°. Groups of 6° are numbered serially from 1 to 15 separately for each quadrant. The numbering starts at the east and west points and reaches to the south and north points as 1—15; 15—1; 1—15; 15—1.

Altitude circles are drawn for every 2°, every third circle is highlighted with dots. Azimuth arcs are drawn for every 3° below the horizon, every third line is highlighted. The prime vertical is highlighted. There are lines for seasonal hours. The plate is calibrated for 27°, but the latitude is not mentioned on the plate, nor are the three sets of lines numbered.

RETE

The three rings of the Tropic of Capricorn, equator and ecliptic are held together by the east-west equinoctial bar without counter change. The ring of the equator is counterchanged where it intersects with the ring of the ecliptic. The rete is elegant; most of the star pointers are fashioned in the form of peacocks (p) in different postures; there are a few parrots (pr) with distinctive curved beaks, and still a smaller number of unidentifiable birds (b). There are some star pointers that are shaped like aigrettes (a), the feather-shaped ornaments worn on the crown and some more are plain curved pointers. These star pointers arise out of the rings of Capricorn and of the equator. On these rings the star names are engraved very distinctly.



Figure D018.2 – Rete, upper half (photo by S. R. Sarma)

The ecliptic is divided into the 12 signs, and labelled with their names. Each sign is divided into five parts and labelled as 6, 12, 18, 24, 30. The sloping edge of the rete is graduated in single degrees. There are 38 star pointers, 16 outside the ecliptic and 22 inside.



Figure D018.3 – Rete, lower half (photo by S. R. Sarma)

Table D018-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī* (p)		β Ceti

	Star Name as engraved	Full/Correct Form	Identification
2	*Machodara* (pr)	*Matsyodara*	β Andromedae
3	*Machodarapīṭha* (b)	*Matsyodarapāda*	γ Andromedae
4	*Pretaśira* (a)		β Persei
5	*Manuṣyapakṣī* (a)	*Manuṣyapārśva*	α Persei
6	*Naharatārā* (p)		γ Eridani
7	*Rohiṇī* (4 holes)		α Tauri
8	*Brahma*	*Brahma-hṛdaya*	α Aurigae
9	*Mithunavāmapāda* (p)		β Orionis
10	*Mithunavāmahasta* (a)		γ Orionis
11	*Ārdrā* (a)		α Orionis
12	*Mithunadakṣiṇapāda* (p)		κ Orionis
13	*Luvadhaka* (p)	*Lubdhaka*	α Canis Majoris
14	*Luvadhakavaṃdhu* (pr)	*Lubdhaka-bandhu*	α Canis Minoris
15	*Āśleṣā* (b)		ζ Cancri
16	*Mahāpuruṣa* (p)		α Hydrae
17	*Phā.da.sujā* (p)	*Fard al-shujā*^{c}	α Hydrae
18	*Kratu*		α Ursae Majoris
19	*Pū.pha*. (a)	*Pūrva-phālgunī*	δ Leonis
20	*U.pha.*	*Uttara-phālgunī*	β Leonis
21	*Siṃhada* (a)	*Siṃha-hṛdaya*	α Leonis
22	*Vaśiṣṭha*		ζ Ursae Majoris
23	*Marīci* (pr)		η Ursae Majoris

	Star Name as engraved	Full/Correct Form	Identification
24	*Citrā* (p)		α Virginis
25	*Svāti* (p)		α Bootis
26	*Visākhā* (p)		α Librae
27	*Anurādhā*		δ Scorpii
28	*Sarpagrī* (pr)	*Sarpa-grīvā*	α Serpentis
29	*Viśākhā mā* (a)	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
30	*Sarpadhārīśira* (pr)		α Ophiuchi
31	*Abhijit*		α Lyrae
32	*Kukuṭacucū* (a)	*Kukkuṭacañcu*	β Cygni
33	*Śravaṇa* (pr)		α Aquilae
34	*Dhaniṣṭhā* (b)		α Delphini
35	*Kukkuṭapuccha*		α Cygni
36	*Aśvamukha* (a)		ε Pegasi
37	*Śatavikhā* (p)	*Śatabhiṣā*	λ Aquarii
38	*Pū. bhā.*	*Pūrva-bhādrapadā*	β Pegasi

It may be noted that 16 (*Mahāpuruṣa*) and 17 (*Phā. da. sujā* = *Fard al-shujā*^{c}) refer to the same star α Hydrae, the former being the Sanskrit name and the latter a corrupt form of the Arabic name. These two names are represented by two separate peacocks here. However, their beaks, which show the actual star positions, are not far apart.



Figure D018.4 – The peacock on the left is labelled *Mahāpuruṣa* and the one on the right *Phā. da. sujā*. The bird on the upper left is a parrot with the label *Lubadhakabaṃdhu* and the small bird to its right is named *Āśleṣā.*

BACK

The entire rim carries a degree scale, divided in 1° and 6°; the latter are numbered from 6 to 90, separately for each quadrant, starting from the east and west points and reaching up to the south and north points. The two upper quadrants are blank.

Shadow squares are drawn very faintly in the lower half. On the right, both the horizontal and vertical scales are divided into 7 units each but not labelled. On the left, the horizontal scale is divided into 6 units, but not labelled. The vertical scale has no divisions at all.

It is surprising that the astrolabe who took great pains to create one of the most charming retes did not complete the engravings on the back.

D019⊙ ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED

19th century, Jaipur

Diameter 284

PLU; ex-Brussels, PC



Figure D019.1 – Front of the astrolabe (photo by S. R. Sarma)

Even though there are some errors in labeling, even though the upper right quadrant on the back is not completed, this is a neatly executed astrolabe; the circles are drawn carefully, the divisions are uniform and the letters are quite neat.

COMPONENTS

Plate with crown (d. 284, h. 310), shackle and ring, rete for 24 stars, alidade with a sighting tube, pin and wedge.

FRONT

Low crown, a very small shackle and a large ring, both with square cross section. The rim carries the degree scale, divided in 1° and 6°; numbered serially in 6s from 1 to 60. Altitude circles are drawn for each 2° and every third line is highlighted with dots. Azimuth arcs are drawn for each 3° both above and below the horizon. But neither the altitude circles, nor the azimuth arcs are numbered. Unequal hour lines (more straight rather curved) are numbered from the west as well as from the east as 1, 2, 3, 4, 5, 6, 6, 5, 4, 3, 2, 1.

The plate is calibrated approximately for 27°, i.e. the latitude of Jaipur, but there is no inscription to this effect.

RETE

The three almost complete rings of the Tropic of Capricorn, the equator and the ecliptic are held together by the equinoctial bar with two counterchanges. The ring of the equator is counterchanged where it intersects with the ring of the ecliptic. In the lower half, the equator and the tropic of Capricorn are joined by two supports. The ecliptic ring is divided into the twelve signs of the zodiac and labelled with their names. Each sign is subdivided into units of 6° and numbered in the usual manner.

There are 24 star pointers, 11 outside the ecliptic and 13 inside. These are mostly dagger-shaped, two are curved like tiger's claws.

Table D019-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Machodara*	*Matsyodara*	α Andromedae
3	*Aśvanā*	*Aśvinī*	β Arietis
4	*Manuṣyapa*	*Manuṣyapārśva*	α Persei

	Star Name as engraved	Full/Correct Form	Identification
5	*Rohiṇī*		α Tauri
6	*Brahmahṛ*	*Brahmahṛdaya*	α Aurigae
7	*Mithunavāpā*	*Mithuna-vāma-pāda*	β Orionis
8	*Ārdrā*		α Orionis
9	*Lubdhaka*		α Canis Majoris
10	*Tipā* ?		?
11	*Lu. Vadhu*	*Lubdhaka-bandhu*	α Canis Minoris
12	*Mahāpuruṣa*		α Hydrae
13	*U. phā.*	*Uttara-phālguṇī*	β Leonis
14	*Hasta*		δ Corvi
15	*Citrā*		α Virginis
16	*Marīcī*	*Marīci*	η Ursae Majoris
17	*Svāti*	*Svāti*	α Bootis
18	*Sarpagrīvā*		α Serpentis
19	*Abhijit*		α Lyrae
20	*Śravaṇa*		α Aquilae
21	*Kukkuṭapucha*	*Kukkuṭapuccha*	α Cygni
22	*Aśvamukha*		ε Pegasi
23	*Śatabhiṣā*		λ Aquarii
24	*Pūrvābhādrapa*	*Pūrva-bhādrapada*	β Pegasi

BACK

The entire rim is covered by the two circular scales of 1° and 6° as in the front. But the only in the upper two quadrants, the outer scale is labelled in 6s, starting from

the east and west points respectively and reaching up to the south point at the top as 6—90; 90—6.

A trigonometric quadrant is drawn in the upper left with 30 horizontal and 30 vertical parallels, which are not numbered. The upper right quadrant bears just two quarter circles; otherwise incomplete.



Figure D019.2 – Back of the astrolabe (photo by S. R. Sarma)

In the lower half there are shadow squares, on the left for the gnomon of 12 units and on the right for the gnomon of 7. The scales are divided and numbered appropriately. The labels on the left are mixed up: the horizontal scale carries the label *dvādaśāṃgula-śaṃku-viloma-chāyā* (umbra versa of the gnomon of 12 *aṅgulas*) which should have been given to the vertical scale; the vertical scale bears the label *dvādaśāṃgula-śaṃku-lomachāyā* (umbra versa of the gnomon of 12 *aṅgulas*), which

actually belongs to the horizontal scale. On the right, the horizontal scale is named *sapatāṅgula-śaṅku-loma-chayā* and the vertical scale *sapatāṅgula-śaṅku-viloma-chayā.* While *viloma-chāyā* is the correct designation for the umbra versa, the umbra recta should be called *sama-chāyā* and not *loma-chayā* which makes no sense.

ALIDADE

Pivoted to the centre on the back is a plain but beveled alidade (259 mm) with slightly ornate terminals and middle. A slender sighting tube is mounted on the alidade upon two supports. There are also holes in the supports, which can be used for viewing. There is a pin, a washer and a wedge; one end of the wedge is bent to form a large circle for better grip.

PROVENANCE

The astrolabe was exhibited in 1984 at Brussels in an exhibition entitled 'Le Mesure de Temps dans la Collections Belgiques' and is described and illustrated in the exhibition catalogue *Le Mesure de Temps dans la Collections Belgiques: Exposition organisee par le Societe Generale de Banque*, 26.1.-7.4.1984, rue Ravenstein, 1000 Bruxelles, Catalogue, No. 21.

At the time of the exhibition in 1984 and twelve years later when I saw it in 1996, it was in a private collection in Brussels. Subsequently it was sold off to an unknown collector.

D020 ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED[861]

19th century, Jaipur

Diameter 172 mm

PLU, ex-Tesseract, Hastings-on-Hudson, NY



Figure D020.1 – Front of the astrolabe (courtesy Museum of the History of Science, Oxford)

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[861] Entry based on the description in the Tesseract catalog 2, no. 3 and Sotheby's catalogue of 27 May 1982, and the photos in the archives of the Museum of the History of Science, Oxford.

It is a finely made astrolabe with a low but highly ornate crown; the lines, scales and divisions are drawn very accurately. The orthography is good, but *visargas* are added very pedantically to every name even where it is unnecessary (e.g. *tulāḥ* for Libra).

COMPONENTS

Plate with low crown (d. 172), shackle and ring, rete for 30 stars, alidade with a sighting tube; original pin and wedge are missing.

FRONT

The low crown is reticulated with with an elegant floral pattern and reinforced on the back by a riveted sheet of brass of the same outline. Engraved lines are filled with black mastic.

The limb carries two bands of scales. The inner band is divided in 1°. The outer band, which is unusually wide, is divided in 6° and numbered only in the upper two quadrants as 6—90; 90—6; in the lower half the cells are blank. Altitude circles are drawn for each 2° and every third circle is highlighted with dots. Azimuth arcs are drawn both above and below the horizon for every 3°; here also every third circle is highlighted. Lines for the seasonal hours are drawn in the lower half. None of these three sets of lines are numbered. However, between the local horizon and the Tropic of Cancer is inscribed *akṣabhā 6/6 akṣāṃśa 27,* 'midday equinoctial shadow 6;6, latitude 27.'

RETE

The rete consists of almost complete rings of the Tropic of Capricorn, equator and ecliptic, held together by the east-west equinoctial bar without counter change. The ring of the equator is counterchanged where it intersects with the ring of the ecliptic. A small fragment of the vertical bar joins the ecliptic ring with the central ring; and two short bars join the equatorial ring with the Capricorn ring in the lower half. There is a turning knob on the short bar between the equatorial ring with the Capricorn ring. The ecliptic ring is divided in 12 zodiac signs and labelled with their names; each sign is divided into groups of 6° and numbered. These divisions are further subdivided into single degrees. There are 29 star pointers; many of these are dagger-shaped; three (3, 8 and 15) are created by small incisions in the ecliptic ring and in the solstitial bar.

Table D020-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Matsyodara*		β Andromedae
3	*A*	*Aśvinī*	β Arietis
4	*Naharatārā 14*[862]	*Nadyantaka*	θ Eridani
5	*Pre. śi.*	*Pretaśira*	β Persei
6	*Rohiṇī*		α Tauri
7	*Bra.hṛ.*	*Brahmahṛdaya*	α Aurigae
8	*Prajapa*	*Prajāpati*	δ Aurigae
9	*Mithunavāmapādaḥ*		β Orionis
10	*Ārdrā*		α Orionis
11	*Lubdhakaḥ*		α Canis Majoris
12	*Lubdhakabaṃdhuḥ*		α Canis Minoris
13	*Mahāpuruṣa*		α Hydrae
14	*Maghā*		α Leonis
15	*Pū phā*	*Pūrva-phālgunī*	δ Leonis
16	*Siṃhahṛdayaḥ*		?
17	*Vasiṣṭha*		ζ Ursae Majoris
18	*Citrā*		α Virginis
19	*Marīcī*		η Ursae Majoris
20	*Svātiḥ*		α Bootis

[862] The Sanskrit name is *Nadyantaka.* Occasionally the Arabic word *nahar* is used in Sanskrit astrolabes. Here it is a combination of Arabic *nahar* (river) and Sanskrit *tārā* (star). The name is followed by the number ‘14’ the significance of which is not clear. It occurs also on D032.

	Star Name as engraved	Full/Correct Form	Identification
21	*Aiśākhā.mā.maṃ*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
22	*Anurādhā*		δ Scorpii
23	*Sarpadhārīśiraḥ*		α Ophiuchi
24	*Abhiji.*	*Abhijit*	α Lyrrae
25	*Śravaṇa*		α Aquilae
26	*Ku.pu.*	*Kukkuṭa-puccha*	α Cygni
27	*Aśvamukha*		ε Pegasi
28	*Śatabhi.*	*Śatabhiṣā*	λ Aquarii
29	*Pūrvābhā*	*Pūrvā Bhādrapada*	β Pegasi

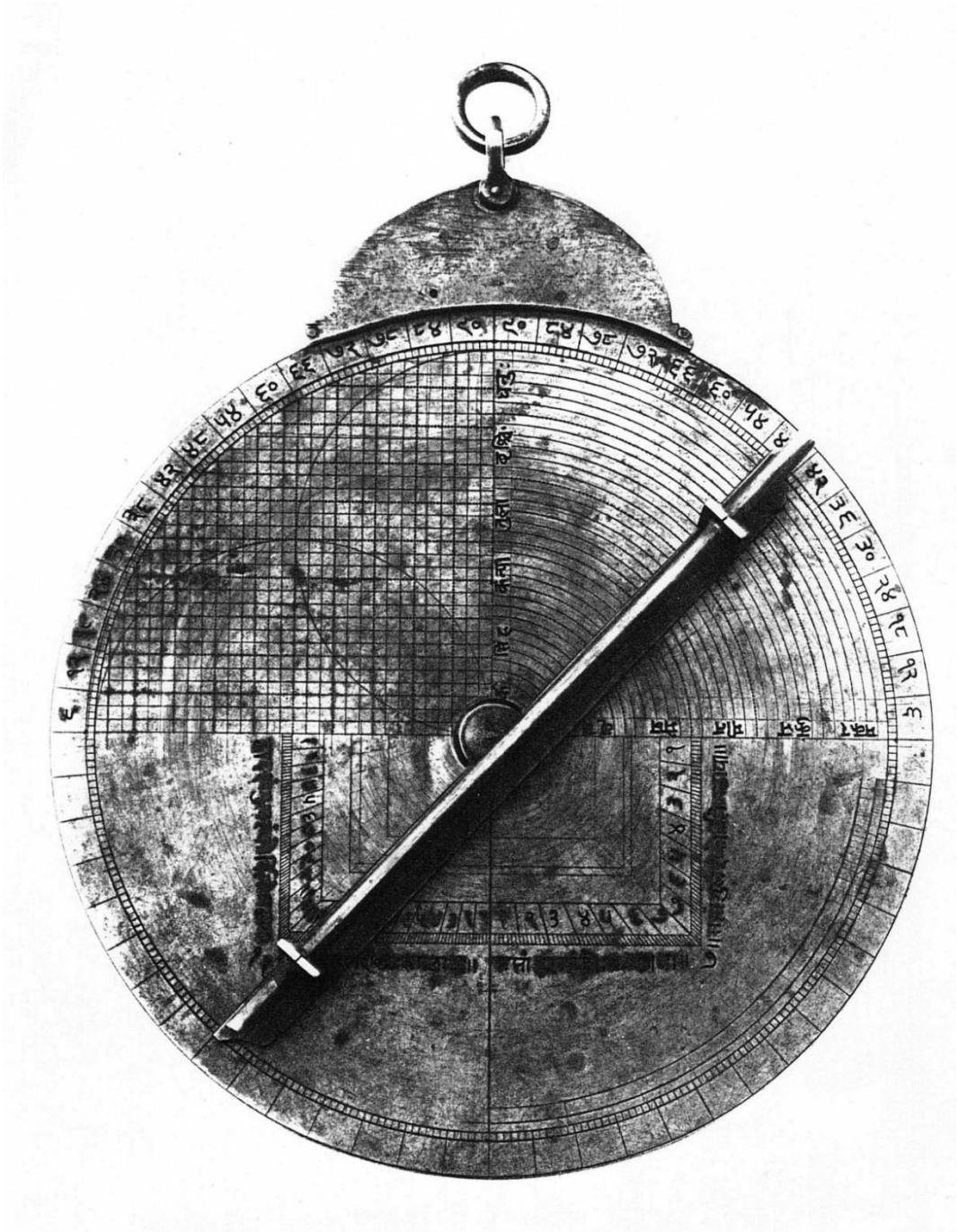


Figure D020.2 – Back of the astrolabe (courtesy Museum of the History of Science, Oxford)

BACK

As in the front, on the back also the entire rim is covered with a degree scale in two columns. The inner scale is divided in 1° and the outer scale in 6°. The outer scale in the upper half is numbered in 6s, from 6 to 90, separately in each quadrant, as 6—90; 90—6. The scale is not numbered in the lower half.

In the upper left is engraved a trigonometric quadrant with 30 horizontal and 30 vertical parallels. Semicircles are drawn about the two radii. In the upper right quadrant

are drawn the some 33 (!) declination arcs. On the vertical radius are engraved the names of the signs from summer solstice to winter solstice, starting from the centre (*Karka, Siṃha, Kanyā, Tulā, Vṛśi[ka], Dhanuḥ*). On the horizontal radius are engraved the names of the signs from the winter to the summer solstice, from the periphery to the centre (*Makara, Kumbha, Mīna, Meṣa, Vṛṣabha, Mithuna*).

Shadow squares are drawn in the lower half, on the left for the gnomon of 12 digits, on the right for a gnomon of 7 digits. The scales are divided into 12 or 7 units respectively; these units are further subdivided very accurately into 6 very fine divisions. The labels on the scale are as follows:

Vertical scale on the left: *dvādaśāṃgulaśaṃkor vilomachāyā* (umbra versa of the gnomon of 12 digits),

Horizontal scale on the left: *dvādaśāṃgulaśaṃkoḥ samachāyā* (umbra recta of the gnomon of 12 digits),

Horizontal scale on the right: *saptāṃgulaśaṃkoḥ samachāyā* (umbra recta of the gnomon of 7 digits),

Vertical scale on the right: *saptāṃgulaśaṃkor vilomachāyā* (umbra versa of the gnomon of 7 digits).

Inside this double shadow square there is another faintly drawn pair of shadow sqaures; in contrast to the outer pair, here the square on the left is for the gnomon sof 7 digits and that on the right is for a gnomon of 12 digits. The scale are divided accordingly, but not numbered, nor are they accompanied by labels. It is difficult to say whether the inner pair was a trial attempt which was abandoned in favour of the outer pair or whether both the pairs were deliberately drawn so that for one setting of the alidade, the shadow length can be measured on the scale of 7 as well as on the scale of 12.

ALIDADE

The alidade is equipped with a sighting tube.

BIBLIOGRAPHY

Sotheby's, London, auction catalogue of 27 May 1982, lot 11, p. 8.

Tesseract, Tesseract, Hastings-on-Hudson, NY , catalog 2, no. 3.

D021⊙ ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED

19th century, Jaipur

Diameter 177 mm

Brussels, PC



Figure D021.1 – Front of the astrolabe (photo by S. R. Sarma)

COMPONENTS

Plate (d. 177, h. 215, t. 1) with crown, shackle and ring, rete (d.157) for 20 stars, alidade (178) with a sighting tube (179), pin; the wedge is missing.

FRONT

The ring is rather small, its two ends are not soldered together. The shackle is small with trifoliate terminals. The crown is high, the profiles are made up of ogees at the base followed by lobes.

The limb carries a degree scale, divided in 1° and 6°; groups of 6° are numbered serially from 1 to 60. Altitude circles are drawn very neatly for every 3°, but not numbered. The plate is calibrated for the latitude of 27°, but there is no inscription to this effect. There are no azimuth arcs. In the lower half, there are lines for seasonal hours, but these are not numbered either.

RETE

The three almost complete rings of the Tropic of Capricorn, the equator and ecliptic are held together by the equinoctial bar without any counter change and by a segment of the solstitial bar. The ring of the equator is counterchanged where it intersects with the ring of the ecliptic. The ecliptic is divided into 12 signs and labelled (often with errors). Each sign is divided into 5 units and numbered as 6, 12, 18, 24, 30. Sometimes the zero sign after 3 is omitted. There are 20 dagger-shaped star pointers, 9 outside the ecliptic and 11 inside.

Table D021-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Matsyodara*		β Andromedae
3	*Rohiṇī*		α Tauri
4	*Vrahmadṛda*	*Brahmahṛdaya*	α Aurigae
5	*Ādrā*	*Ārdrā*	α Orionis
6	*Lavathaka*	*Lubdhaka*	α Canis Majoris

	Star Name as engraved	Full/Correct Form	Identification
7	*Lavadhakavadha*	*Lubdhakabandhu*	α Canis Minoris
8	*Mahāpuruṣa*		α Hydrae
9	*Uttarā phā*	*Uttara-phalgunī*	β Leonis
10	*Hasta*		δ Corvi
11	*Pitrā*	*citrā*	α Virginis
12	*Vima*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
13	*Svātī*	*Svāti*	α Bootis
14	(not named)	*Sarpa-grīvā*	α Serpentis
15	*Sarpadhārā*	*Sarpadhārīśirā*	α Ophiuchi
16	*Abhā*	*Abhijit*	α Lyrae
17	*Śravaṇa*		α Aquilae
18	*Aśvamaṣa*	*Aśvamukha*	ε Pegasi
19	*Satabhi*	*Śatabhiṣā*	λ Aquarii
20	*Pūbhā*	*Pūrva-bhādrapada*	β Pegasi



Figure D021.2 – Back of the astrolabe (photo by S. R. Sarma)

BACK

As in the front, the entire rim on the back carries a degree scale divided in 1° and 6°. In the upper half, groups of 6° are numbered from 6 to 90, separately for each quadrant (6—90; 90—6). The scales are not numbered in the lower half.

In the upper left is the trigonometric quadrant with 30 horizontal and 30 vertical parallels. Just a little above the 12th line, a quarter circle is drawn to show the obliquity of the ecliptic. The other three quadrants are blank.

ALIDADE

The ungraduated alidade bears ornate ends and an ornate centre-piece.

D022⊙ ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED

19th century, Jaipur

Diameter 214 mm

Oxford, Museum of the History of Science (# 52478)

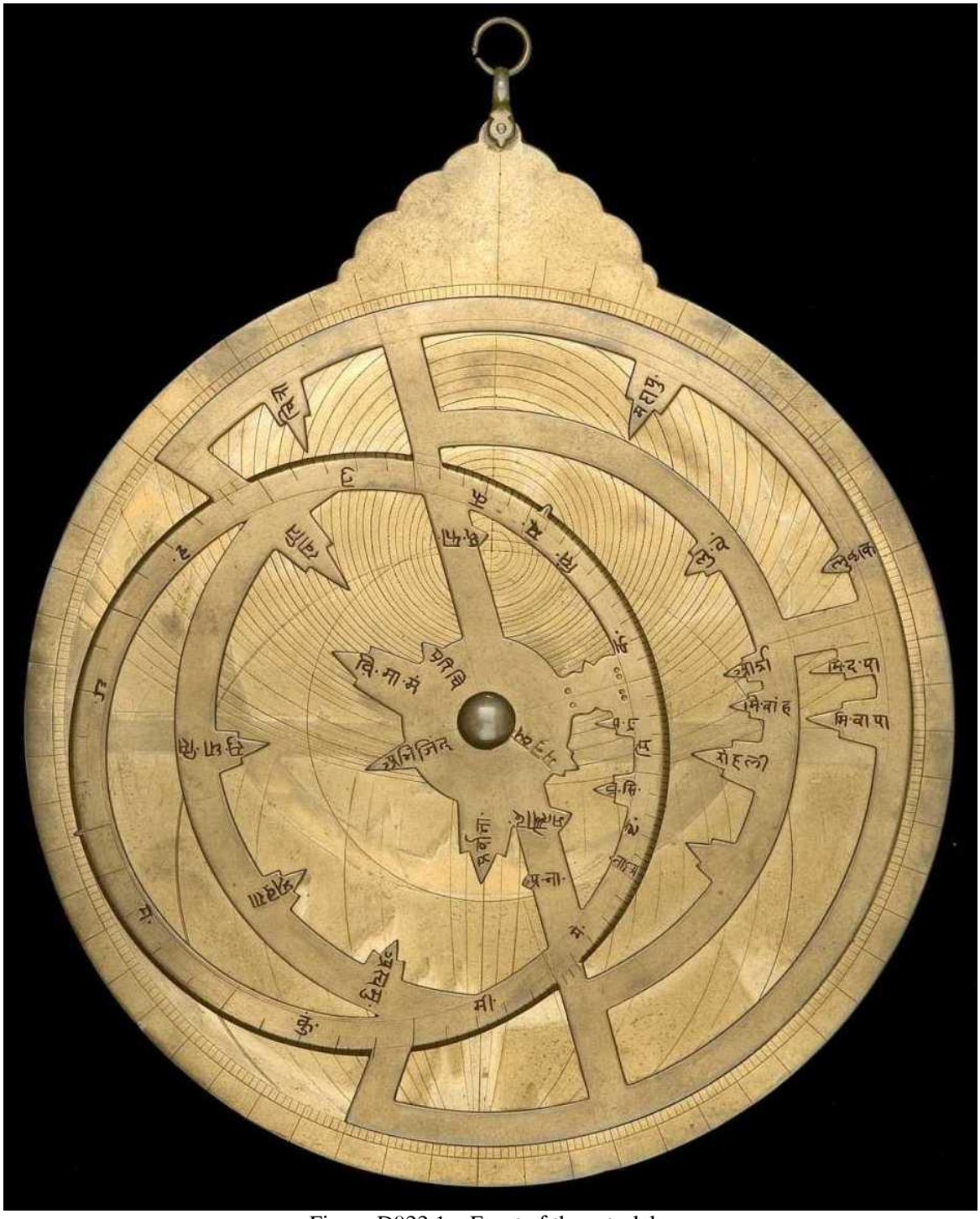


Figure D022.1 – Front of the astrolabe
(© Museum of the History of Science, Oxford)

COMPONENTS

Plate with crown (d. 214, h. 247), shackle and ring, rete (d. 196) for 26 stars, alidade with a sighting tube, pin and wedge.

FRONT

The ends of the ring are not soldered together; the mall shackle has ornate bases. The crown is high and lobed. The scale on the rim is divided in 1° and 6°, but not numbered. Altitude circles are drawn for every 2° and each third (6°) is dotted. Azimuth arcs are drawn, not very accurately, below the horizon for every 6°. Neither of the two sets of lines is numbered. There are no hour lines. The plate is designed for latitude 27, but this fact is not stated by an inscription.



Figure D022.2 – Rete of the Astrolabe
(© Museum of the History of Science, Oxford)

RETE

The rete consists of three rings of the Tropic of Capricorn, the equator and the ecliptic, held together by the straight equinoctial bar which has no counter change. The equatorial ring is joined to that of Capricorn below by a segment of the solstitial bar. Moreover, the central disc is joined to the ecliptic ring below by a bar with curved edges and containing three pairs of holes of unknown significance. The ecliptic ring is divided into the 12 zodiac signs and labelled with the initial syllables of their names. Each sign is divided into 5 parts of 6°, but not numbered.

There are 26 dagger-shaped star pointers; one of these is not named; the others carry the names often in abbreviated form.

Table D022-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Matsoda.*	*Matsyodara*	β Andromedae
2	(no name)		
3	*Nā.pra.*	*Matsyodarapāda* ?	γ Andromedae
4	*Vra.si.*	*Pretaśira*	β Persei
5	*Manuṣyapā*	*Manuṣyapārśva*	α Persei
6	*Rohalī*	*Rohiṇī*	α Tauri
7	*Pra.dra*	*Brahmahṛdaya*	α Aurigae
8	*Mi.vā.pā.*	*Mithuna-vāma-pāda*	β Orionis
9	*Mi.vā.ha.*	*Mithuna-vāma-hasta*	γ Orionis
10	*Mi.da.pā.*	*Mithuna-dakṣiṇa-pāda*	κ Orionis
11	*Ārdrā*	*x*	α Orionis
12	*Lubdhaka*	*x*	α Canis Majoris
13	*Lu.va.*	*Lubdhakabandhu*	α Canis Minoris

	Star Name as engraved	Full/Correct Form	Identification
14	*Mahāpu.*	*Mahāpuruṣa*	α Hydrae
15	*Ma*	*Maghā*	α Leonis
16	*Pū.phā.*	*pūrvaphālgunī*	δ Leonis
17	*Citrā*	*x*	α Virginis
18	*Marīci*	*x*	η Ursae Majoris
19	*Svāti*	*x*	α Bootis
20	*Vi.mā.maṃ.*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
21	*Su.dhā.śi.*	*Sarpadhārīśira*	α Ophiuchi
22	*Abhijit*	*x*	α Lyrae
23	*Śravaṇa*	*x*	α Aquilae
24	*Asvamu.*	*Aśvamukha*	ε Pegasi
25	*Pūrvābhā.*	*Pūrva-bhādrapadā*	β Pegasi
26	*A.nā.*	*Aśvanābhi*	δ Pegasi



Figure D022.3 – Back of the astrolabe
(© Museum of the History of Science, Oxford)

BACK

The scale on the rim is divided in 1° and 6°. Groups of 6° are numbered only in the upper left quadrant from 6 to 90, starting from the east point and proceeding to the south point. The upper left quadrant bears an incomplete sine-cosine graph. The other quadrants are blank.

ALIDADE

The alidade has ornate ends and an ornate cetre-piece; it is fitted with a sighting tube.

BIBLIOGRAPHY

F. R. Maddison, A Catalogue of Scientific Instruments ... from the Collection of J. A. Billmeir, 1954, pp. 29-30, pl. xxxvii.

D023 ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED[863]

19th century, Jaipur

Diameter ?

Ahmedabad, Museum of the L. D. Institute of Indology



Figure D023.1 – Front of the astrolabe (courtesy Professor Nalini Balbir)

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[863] The entry is based on a photo kindly sent by Professor Nalini Balbir, Paris. My repeated letters requesting permission to study the astrolabe did not receive any response from the L. D. Institute.

COMPONENTS

Plate with crown, shackle, rete for 14 stars, alidade with a sighting tube, washer, pin and wedge. The ring is missing.

FRONT

Very low crown, its outline forming an arc of a circle. The scale on the rim is divided in 1° and in 6° and numbered in 6s from 1 to 60. Altitude circles are drawn for every 2°and azimuth arcs for 6°; there are lines for unequal hours. None of these is numbered. The plate is calibrated for the latitude of ca. 27°.

RETE

The rete consists of the three rings of the Tropic of Capricorn, equator and ecliptic and the small disc around the hole at the centre. These are held together by the equinoctial bar which has no counter change. The ring of the ecliptic is divided into the 12 zodiac signs and labelled with their names. Each sign is divided into 15 parts of 2° each, but not numbered.

There are 14 dagger-shaped star pointers. Their names are listed below.

Table D023-1 Star Names on the Rete

	Star Name as engraved	Full/Correct form	Identification
1	illegible	*Matsyodara*	β Ceti
2	*Rohiṇī*		α Tauri
3	*Brahmahṛdaya*		α Aurigae
4	*Ārdrā*		α Orionis
5	illegible	*Lubdhaka*	α Canis Majoris
6	*Maghā*		α Leonis
7	*Pūphā*	*Pūrva-phālgunī*	α Leonis
8	*Citrā*		α Virginis
9	*Marici*	*Marīci*	η Ursae Majoris
10	*Svāti*		α Bootis

	Star Name as engraved	Full/Correct form	Identification
11	*Abhijita*	*Abhijit*	α Lyrae
12	illegible	*Śravaṇa*	α Aquilae
13	*A.mu.* (?)	*Aśvamukha*	ε Pegasi
14	illegible	*Pūrva-bhādrapadā*	β Pegasi

BACK

No photo is available of the back. The alidade is equipped with a sighting tube.

D024 ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED[864]

19th century, Jaipur

Diameter 175 mm

PLU

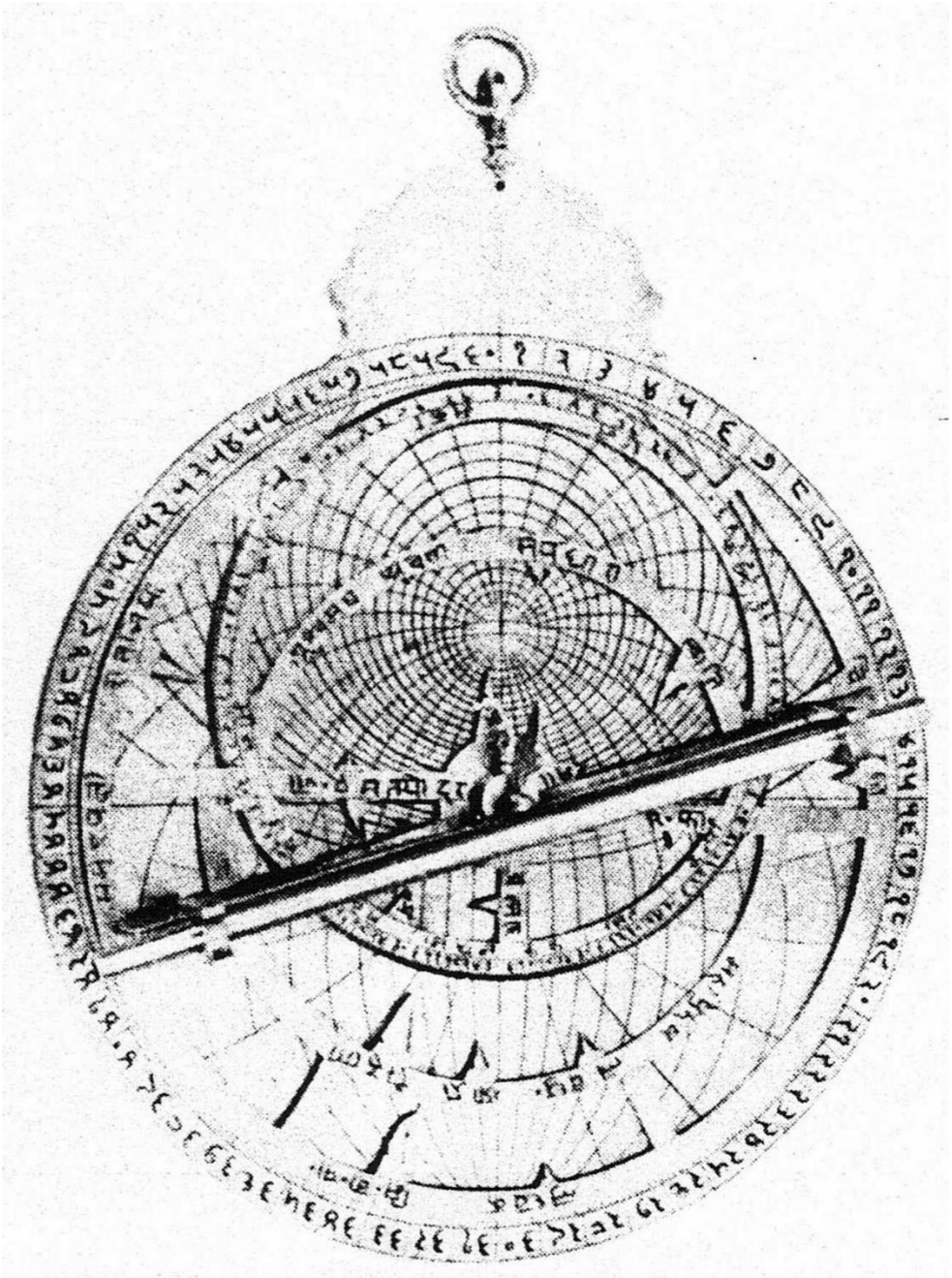


Figure D024.1 – Front of the astrolabe (photo from Moskowitz 1979)

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[864] Entry based on Moskowitz 1979, item 88, p. 21.

COMPONENTS

Plate with crown (d. 175, h. 210), shackle and ring, rete (d. 159) for 21stars, alidade (l. 165) with a sighting tube and pin. Washer and wedge are modern replacements.

FRONT

The crown is high and lobed. The scale on the rim is divided in 1° and 6° and numbered in 6s serially from 1 to 60. Altitude circles are drawn for every 3° and azimuth arcs for every 10° below and above the horizon. There are lines for seasonal hours. None of these is numbered. The plate is calibrated for the latitude of 27°; but this is not recorded either.

RETE

The rete consists of the three almost complete rings of the Tropic of Capricorn, the equator and the ecliptic which are held together by the equinoctial bar without counter change. There are 21 dagger-shaped star pointers, 12 to the north of the ecliptic and 9 to the south. All the names could not be deciphered in the photo published in the catalogue.

BACK

On the back, the rim carries a degree scale divided and numbered exactly as in the front. Rest is said to be blank.

BIBLIOGRAPHY

Moskowitz 1979, item 88, p. 21.

D025 ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED[865]

19th century, Jaipur

Diameter 427 mm

Vicenza, PC of Mr Giancarlo Beltrame (# 412)

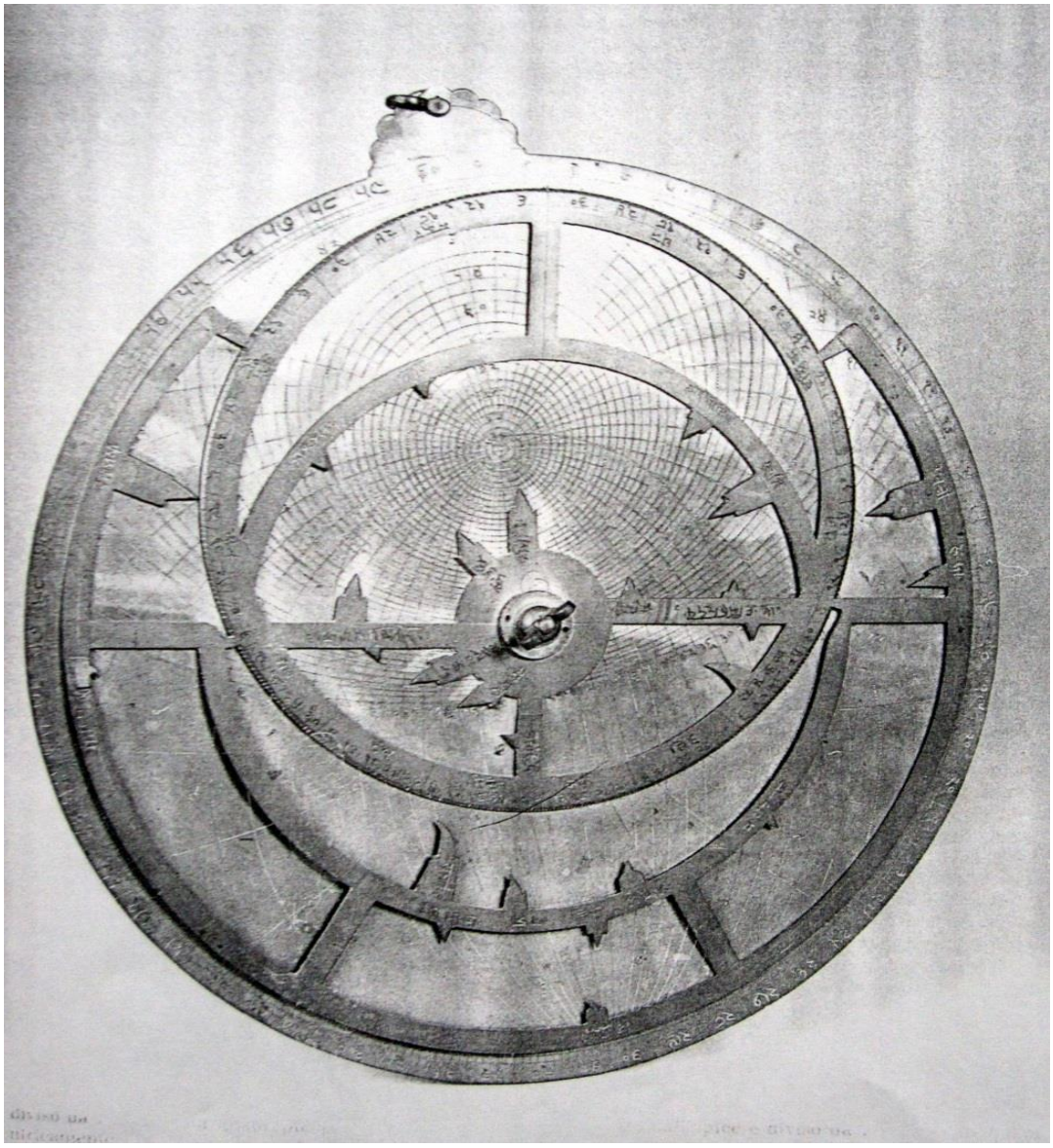


Figure D025.1 – Front of the astrolabe (courtesy Anthony J. Tuner)

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865 This entry is based on the notes and photos kindly provided by Anthony J. Turner. The Beltrame collection is catalogued by Anthony Turner and others; cf. Brenni 1996, p. 16.

COMPONENTS

Plate (d. 427) with crown and shackle, rete for 25 stars; the alidade is missing. The components are held together by a modern bolt and nut. One of the star pointers (β Cet) has been soldered to the rete in the course of a later repair.

FRONT

The lobed crown is small, so also the shackle. The scale on the rim is divided in 1° and in 6°. The groups of 6° are numbered serially from 1 to 60. Altitude circles appear to have been drawn for every 2° and numbered. Azimuth arcs are engraved above and below for every 6° and numbered along the horizon line. Lines are drawn for unequal hours. The plate is calibrated for the latitude of 27°, but there is no inscription to this effect.

RETE

The rete consists of three rings of the Tropic of Capricorn, the equator and the ecliptic held together by the equinoctial bar, which has a counter change at the centre. Segments of the solstitial bar join the ecliptic ring and that of equator in the upper half, and central disc with the ecliptic ring below. In the lower half, the ring of the equator and that of the Tropic of Capricorn are joined by two straight bars situated on either side of the meridian.

The ecliptic ring is divided into 12 the signs of the zodiac and labelled with their names. Each sign is divided into 5 parts and numbered as 6, 12, 18, 24, 30.

There are 25 dagger-shaped star pointers. It is difficult to read their names in the photo, but they are likely to represent the following stars.

Table D025-1 Stars on the Rete

	Star Name	Identification
1	*Samudrapakṣī*	β Ceti
2	*Matsyodara*	β Andromedae
3	*Matsyodarapāda*	γ Andromedae
4	*Rohiṇī*	α Tauri
5	*Brahmahṛdaya*	α Aurigae

	Star Name	Identification
6	*Prajāpati*	δ Aurigae
7	*Ārdrā*	α Orionis
8	*Lubdhaka*	α Canis Majoris
9	*Punarvasu*	β Geminorum
10	*Lubdhakabandhu*	α Canis Minoris
11	?	
12	*Pūrvaphālgunī*	δ Leonis
13	*Hasta*	δ Corvi
14	*Siṃhahṛdaya*	α Leonis
15	*Marīci*	η Ursae Majoris
16	*Citrā*	α Virginis
17	*Svāti*	α Bootis
18	*Sarpagrīvā*	α Serpentis
19	*Abhijit*	α Lyrae
20	*Śravaṇa*	α Aquilae
21	*Kukkuṭapuccha*	α Cygni
22	*Aśvamukha*	ε Pegasi
23	*Śatabhiṣā*	λ Aquarii
24	*Pūrvabhādrapadā*	β Pegasi
25	?	

BACK

No photo is available of the back. The scale on the rim is divided in 1° and in 6°. But only in the upper half the groups are numbered, as 6—90; 90— 6. It is not known what is contained in the upper left quadrant. There is sine graph in the upper right quadrant. The two lower quadrants contain the shadow squares of 12 (left) and 7 (right) divisions.

BIBLIOGRAPHY

Brenni 1996, p. 16.

D026⊙ ASTROLABE FOR LATITUDE 27°, WITH A FAMILY OF HORIZONS ON THE BACK, NOT SIGNED, NOT DATED[866]

19th Century

Diameter 302 mm

Bielefeld, Kunstgewerbesammlung der Stadt Bielefeld, Stiftung Huelsman (# H-W 93)



Figure D026.1 – Front of the astrolabe (photo by S. R. Sarma)

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866 Described briefly, without drawing attention to the unusual feature on the back, in Syndram 1989, pp. 64-65, fig. 5 (front view).

It is a well-crafted astrolabe with a reticulated crown and with an unusual feature of a family of horizons at the back, but marred by various errors.

COMPONENTS

Plate with crown (d. 303, h. 333), shackle and ring, rete (d. 274), washer, alidade, washer, pin. The wedge is a modern substitute.



Figure D026.2 – Crown of the astrolabe (photo by S. R. Sarma)

FRONT

The ring is large with circular section; the shackle is relatively small, but with large trifoliate bases. The crown is fashioned in the form of two swans (*haṃsa-s*) with engraved lines to show the wings, tail feathers, neck, eyes and beaks. These lines are engraved on both sides of the astrolabe.

The limb is graduated in 1° and 6° and numbered in 6s serially from 1 to 60. The circular rim is cut very deeply, so that part of the scale is coming apart between 36° and 42° in the north-east. Altitude circles are drawn for each 6° and labelled on both sides of the meridian. The plate is calibrated roughly for the latitude of 27°, but there is no inscription to this effect. Azimuth arcs are drawn above and below the horizon, somewhat irregularly for every 6°; these are labelled along the oblique horizon. Some arcs, drawn wrongly, are apparently discarded; they are not cut deeply like the others.

There are three unusual features on this plate: In the upper half, four radial lines, two on either side of the meridian, are drawn from the centre at a distance of 6 degrees. The purpose is not clear. Parallel to the east west line, 43 mm to the north, there is another horizontal line with deeply cut dots; the purpose of this is not clear either. No hour lines are drawn in the lower half.



Figure D026.3 – Front of the plate (photo by S. R. Sarma)

RETE

The rete is made of very thin copper sheet and is rather wobbly. Here the almost complete rings of Capricorn, the equator and the ecliptic are held together by a broad equinoctial bar without any counter change. The equator is counterchanged where it intersects with the ring of the ecliptic. The ecliptic ring is divided into 12 signs of zodiac and labelled with the names of the signs; each sign is subdivided into groups of 6° and labelled from 6 to 30, and the edge of the ecliptic ring is calibrated for single degrees. The numerals here are slightly different from those on the mater plate, especially 4 and 8. There are 22 dagger-shaped star pointers, 10 outside the ecliptic and 12 inside. The star names are often abbreviated and often poorly engraved.

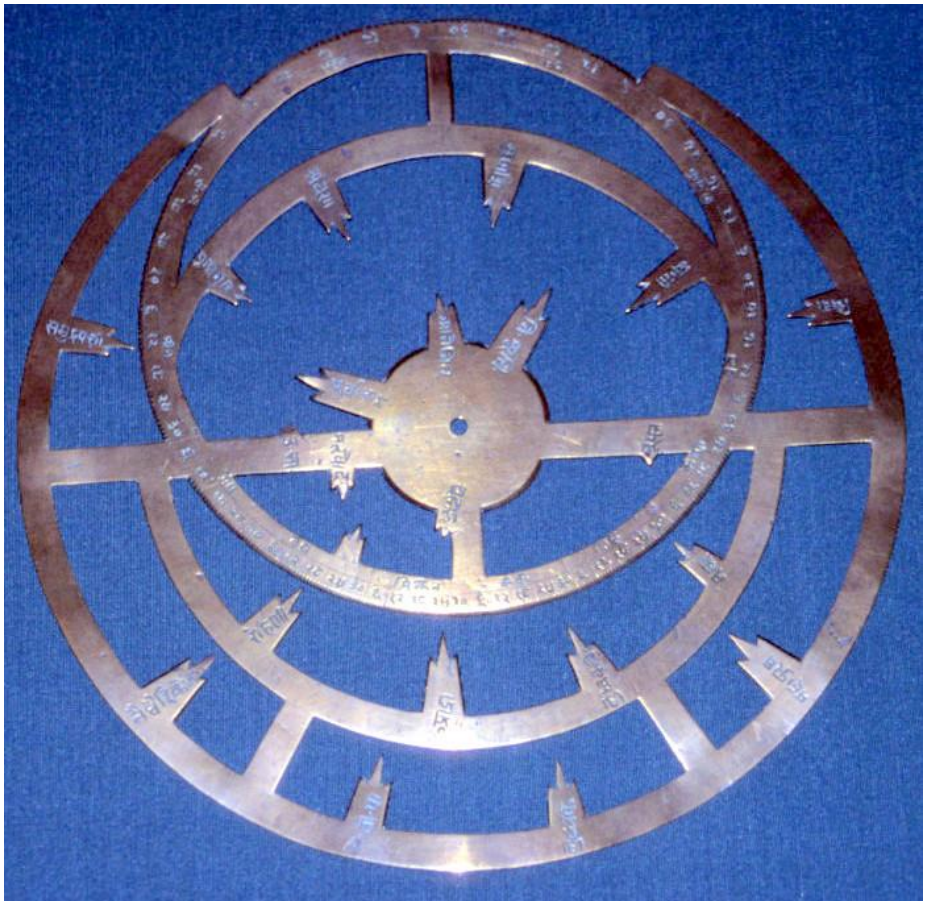


Figure D026.4 – Rete of the astrolabe (photo by S. R. Sarma)

Table D026-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Matsyoda*	*Matsyodara*	β Andromedae
2	*Naighairikota*	*Nahara-kulyā ?*	γ Eridani
3	*Rohaṇī*	*Rohiṇī*	α Tauri
4	(not named)	*Pretaśira*	β Persei
5	*Vrahmahṛ*	*Brahma-hṛdaya*	α Aurigae
6	*Mivāpā*	*Mithuna-vāma-pāda*	β Orionis
7	*Ārdrā*		α Orionis
8	*Lubdhaka*		α Canis Majoris
9	*Ludhvakba*	*Lubdhaka-bandhu*	α Canis Minoris

	Star Name as engraved	Full/Correct Form	Identification
10	*Mahāpuraṣa*		α Hydrae
11	*Maghā*		α Leonis
12	*Pūphā*	*Pūrva-phālgunī*	δ Leonis
13	*Citrā*		α Virginis
14	*Svātī*	*Svāti*	α Bootis
15	*Vi. bhū. ci.*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
16	*Sa.dhā.śi.*	*Sarpadhārī-śira*	α Ophiuchi
17	*Abhijit*		α Lyrae
18	*Śravaṇa*		α Aquilae
19	*Aśvamuṣa*	*Aśvamukha*	ε Pegasi
20	*Pūrvā-bhādra*	*Pūrva-bhādrapadā*	β Pegasi
21	*Samudrapakṣī*(!)	*Śatabhiṣā*	λ Aqarii
22	*Ubhā*	*Uttara-bhādrapadā*	γ Pegasi

BACK

The rim on the upper half carries the altitude scale, divided in 1° and 6° and labelled from 6 to 90, separately in each quadrant (6—90; 90—6). Here the division 36 is wrongly labelled as 35 on the right as well as on the left. The double scale continues in the lower half, but not labelled.

Inside the scale are drawn the south-north and the east-west lines. In addition, there are also four concentric circles instead of the three for the tropics and equator. The circle of Cancer is much larger than in the front; here it has a diameter of 63 mm while in the front it measures 56 mm only.

The upper right quadrant carries a sine-cosine grid, formed by 33 equi-distant vertical parallel lines and 32 equidistant horizontal parallel lines, instead of 30 parallels!

The lower right quadrant carries a single shadow square for a gnomon of 7 feet. It is drawn very carelessly, the vertical side is slanted and the two sides form an angle of less than 90°.



Figure D026.5 – Back of the Astrolabe (photo by S. R. Sarma)

The left half consisting of the upper and lower left quadrants is filled with the projection of a family of half-horizons from 12° to 66°, at intervals of 6°. These are numbered at both ends. Usually such families of horizons are engraved on a special plate of the astrolabe, often with declination scales. This is the only astrolabe where this feature occurs on the back, but without declination scales. Interestingly, Joshi Dharm

Chand of Lahore (*fl*. 1854-73) made two identical sine quadrants (J.forthcoming) where the reverse side is filled by such a family of horizons. It is possible that this astrolabe also may have been made by him, but then it is intriguing why the obverse side was calibrated for the latitude of 27° and not for the latitude of Lahore at 32°.

ALIDADE

The alidade is about 274 mm long; it is not graduated. A finely made sighting tube is attached to this upon two struts. The tube is slightly longer than the diameter of the astrolabe itself.

BIBLIOGRAPHY

Syndram 1989, pp. 64-65, fig. 5.
Sarma 2015b, pp. 293-294, no. [36].

D027⊙ ASTROLABE FOR LATITUDE 27°, MADE FOR MADANAMOHANA ŚARMĀ

Mid 20th century, Jaipur

Diameter 230 mm, copper

Jaipur, Museum of Indology

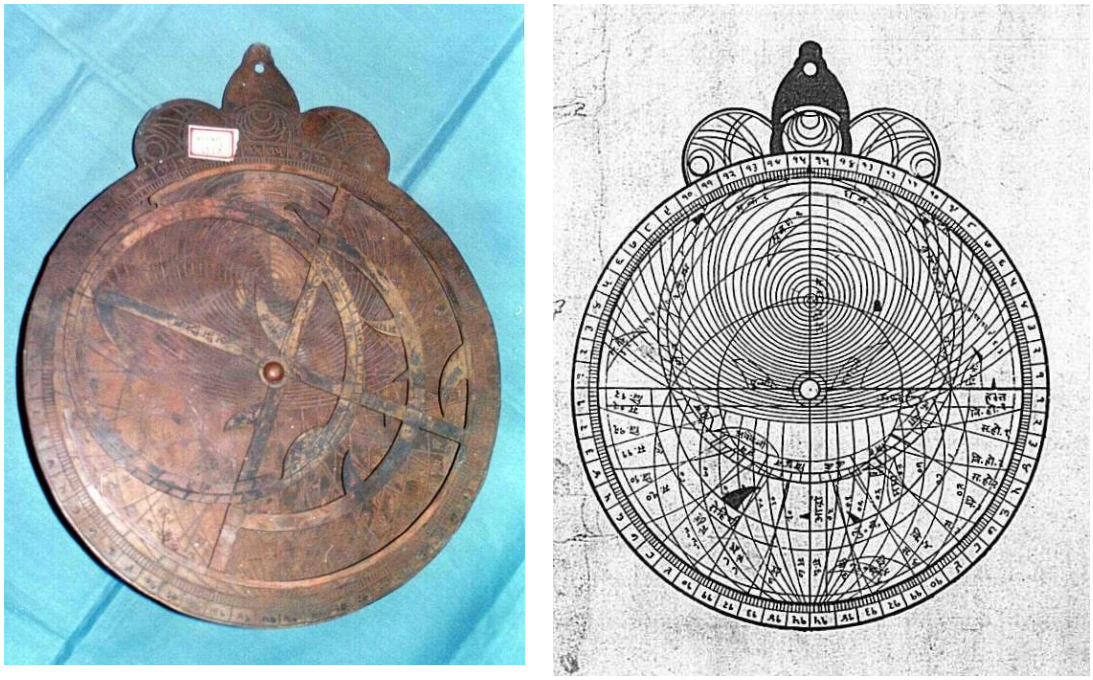


Figure D027.1 – Front of the astrolabe. On the left, the actual specimen (photo by S. R. Sarma); on the right, the drawing from Madanamohana Śarmā's book

In 1951, Madanamohana Śarmā of Jaipur, who prepares annual *pañcāṅgas* (Sanskrit almanacs), published a Hindi translation of Mahendra Sūri's *Yantrarāja.* About this time, he appears to have designed an astrolabe for the latitude of 27° and got it made. In the book are reproduced the original drawings according to which the astrolabe was made around 1950. Therefore, chronologically this is the last astrolabe made according to tradition.

COMPONENTS

Plate with crown (d. 230), rete for stars, alidade with a sighting tube, pin. Shackle, ring, wedge are missing.

FRONT

The crown and the plate are cut out from a copper sheet somewhat crudely. The crown has a strange shape with decorative lines. The rim carries the degree scale divided in 1° and 6°; groups of 6° are numbered serially from 1 to 15, separately for each

quadrant, starting at the east and west points and reaching up to the north or south points. Altitude circles are drawn for each 3°. The first ten circles are numbered on both sides of the meridian. Azimuth arcs are drawn for each 10° below the horizon and numbered. There are lines for seasonal hours and lines for equal hours counted from the eastern and western horizons.

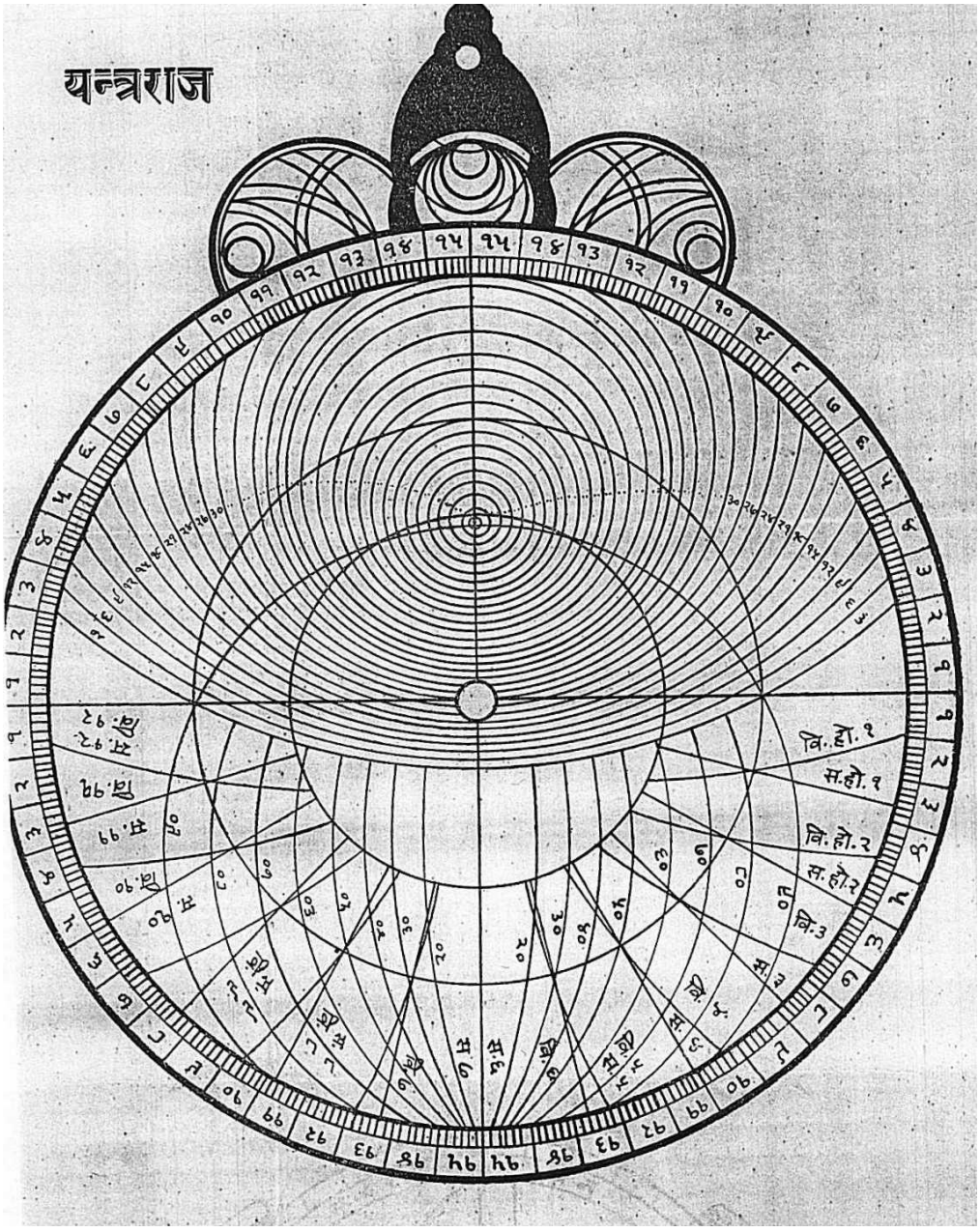


Figure D027.2 – Drawing the latitude plate

Both sets of lines are numbered from the western horizon from 1 to 12, the equal hours as *sa[ma]ho[rā]* and the seasonal hours as *vi[ṣama]ho[rā].* The plate is calibrated for the latitude 27° but is not labelled to this effect.

RETE

The rete consists of the ring of the Tropic of Capricorn, the ring of the ecliptic, and the lower half of the equatorial ring. These are joined by the east-west and south-north bars without any counter change. The ecliptic is divided into the 12 signs and labelled. Each sign is divided into five units, but not labelled. There are 15 star pointers which are shaped like tiger's claws. Interestingly 13 of these stars are the junction stars of the traditional lunar mansions; *lubdhaka* is not a lunar mansion, but is known to Sanskrit astronomy. Only *lubdhaka-bandhu* is the new astrolabe star introduced by Mahendra Sūri.

Table D027-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Aśvinī*		β Arietis
2	*Rohiṇī*		α Tauri
3	*Ārdrā*		α Orionis
4	*Lubdhaka*		α Canis Majoris
5	*Lu.ba.*	*Lubdhaka-bandhu*	α Canis Minoris
6	*Maghā*		α Leonis
7	*U.phā.*	*Uttara-phālgunī*	β Leonis
8	*Hasta*		δ Corvi
9	*Citrā*		α Virginis
10	*Svātī*	*Svāti*	α Bootis
11	*Anurādhā*		δ Scorpii
12	*Abhijit*		α Lyrae
13	*Śravaṇa*		α Aquilae
14	*Śa.vi.*	*Śatabhiṣā*	λ Aquarii
15	*Pū.bhā*	*Pūrva-bhādrapadā*	β Pegasi

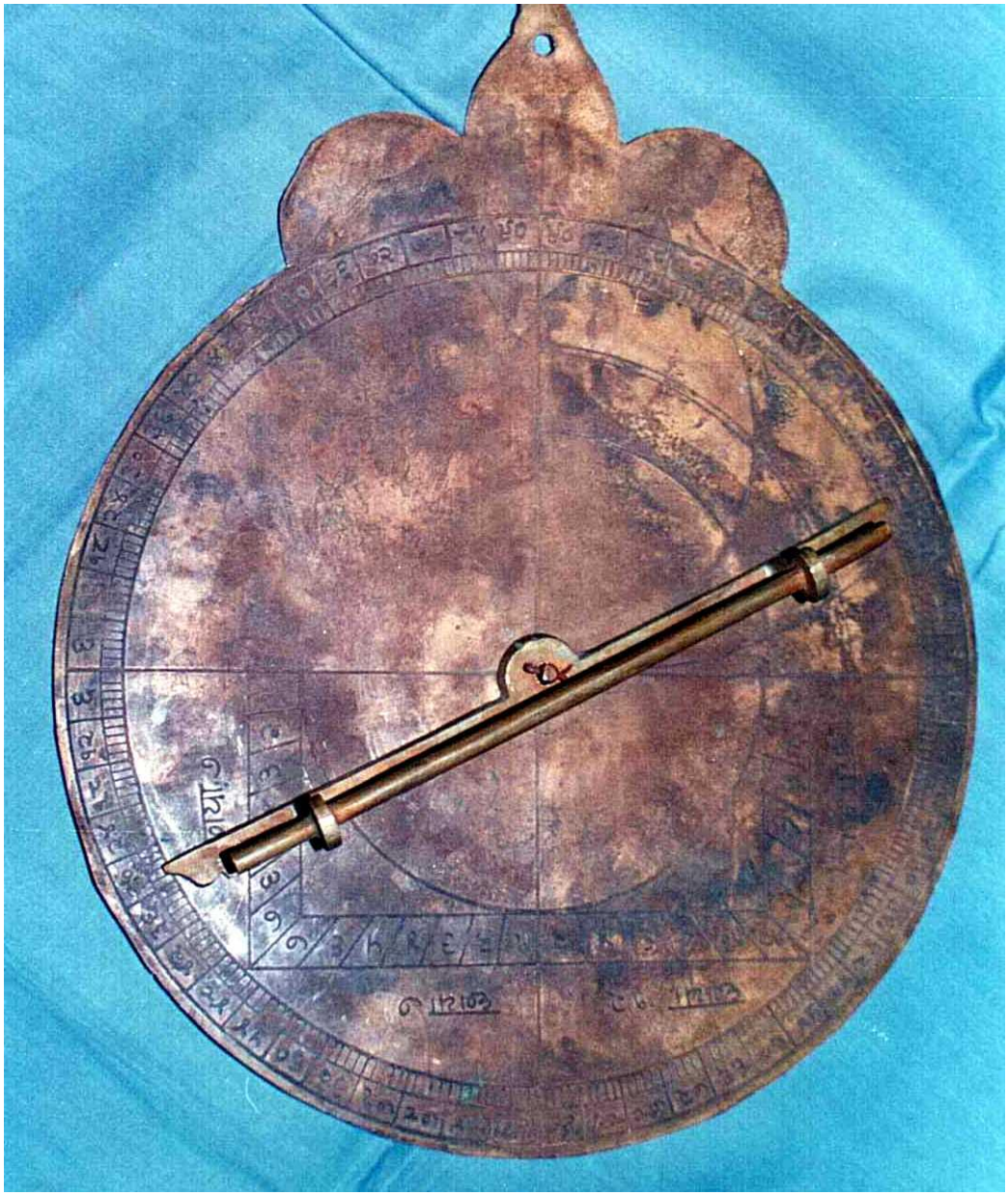


Figure D027.3 – Back of the astrolabe (photo by S. R. Sarma)

BACK

The rim on the back is graduated in 1° and 6°, and numbered in 6s from 6 to 90, separately for each quadrant, starting at the east and west points and reaching up to the north or south points.

On the back, the upper left quadrant is blank. On the upper right quadrant, attempt was made to draw declination arcs and the curves for unequal hours but the exercise was abandoned midway. On the lower half are drawn the shadow squares, on the left for the gnomon of 7 digits and on the right for the gnomon of 12 digits. The scales on the left are divided into 7 divisions, those on the right into 6 divisions only. The legends do not distinguish between the umbra recta (*sama-chāyā*) and umbra versa (*viloma*

chāyā) but simply mention *chāyā* (shadow) for both the vertical and horizontal scales. Thus on the left, both vertical and horizontal scales carry the legend *chāyā 7* (shadow 7) and on the right again both the scales the legend *chāyā 12* (shadow 12).

The alidade is equipped with a sighting tube.

BIBLIOGRAPHY

Madanamohana Śarmā, *Yantrarāja-Paricaya,* Jaipur 1951.

SILVER ASTROLABES MADE IN JAIPUR IN THE 20TH CENTURY

In the twentieth century some enterprising jewellers produced silver astrolabes for foreign buyers. Five specimens are known in different collections. These are not original creations, but are copied from earlier brass astrolabes. The first three specimens, D028, D029 and D030, are copied from D007 which is still in Jaipur or another similar specimen. The exact models for D031 and D032 have not come to light so far; they may be in some private collections in Jaipur.

Besides these silver astrolabes, there is a double ring dial preserved in the National Museum at New Delhi; this too appears to have been produced in the twentierh century at Jaipur, in imitation of some brass model. It will be described in section Y.

Different from these is a special type of sine quadrant made in silver; it is not a twentieth centurycopy of an existing brass model, but an original device which Raja Ram Singh of Kota, got designed by a certain Vaijanātha's son and presented to the Givernment of India ca. 1839.[867] Its present location is not known. It will described in section K.

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867 Cf. Middleton 1839.

D028⊙ SILVER ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED

20th century, Jaipur

Diameter 212 mm

New Delhi, National Museum (# 86.193/1)



Figure D028.1 – Front of the astrolabe (photo by S. R. Sarma)

This astrolabe closely imitates D025 in the numbering of the degree scale, in the design of the rete and in the unusual pairs of shadow squares on the back. There are slight differences in the stars on the rete. Either D025 or some other astrolabe akin to it must have used as the model for producing this silver astrolabe.

COMPONENTS

Plate with crown (d. 212, h. 253.3, t. 1.5), shackle and ring, rete (d. 187, t. 2.5) for 32 stars, alidade (length 193) with a sighting tube (length 203), rule (length 113, w. 8).

FRONT

High crown with lobes but roughly rectangular in outline, shackle with circular bases, and a plain ring. The degree scale on the rim consists of three bands, the narrow outer and inner bands are divided in 1°, the broader middle band is divided in 6° and numbered in rather large numerals from 1 to 60, most unusually, starting from the east point and proceeding in counter-clockwise direction. Altitude circles are drawn for each 2° and azimuth arcs for each 6° below the horizon. In the lower half, there are lines for seasonal hours and dotted lines for equal hours counted from the eastern and western horizons. None of these lines is numbered. The altitude circles are arranged for the latitude of 27°, but this is not stated.

RETE

The rete is made of a heavier plate with a thickness of 2.5 mm. It consists of four circular rings, viz., the two tropics, equator and the ecliptic, and the four are held together by the complete equinoctial and solstitial bars which are without counter change. In the lower half, the equatorial ring and that of the Tropic of Capricorn are joined by two straight supports. The ecliptic ring is divided into the 12 zodiac signs and each sign into three units. These are labelled as follows. In the first unit of each sign is written the name of the sign and 10, in the next unit 20 and in the third unit 30 and so on. In engraving 10, often a dot is used instead of the zero. Each unit of 10 is subdivided into single degrees on the outer rim and on the edge of the ecliptic ring.

Star pointers are mostly dagger-shaped. However, there are seven which are created inside the circular rings of ecliptic and the Tropic of Cancer by heart-shaped incisions.



Figure D028.2 – Rete of the Astrolabe (photo by S. R. Sarma)

Table D028-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Sa.pakṣīmuṣa*[868]	*Samudrapakṣī-mukha*	γ Ceti

[868] This is the first time this star *Samudra-pakṣī-mukha,* literal translation of *fam al-qīṭus,* is shown on a Sanskrit astrolabe.

	Star Name as engraved	Full/Correct Form	Identification
3	*Vretaśira*	*Pretaśira*	β Persei
4	*Rohiṇī*		α Tauri
5	*Vrahmahṛ*	*Brahma-hṛdaya*	α Aurigae
6	*Prajāpati*		δ Aurigae
7	*Mi.vāmapāda*	*Mithuna-vāma-pāda*	β Orionis
8	*Mi.vāmahasta*	*Mithuna-vāma-hasta*	γ Orionis
9	*Ārdrā*		α Orionis
10	*Ludhaka*	*Lubdhaka*	α Canis Majoris
11	*Suvdhakabadhu*	*Lubdhaka-bandhu*	α Canis Minoris
12	*Puna*	*punarvasu*	β Geminorum
13	*Aślayā*	*Aśleṣā*	ζ Cancri
14	*Mahāpuruṣa*		α Hydrae
15	*Pūrvāphālgunī*		δ Leonis
16	*Kākapada*	*Kākapakṣa*	γ Corvi
17	*Hasta*		δ Corvi
18	*Sitaha*	*Pulaha ?*	β Ursae Majoris
19	*Vasiṣṭa*	*Vasiṣṭha*	ζ Ursae Majoris
20	*Citrā*		α Virginis
21	*Svāti*		α Bootis
22	*Marīci*		η Ursae Majoris
23	*Sapagrīvā*	*Sarpagrīvā*	α Serpentis
24	*Viyānyya*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis

	Star Name as engraved	Full/Correct Form	Identification
25	*Abhijit*		α Lyrae
26	*Śravaṇa*		α Aquilae
27	*Dhaniṣṭa*	*Dhaniṣṭhā*	β Delphini
28	*Kukuṭapu*	*Kukkuṭa-puccha*	α Cygni
29	*Aśvamuṣa*	*Aśvamukha*	ε Pegasi
30	*Śatabhiṣā*		λ Aquarii
31	*Pū.bhā*	*Pūrva-bhādrapadā*	β Pegasi
32	*U.bhādra*	*Uttara-bhādrapadā*	γ Pegasi

BACK

As in the front, the degree scale on the rim at the back also consists of three bands, but the outer band is not graduated, the inner band is divided in 1°, rather unevenly, and the middle band in 6° and numbered from 6 to 90, separately for each quadrant, starting from the east and west points and reaching up to the south and north points. The upper left quadrant contains a sine-cosine graph with 30 horizontal and 30 vertical parallels, where each fifth line is highlighted with dots. The upper right quadrant is empty.

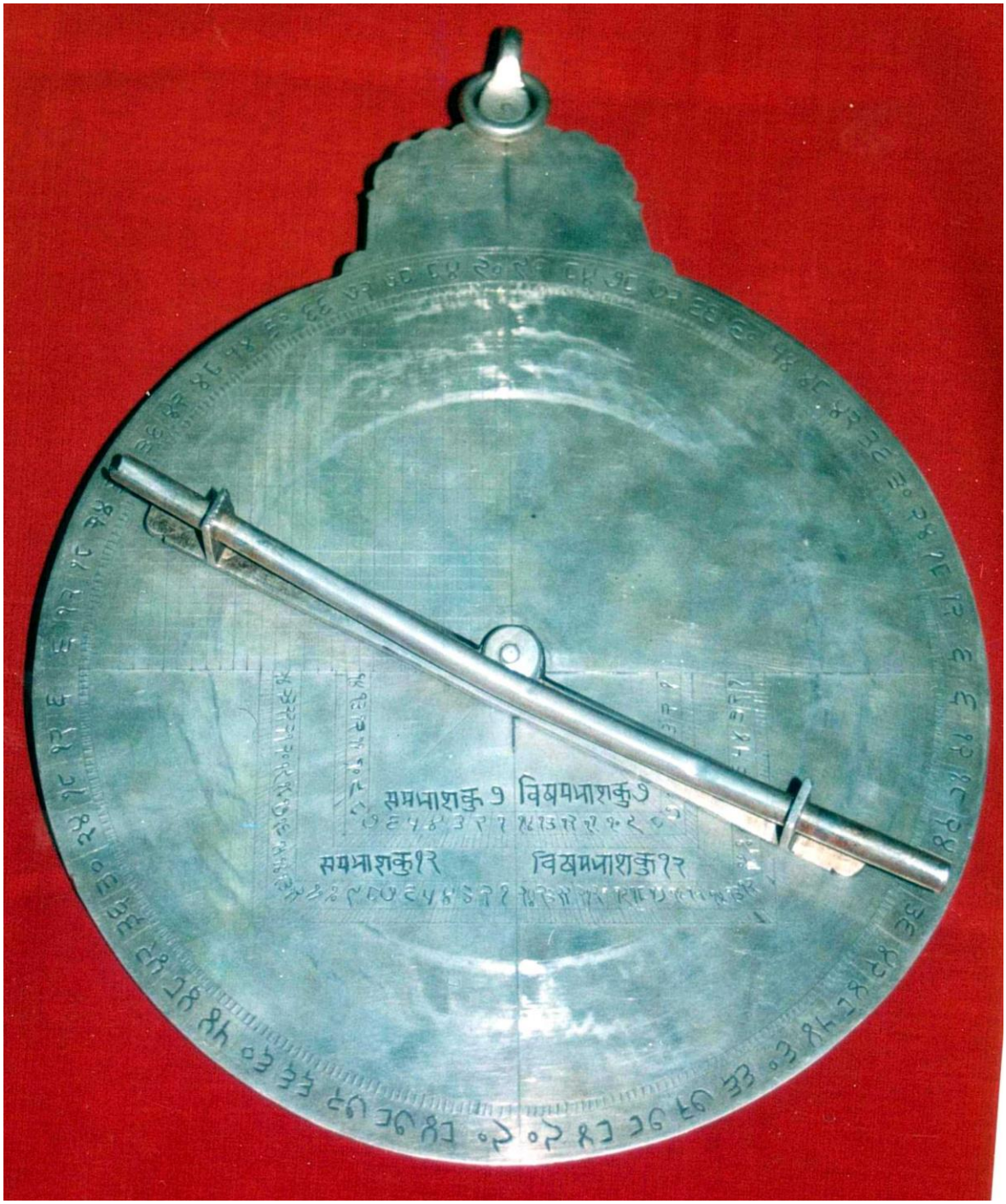


Figure D028.3 – Back of the astrolabe (photo by S. R. Sarma)

In the lower half, there are two sets of shadow squares, one inside the other. The outer one is for the gnomon of 12 digits; here all the four scales are divided into 12 parts each, and each part into 4 smaller units. On the left, the horizontal scale is numbered from 1 to 12, starting from the meridian and proceeding leftwards; the numbering is continued in the vertical scale up to 24. On the right the numbering commences at the top of the vertical scale and continues on the horizontal scale up to 24 at the meridian. The label above the horizontal scale on the left reads *samabhā śa[ṃ]ku 12* (umbra recta,

gnomon [of] 12 [digits]); the label above the horizontal scale on the right reads *viṣamabhā śa[ṃ]ku 12* (umbra versa, gnomon [of] 12 [digits]).

The inner squares are for the gnomon of 7 digits; here all the four scales are divided into 7 parts each, and each part into 4 smaller units. On the left, the horizontal scale is numbered from 1 to 7, starting from the meridian and proceeding leftwards; the numbering is continued in the vertical scale up to 14. On the right the numbering commences at the top of the vertical scale and continues on the horizontal scale up to 14 at the meridian. The label above the horizontal scale on the left reads *samabhā śa[ṃ]ku 7* (umbra recta, gnomon [of] 7 [digits]); the label above the horizontal scale on the right reads *viṣamabhā śa[ṃ]ku 7* (umbra versa, gnomon [of] 7 [digits]).

Alidade and Rule

The alidade has ornate ends and a matching centre piece. A sighting tube, somewhat longer than the alidade, is attached to it. The tube is slightly bent now. In the front there is a rule with an ornate terminal like those of the alidade. Unlike D025, this does not have a longitudinal slit with a cursor, nor is it graduated. There is a washer and a pin, but the original wedge is missing. The whole ensemble is held together by a twisted wire loop.

D029⊙ SILVER ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED

20th century, Jaipur

Diameter 213 mm

London, Science Museum (# 1990-605)



Figure D029.1 – Front of the astrolabe (photo by S. R. Sarma)

This astrolabe is exactly like the previous astrolabe at the National Museum of New Delhi in all respects including the size and must have made by the same jeweller of Jaipur who produced the previous one. The only difference is that there is a nicely crafted wooden case to keep this astrolabe.

COMPONENTS

Plate with crown (d. 213, h. 253), shackle and ring, rete (d. 189) for 32 stars, alidade with sighting tube, pin, washer, wedge, wooden box, cloth bag. In the wooden box, there is a recess for the alidade.

FRONT

The crown is exactly like the crown of the previous astrolabe. The degree scale is numbered in the same manner in large numerals starting from the east point and proceeding in counter-clockwise direction. The altitude circles, azimuth arcs and hour lines are drawn in the same fashion.

RETE

The rete is designed in the same manner with the same number of star pointers; even the errors in star names are the same.



Figure D029.2 – Back of the astrolabe (photo by S. R. Sarma)

BACK

The scale on the rim, the sine-cosine graph in the upper left quadrant and the double shadow squares in the lower half are exactly like in the previous astrolabe, so too are the alidade pivoted at the back and the rule in the front.



Figure D029.3 – Wooden box (photo by S. R. Sarma)

PROVENANCE

Acquired from Christie's auction on 27 September 1990; cf. the auction catalogue, lot 191, pp. 41-42.

D030 SILVER ATROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED[869]

20th century, Jaipur

Diameter ?

PLU



Figure D030.1 – Front of the astrolabe (photo courtesy Jeremy Collins, Christie's)

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[869] Entry based on a photo kindly given by Jeremy Collins, Christie's, in 1993.

This astrolabe shares many of the unusual features of the previous two astrolabes, but is slightly different from them.

COMPONENTS

Plate with crown, rete for 37 stars, pin. The shackle and ring are missing. No information about the alidade and the sighting tube, and the wedge. There is no rule in the front as in the other specimens of this group.

FRONT

Unlike the crown of the previous two astrolabes, the crown here is quite plain without any lobes in the profiles. At the base are two circular projections on each side, at the top a circular finial with a hole, through which the suspension mechanism passes.

But scale on the rim imitates the rim of the previous two astrolabes with three bands and is numbered in the same fashion serially from 1 to 60, starting at the east point and proceeding in counter-clock direction. The altitude circles, azimuth arcs and the lines for seasonal and equal hours are drawn in the same style.

RETE

The rete is also designed in the same fashion with four rings held together by the complete equinoctial and solstitial bars which are without counter change. But unlike in the previous two astrolabes, there are 37 star pointers which are listed below.

Table D030-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Machodara*	*Matsyodara*	β Andromedae
3	*Samudrapakṣīpṛṣṭha*[870]		π Ceti
4	*samudra.dvi.pṛ.*?		?

[870] This name, *Samudrapakṣī-pṛṣṭha* (back of the sea bird) occurs here for the first time and may refer to *Ṣadr al-qayṭus* (the breast of Cetus, π Ceti).

5	*Aśvanī*	*Aśvinī*	β Arietis
6	*Samudra.pa.pucha*[871]	*Samudrapakṣī-puccha* !	γ Ceti
7	*Rohiṇī*		α Tauri
8	*Bramahṛdaya*	*Brahma-hṛdaya*	α Aurigae
9	*Mi.vā.ha.*	*Mithuna-vāma-hasta*	γ Orionis
10	*Mi.vā.pāda*	*Mithuna-vāma-pāda*	β Orionis
11	*Mṛgaśi*	*Mṛgaśirā*	λ Orionis
12	*Prajāpa*	*Prajāpati*	δ Aurigae
13	*Mi.da.mā.*	*Mithuna-dakṣiṇa-pāda*	κ Orionis
14	*Ārdrā*		α Orionis
15	*Lubdhaka*		α Canis Majoris
16	*Lu.badhu*	*Lubdhaka-bandhu*	α Canis Minoris
17	*Aśleṣā*		ζ Cancri
18	(not named)	*Maghā*	α Leonis
19	*Mahāpurupa*	*Mahāpuruṣa*	α Hydrae
20	*Kratu*		α Ursae Majoris
21	*Pū.phā.*	*Pūrva-phālgunī*	δ Leonis
22	*U.phā.*	*Uttara-phālgunī*	β Leonis
23	*Hasta*		δ Corvi
24	*Vasiṣṭha*		ζ Ursae Majoris
25	*Citrā*		α Virginis

871 *Samudrapakṣī-puccha* (tail of the sea bird). But *Samudrapakṣī* itself indicates the southern tip of the tail, while the northern tip is designed as *Uttara-samudrapakṣī.* Therefore the star named here as *Samudrapakṣī-puccha* might in fact be the mouth of the sea bird (*fam al-qayṭus,* γ Ceti).

26	*Marīci*		η Ursae Majoris
27	*Svāti*		α Bootis
28	*Viśākhā*		α Librae
29	*Vi.mātr.*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
30	*Sarpagrīvā*		α Serpentis
31	*Anurādhā*		δ Scorpii
32	*Abhijit*		α Lyrae
33	*Śravaṇa*		α Aquilae
34	*Dhaniṣṭa*	*Dhaniṣṭhā*	β Delphini
35	*Kukuṭapucha*	*Kukkuṭa-puccha*	α Cygni
36	*Śatabhiṣā*		λ Aquarii
37	*Pū.bhādra.*	*Pūrva-bhādrapadā*	β Pegasi
37	*Uttarā.bhā.*	*Uttara-bhādrapadā*	γ Pegasi

Back

No information is available about the back.

D031 SILVER ASTROLABE FOR LATITUDE 26°, NOT SIGNED, NOT DATED[872]

20th century, Jaipur

Diameter 317 mm

PLU; ex-Time Museum, Rockford



Figure D031.1 – Front View of Astrolabe (courtesy Sotheby's)

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872 Based on detailed photos kindly provided by Sotheby's, London.

This large silver astrolabe is quite different from the preceding three specimens and is modelled on astrolabes produced in Kuchaman which will be discussed in a following section. In particular, the rete of the present astrolabe has a remarkable similarity with the rete in C035, a large (d. 304) and heavy 6-plate Sanskrit astrolabe now in a private collection in France. Obviously the maker of this silver astrolabe had a Kuchaman astrolabe as his model. The astrolabe is neatly made, the geometrical lines are drawn accurately, and the legends and numbers are engraved almost correctly. The numerals bear close resemblance to modern printed characters.

COMPONENTS

Plate with crown (d. 317, h. 383), shackle, ring, rete for 25 stars, alidade without sights, pin and wedge.

FRONT

The high crown is lobed and scalloped. The degree scale on the rim is divided in 1° and in 6°. Groups of 6° are numbered serially from 1 to 15, separately in each quadrant, starting from the east and west points and reaching up to the south and north points as 1—15; 15—1; 1—15; 15—1.

On the plate are drawn south-north and east-west lines, and the concentric circles representing the Tropic of Capricorn, the celestial equator, and the Tropic of Cancer. Altitude circles are drawn for each 2°, and azimuth arcs for each 4° above the horizon and for each 2° below the horizon. Lines for unequal hours are drawn as continuous arcs from the centre. However, none of these three sets of lines is labelled. The plate is calibrated for the latitude of 26° but there is no label displaying this value.[873]

RETE

The three rings of Capricorn, equator and ecliptic are held together by the equinoctial bar with two counter changes, both on the west. The lower segments of the equinoctial ring and the ring of Capricorn are joined together by three X shaped ornate

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873 It is difficult to say whether the choice of this latitude 26° was deliberate or accidental; probably the latter. The model for this astrolabe emanates from Kuchaman whose latitude is 27°. Jaipur, where the silver astrolabes are most probably produced, is also situated on the same latitude of 27°.

supports which appear in the astrolabes made by Lakṣmīnārāyaṇa at Kuchaman. The support in the middle has a different design, matching with the arches under the eastern and western ends of the east-west bar. A similar arch joins the rings of the equator and the ecliptic in the upper half. In the middle of the X-shaped support to the left in the lower half, there is a handle to rotate the rete around the centre.



Figure D031.2 – Rete of the Astrolabe (photo courtesy Sotheby's)

The ecliptic is divided into 12 signs and labelled with their names; each sign is divided into groups of 6° and numbered; the bevelled edge of the ecliptic ring is graduated in 1°. There are 22 curved dagger-shaped star pointers. The following is roughly the sequence in increasing order of right ascension.

Table D031-1 Stars on the Rete

	Star Names as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Siṃha-hṛdaya* (sic!)	*Matsyodara*	β Andromedae
3	*Aśvinī*		β Arietis
4	*Bharaṇī*		41 Arietis
5	*Manuṣyapakṣī*	*Manuṣyapārśva*	α Persei
6	*Rohiṇī*		α Tauri
7	*Mi.vā.pā.*	*Mithuna-vāma-pāda*	β Orionis
8	*Vrahmahṛdaya*	*Brahma-hṛdaya*	α Aurigae
9	*Ārdrā*		α Orionis
10	*Lubdhaka*		α Canis Majoris
11	*Ni.pā.*	*Prajāpati* ?	δ Aurigae ?
12	*Lubdhabaṃdhu*	*Lubdhaka-bandhu*	α Canis Minoris
13	*Mahāpuruṣa*		α Hydrae
14	*Hastā*	*Hasta*	δ Corvi
15	*Ja.phā.*	*Uttaraphālgunī*	β Leonis
16	*Citrā*		α Virginis
17	*Marīci*		η Ursae Majoris
18	*Svāti*		α Bootis
19	*Sarghothīvā*	*Sarpagrīvā*	α Serpentis
20	*Abhijit*		α Lyrae
21	*Śravaṇa*		α Aquarii
22	*Kurkaṭapucha*	*Kukkuṭapuccha*	α Cygni

	Star Names as engraved	Full/Correct Form	Identification
23	*Aśvamukha*		ε Pegasi
24	*Śatabhiṣā*		λ Aquarii
25	*Pūrvābhādrapata*	*Pūrva-bhādrapadā*	β Pegasi

Besides these 25 star names, 5 more are engraved on the rete without the corresponding pointers: *Kṛti* (sic! *Kṛttikā,* η Tauri), *Ci.pu.pu.ta.* (sic! *Punarvasu,* β Geminorum), *Pū[rva]phā[lgunī]* (δ Leonis.), *Viśākhā* (α Librae), *Anurādhā* (δ Scorpii).

BACK

On the back, the degree scale on the rim is divided in 1° and in 6°. In the upper half groups of 6° are numbered separately for each quadrant from 6 to 90, starting respectively from the east and west points and reaching the south point. The upper left quadrant contains a sine-cosine graph with 30 horizontal and 30 vertical parallels. The upper right is occupied by a solar quadrant with axial scales and associated quarter circles for each 6° of solar longitude, labelled from the winter solstice to the summer solstice on the vertical axis and from the summer solstice to the winter solstice on the horizontal axis.

The two lower quadrants contain shadow squares, on the left for the gnomon of 12 digits, and on the right for the gnomon of 7 digits. The scales are divided respectively into 12 or 7 units and numbered accordingly; these units are further subdivided into 6 parts each. The vertical scale on the left carries the label *dvādaśāṃgula-vilomachāyā* (umbra versa of [the gnomon of] 12 digits) and the horizontal scale *dvādaśāṃgula-samachāyā* (umbra recta of [the gnomon of] 12 digits); the horizontal scale on the right is designated as *satpāṃgula-samachāyā* (umbra recta of [the gnomon of] 7 digits) and the vertical scale *satpāṃgula-vilomachāyā* (umbra versa of [the gnomon of] 7 digits).

ALIDADE

An alidade is pivoted to the centre on the back. Its right and left halves are divided into 30 parts each and numbered accordingly from the centre. The maker failed to add

sights to the alidade; consequently it is non-functional. A pin and wedge hold the parts together.

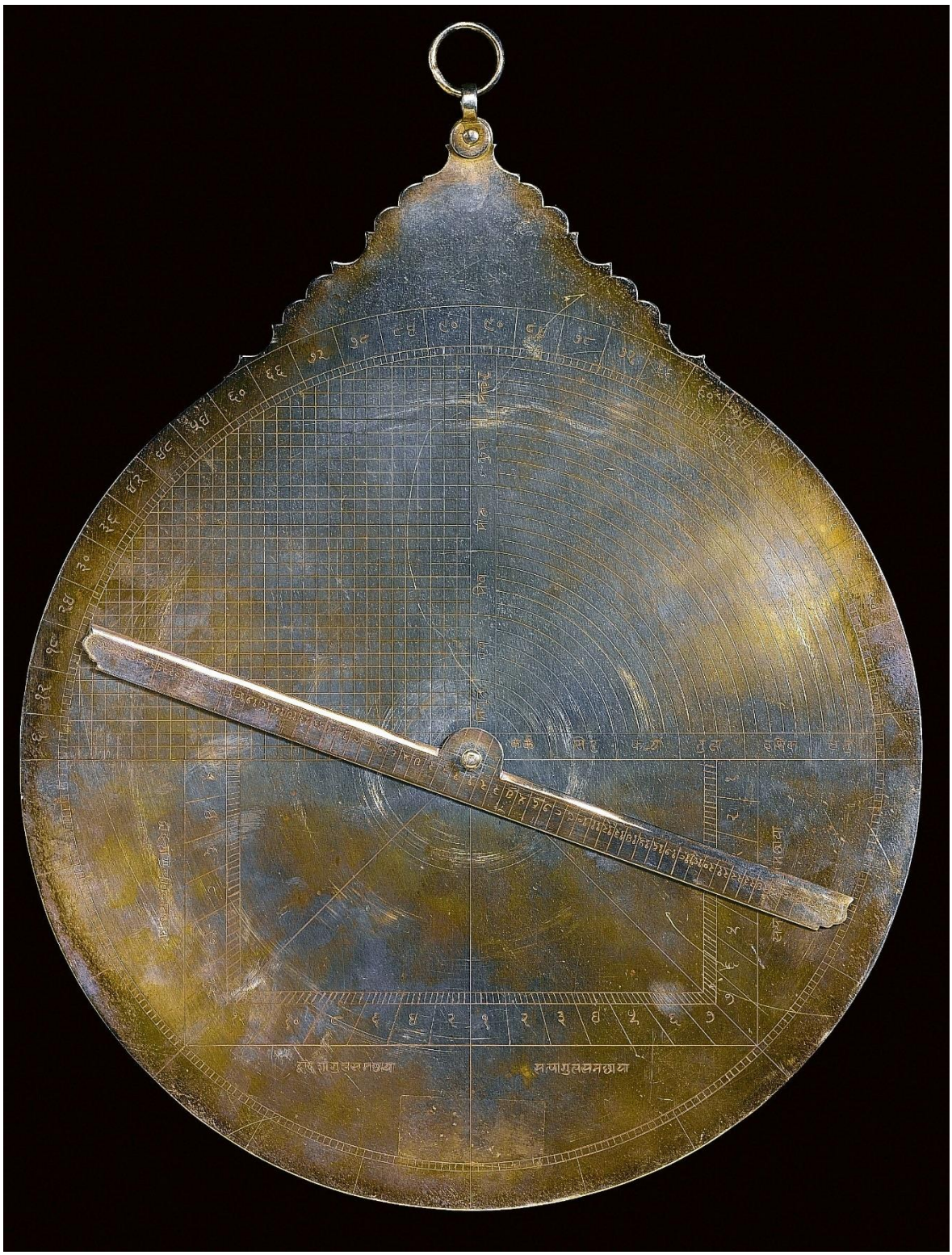


Figure D031.3 – Back of the astrolabe (courtesy Sotheby's)

PROVENANCE

It was formerly in the collection of the Time Museum, Rockford, Ill, USA (inventory no. 1752) and described in Turner 1985. After the dissolution of this museum, the astrolabe changed hands and came up for auction at Sotheby's of London in 2007. Its present location is not known.

BIBLIOGRAPHY

Turner 1985, no. 14, pp. 118-119.

Sotheby's, London, *Arts of the Islamic World, including Fine Carpets and textiles*, auction catalogue of 24 October 2007, item 201, pp. 192-195.

D032 SILVER ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED[874]

20th century, Jaipur, Rajasthan

Diameter 360 mm

PLU



Figure D032.1 – Front of the astrolabe (photo from Linton 1980)

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874 Entry based on the photos in Linton 1980, no. 231, pp. 185-187.

This is a large (d. 360 mm) and heavy (4.580 kg) silver astrolabe with a table of the limits of zodiac signs and a horary quadrant engraved on the back. Tables of limits are engraved on the backs of many Indo-Persian astrolabes, [875] but this is the only Sanskrit astrolabe bearing such a table. There are a few examples of Sanskrit horary quadrants,[876] but this is the only Sanskrit astrolabe with a horary quadrant. It is unlikely that the astrological tables and horary quadrant on the back were introduced for the first time by the maker of the silver astrolabe in the 20th century. Most probably this silver astrolabe is a copy of an earlier brass astrolabe which has not come to light so far.

COMPONENTS

Plate with crown (d. 360), shackle and ring, rete, alidade with sighting tube, pin and wedge.

FRONT

The crown is rather small; each profiles is made up of a large ogee at the base followed by three small lobes. The shackle and ring are plain. Are drawnOn the front of the crown is engraved ‖*śakti*‖ meaning ‘energy’ or ‘energy personified as goddess.’ The degree scale on the rim is divided in ½°, 1° and in 6°. The groups of 6° are numbered only in the upper half, from 6 to 90, separately for each quadrant, starting from the east and west points and reaching up to the south point.[877] In the lower half the cells are blank.

Inside the degree scale are drawn the east-west and north-south diameters and the concentric circles of equator and Cancer are drawn. The maker wanted to draw altitude circles for every 2°, but managed to draw only 40 circles above the local horizon, with every third circle highlighted with dots.[878] These circles are numbered in 6s on both sides of the meridian. Azimuth arcs are drawn above and below for every 6°. Lines for

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875 Cf. Introduction to A, 2.6.4.2; Kaye 1918, p. 125; Sarma 2003, p. 49.

876 See section K on Sanskrit quadrants.

877 This is usually the style of numbering the altitude scales on the back.

878 Linton 1980, p, 185, states that altitude circles are drawn for every 3°. Then only 30 would have sufficed and not 40!

seasonal hours are drawn in the lower half. Neither the azimuth arcs nor the hour lines seem to have been numbered.

At the middle of the plate, just below the line of local horizon, there is an inscription in two lines which is partly blocked by the rete. It commences with *a* in the first line and with the numeral 6 in the second. Possibly the first line reads *akṣabhā* and the second *6/6* (midday equinoctial shadow 6;6) which is valid for the latitude 27°. The Linton catalogue and the Drouot catalogue of 1982 merely say that the plate is calibrated for 27°.

RETE

The rete consists of three rings of Capricorn, equator and ecliptic which are almost complete. These are held together by the equinoctial bar without any counter change. A segment of the solstitial bar joins the central disc to the ecliptic ring below.

The ecliptic ring is divided into the 12 zodiac signs and labelled. Each sign is divided into five parts and numbered in 6s. There are 29 flame-shaped star pointers of which only 20 are named.

Table D032-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Nahar kā tārā 14*[879]	*Nadyantaka*	θ Eridani
2	*Rohiṇī*		α Tauri
3	*Brahmahṛda*	*Brahma-hṛdaya*	α Aurigae
4	*Mithunavāmapāda*		β Orionis
5	*Prajāpati*		δ Aurigae
6	*Ārdrā*		α Orionis
7	*Lubdhaka*		α Canis Majoris
8	*Lubdhakabaṃdhu*	α Canis Minoris	

879 *Nahar kā tārā* (star of the river) is Hindi, the Sanskrit name being *Nadyantaka.* The number 14 after the name is inexplicable.

	Star Name as engraved	Full/Correct Form	Identification
9	*Mahāpuruṣa*		α Hydrae
10	*Maghā*		α Leonis
11	*Pū.bhā.* (sic!)	*Pūrva-phālgunī*	δ Leonis
12	*Citrā*		α Virginis
13	*Marīca*	*Marīci*	η Ursae Majoris
14	*Svāti*		α Bootis
15	*Viśāsāmātṛmadala*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
16	*Sarpadhārīśira*		α Ophiuchi
17	*Abhijit*		α Lyrae
18	*Śravaṇa*		α Aquilae
19	*Śatabhiṣā*		λ Aquarii
20	*Pū.bhā.*	*Pūrva-bhādrapadā*	β Pegasi

BACK

The degree scale on the rim of the back is as in the front. As in the front, here also the circles of equator and the Tropic of Cancer also drawn. In the upper left quadrant is engraved a sine-cosine graph with 60 horizontal and 60 vertical parallels. In the upper right is a solar quadrant with axial scales and 30 declination circles, one for each 6° of solar longitude, labelled from the winter solstice to the summer solstice on the horizontal axis and from the summer solstice to the winter solstice on the vertical axis. A horary quadrant is also drawn in this quadrant.

In the lower half are drawn shadow squares. The square on the left is for the gnomon of 12 digits. Here the vertical and horizontal scales are each divided into 12 parts and numbered accordingly and each part is further subdivided into 5 divisions. Along the vertical scale is engraved the label *dvādaśāṃgulaśaṃkor vilomachāyā* (umbra

versa of the gnomon of 12 digits), and below the horizontal scale the label *dvādaśāṃgulaśaṃkoḥ samachāyā* (umbra recta of the gnomon of 12 digits).

The shadow square on the right is for the gnomon of 7 digits. Here the vertical and horizontal scales are divided into 7 units each and numbered accordingly and each unit is further subdivided into 7 parts. Below the horizontal scale is engraved the label *saptāṃgulaśaṃkoḥ samachāyā* (umbra recta of the gnomon of 7 digits) and along the vertical scale the label *saptāṃgulaśaṃkor vilomachāyā* (umbra versa of the gnomon of 7 digits).

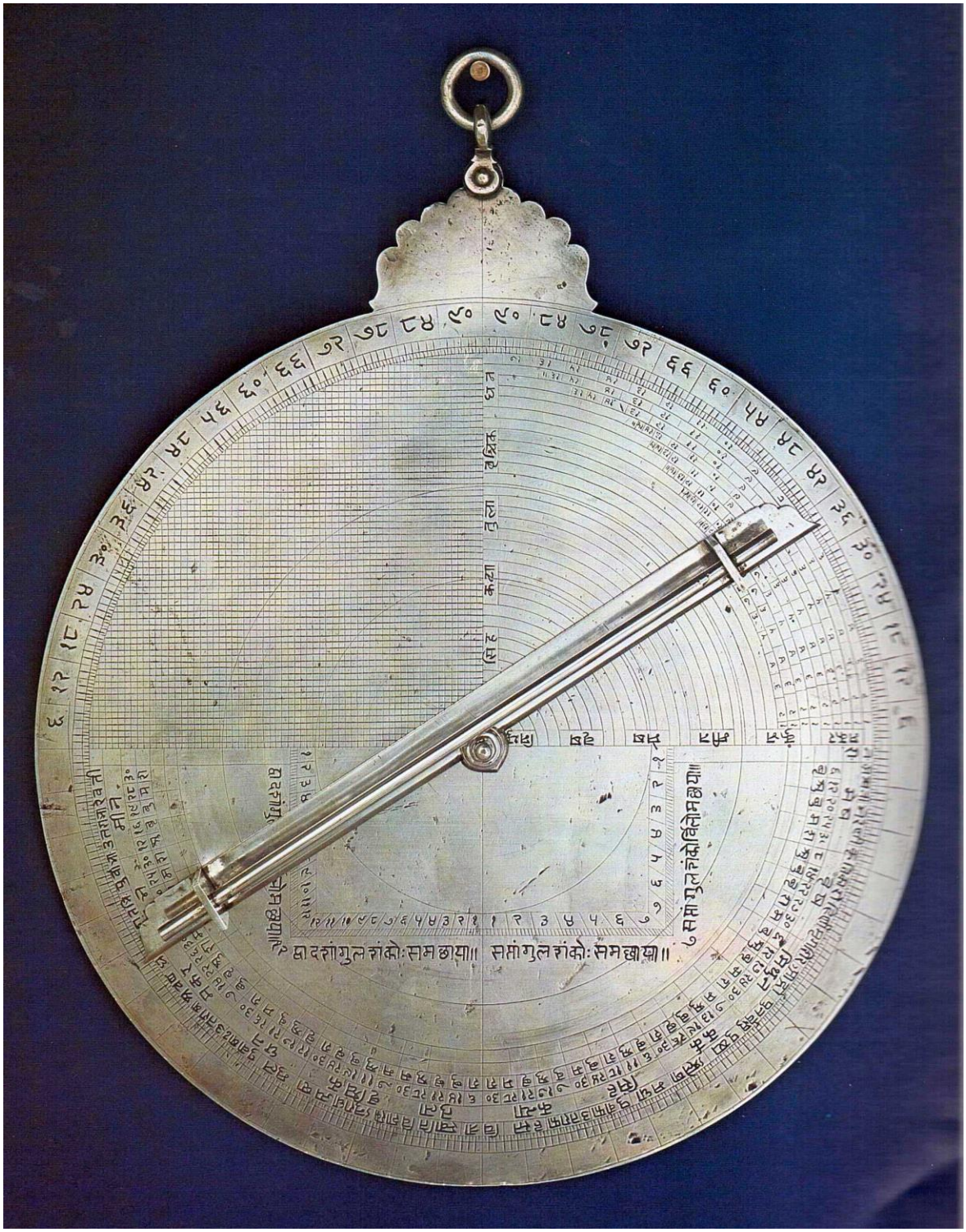


Figure D032.2 – Back of the astrolabe (photo from Linton 1980)

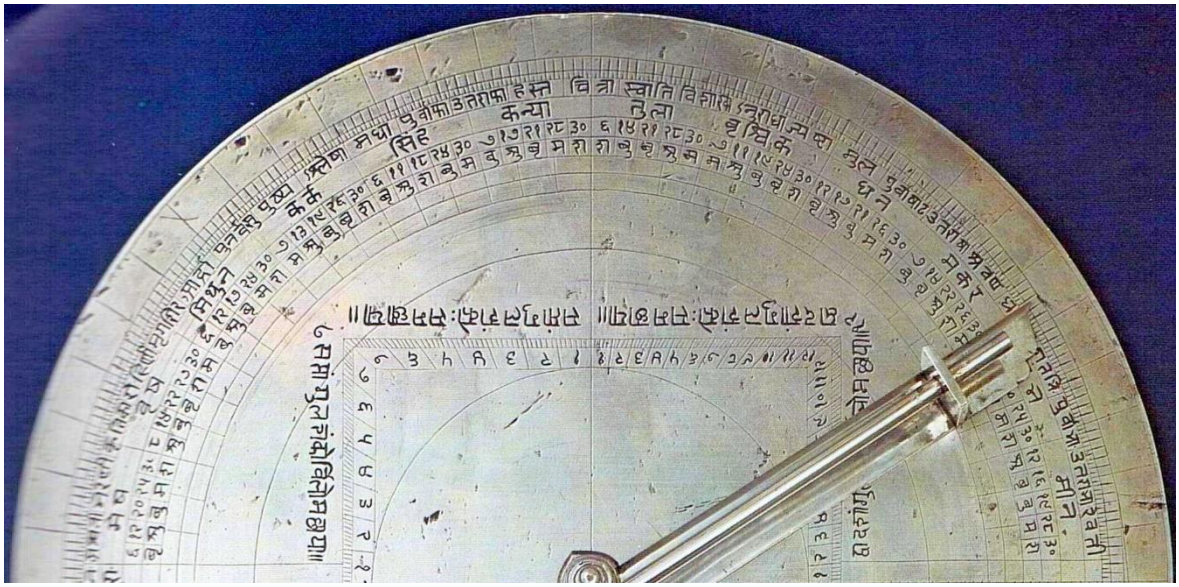


Figure D032.3 – Astrological Tables on the Back (Detail from Figure D032.2)

ASTROLOGICAL TABLES ON THE BACK

Around the shadow tables in the lower half are drawn six semi-circular rows, but the two inner rows are not filled in. The second row from the outside is divided into 12 zodiac signs and filled with their names. The first row contains the names of the corresponding lunar mansions. The names are generally engraved in full; the names which contain the prefixes *pūrva°* and *uttara°* are abbreviated. Interestingly in *Aśleṣā* and *Anurādhā,* the initial *a* is replaced by the *avagraha* sign.

The third and fourth semi-circular rows contain a table of the limits or terms of the signs, which are called *ḥudūd* in Arabic and *haddās* in Sanskrit *Tājikā* astrology.[880] Here the 30 degrees of each sign are divided into 5 parts and each part is assigned to a planet other than the sun and moon. In these tables usually in each cell the individual strength of the planet concerned is given, but the present table shows the cumulative strength of a particular planet and the strength of the preceding planets.[881] Thus the distribution of the *haddās* of Aries is shown as follows: 6 Jupiter, (6 + 6 =) 12 Venus, (6+6+8 =) 20 Mercury, (6+6+8+5 =) 25 Mars, (6+6+8+5+3 =) 30 Saturn.

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880 I am grateful to Dr Martin Gansten for this information.

881 See, for example, Table A003-5.

Table D032-2 Limits of the Signs

Aries	6 Jupiter	12 Venus	20 Mercury	25 Mars	30 Saturn
Taurus	8 Venus	14 Mercury	22 Jupiter	27 Saturn	30 Mars
Gemini	6 Mercury	12 Venus	17 Jupiter	24 Mars	30 Saturn
Cancer	7 Mars	13 Venus	19 Mercury	26 Jupiter	30 Saturn
Leo	6 Jupiter	11 Venus	18 Saturn	24 Mercury	30 Mars
Virgo	7 Mercury	17 Venus	21 Jupiter	28 Mars	30 Saturn
Libra	6 Saturn	14 Mercury	21 Jupiter	28 Venus	30 Mars
Scorpio	7 Mars	11 Venus	19 Mercury	24 Jupiter	30 Saturn
Sagittariuds	12 Jupiter	17 Venus	21 Mercury	26 Mars	30 Saturn
Capricorm	7 Mercury	14 Jupiter	22 Venus	26 Saturn	30 Mars
Aquarius	7 Venus	13 Mercury	20 Jupiter	25 Mars	30 Saturn
Pisces	12 Venus	16 Jupiter	19 Mercury	28 Mars	30 Saturn

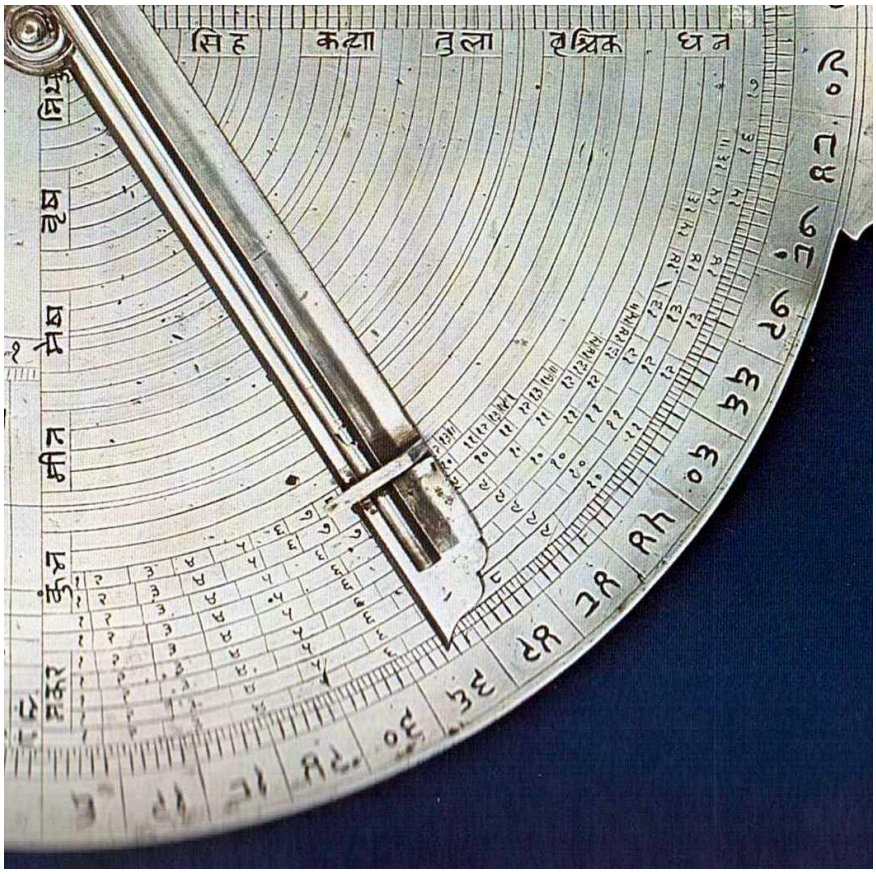


Figure D032.4 – The Horary Quadrant in the Upper Right Quadrant (Detail from Figure D032.2)

HORARY QUADRANT

In the solar quadrant in the upper right is incorporated a horary quadrant with nine scales to be used in different seasons. In the last cell of each scale is written the duration of the half day in *ghaṭīs*. The values in the second to the ninth scale are: 13 ½, 14 ¼, 14 ½, 15, 15 ½, 16, 16 ½, 17. The value in the first, i.e., the innermost, scale is blocked by the alidade in the photo. It is likely to be 13. These nine scales can be used for the six months from the winter solstice to summer solstice; the same scales can be used in the reverse order for the six months from summer solstice to winter solstice. At winter solstice, the duration of half the day is 13 *ghaṭīs*; the length of the full day is 27 *ghaṭīs* or 10 hrs 48 min. At summer solstice, the duration of half day is 17 *ghaṭīs*; then the day-length is 34 *ghaṭīs* or 13 hrs 36 min.

PROVENANCE

Came up for auction at Paris in 1980 along with Linton's collection; and again in 28 April 1982 in the Nouveau Drouot auction. Its present location is not known.

ASTROLABES FOR LATITUDE 27° MADE AT KUCHMAN

Kuchaman (27;10° N, 74;52° E) has been a small princely estate (ṭhikānā) in Rajasthan and its ruler bore the title Ṭhākur. It is some 120 km north-west of Jaipur (26;54° E, 75;48° N) and situated roughly on the same latitude 27° as Jaipur. It became a major centre of production of Sanskrit astrolabes and other instruments in the nineteenth century, either through the patronage of the rulers or through the initiative of certain astronomers.

The earliest dated instrument produced here (D033) is dated 1813. About the same time was produced also D034. The last dated astrolabe (D037) was made in 1903. Between these two dates were produced several astrolabes and other instruments at Kuchaman.

Astrolabe D034 is the most ornate specimen of the Sanskrit astrolabes with single plates. The unknown astrolabe maker of Kuchaman designed the crown very elegantly in form of a stylized lotus. In the rete, he connected the equator ring by means of ornate bridges with the ecliptic ring in the south and with the Capricorn ring in the north.

These decorative features were copied in several astrolabes and thus distinguish the astrolabes produced at Kuchaman from others. Among these, the four astrolabes (D036, D037, D038 and D039) produced around the close of the nineteenth century deserve special mention. Three of these were designed by the astronomer Jayakṛṣṇadāsa and one by his son Haridatta, but all the four were fabricated by the artisan Lakṣīnārāyaṇa. The obverse sides of these four astrolabes are designed for the latitude of 27°; for some unknown reason, the reverse side is also engraved with altitude circles, not for 27°, but for 18°. Besides this strange and inexplicable anomaly, they share the same characteristics in the design of the crown and rete with the other astrolabes of Kuchaman.

D033 ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED, WITH STAR POSITIONS MARKED ON THE PLATE[882]

1813, Kuchaman, Rajasthan

Diameter 203 mm

Washington DC, PC

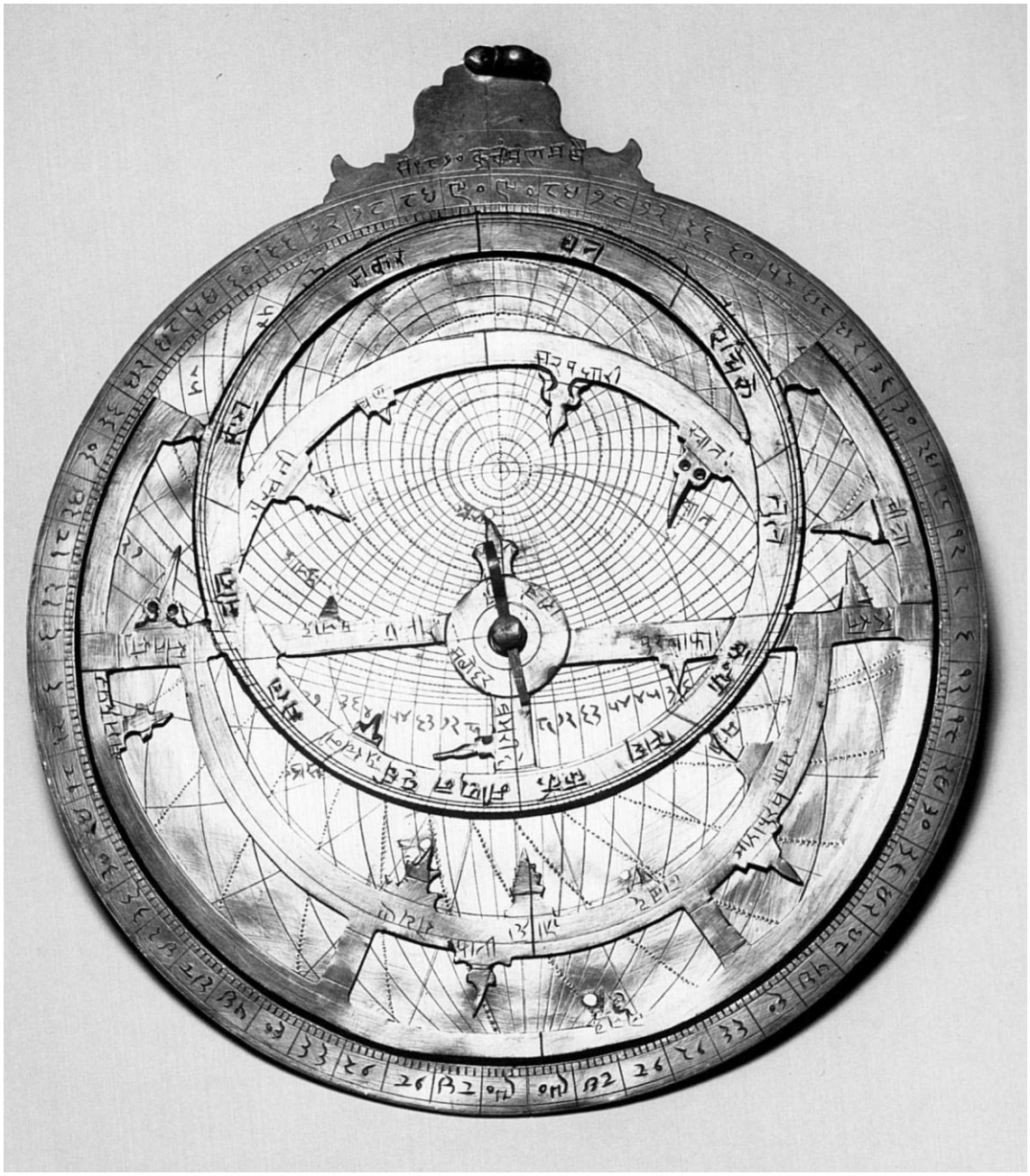


Figure D033.1 – Front of the astrolabe (courtesy the owner)

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[882] Entry based on photos kindly provided by the owner.

On the crown of this instrument is engraved *saṃ. 1870 Kucaṃmaṇa-madhyai,* 'VS 1870 = AD 1813-1814, at Kuchaman'. Thus it is the earliest dated astrolabe made at Kuchaman which is extant. It does not have any of the characteristic features of the Kuchaman astrolabes which developed subsequently in this town. The style of the crown and the style of the inscription resemble the same in two astrolabes made at Jodhpur D049 and D050). It is apparently made out of a rather thin sheet of brass; the engravings on the front side have left strong impressions on the back. Though rete carries 22 named star pointers, the positions of 9 stars are shown on the plate with inlaid silver nails.

COMPONENTS

Plate (d. 203) with crown and shackle, rete for 22 stars, alidade with a sighting tube, pin and wedge.

FRONT

The crown has two lobes and one scallop on each profile and there are projections resembling tiger's claws at the base on either side. The shackle has a trifoliate shape. The degree scale on the rim is divided in 1° and 6° and numbered in 6s separately for each quadrant as 6—90; 90—6; 6—90; 90—6. The inner periphery of the scale constitutes the Tropic of Capricorn. Inside this are drawn the circles of equator and that of the Tropic of Cancer.

Altitude circles are drawn for each 3° and every third circle is highlighted with dots. These are not numbered.

Azimuth arcs are drawn for each 9° above and below the horizon. These are numbered just below the horizon line and above the horizon all along the periphery. In the lower half, lines are drawn for seasonal hours and equal hours (dotted) counted from the western horizon. But these are not numbered.

Below the local horizon is engraved *27 chai 6 5.* This would mean that the altitude circles are drawn for the latitude of 27° where the midday equinoctial shadow (*chai,* corrupt for *chāyā,* 'shadow') is 6;5.

Most unusual is the fact that silver pins are inlaid on the surface of the plate to indicate the positions of nine stars with their names engraved next to them. The points have been hammered from the front side of the plate and where they projected outside of the surface at the back, there were cut off flush with the surface of the back. Therefore

in the photo of the back of the astrolabe, these nine bright points can be seen. The names are very carelessly engraved. These positions practically correspond to those on the rete when the rete is at rest, i.e. at the zero point.

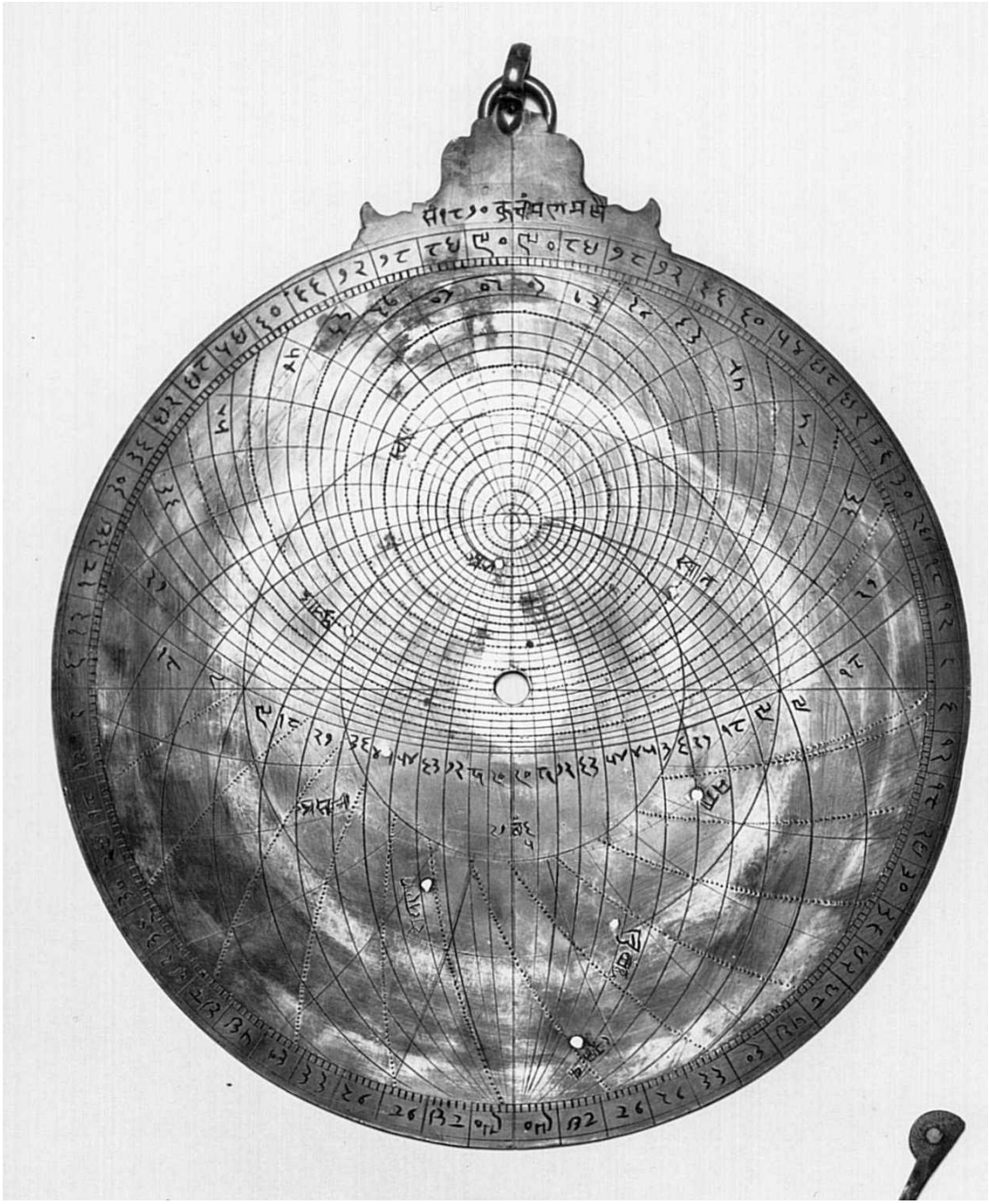


Figure D033.2 – Star Positions marked on the Latitude Plate (courtesy the Owner)

Table D033-1 Stars on the Plate

	Star Name as engraved	Full/Correct Form	Identification
1	*Asvinī*	*Aśvinī*	β Arietis

	Star Name as engraved	Full/Correct Form	Identification
2	*Royaṇī*	*Rohiṇi*	α Tauri
3	*Lubdhaka*		α Canis Majoris
4	?	*Lubdhaka-bandhu*	α Canis Minoris
5	*Maghā*		α Leonis
6	*Svāta*	*Svāti*	α Bootis
7	*Abha*	*Abhijit*	α Lyrae
8	*Svaṇa*	*Śravaṇa*	α Aquilae
9	*Pū.bhādra*	*Pūrva-bhādrapada*	β Pegasi

RETE

The three rings of the Tropic of Capricorn, equator and ecliptic are held in place by the equinoctial bar which has a counter change at the centre. In the lower half, two straight bars, placed asymmetrically on either side of the meridian join the rings of the equator and that of the Tropic of Capricorn. A segment of the solstitial bar joins the central ring with the lower part of the ecliptic ring. The ecliptic ring is divided into the 12 signs of the zodiac and filled with the names of the signs very carelessly. The signs are not further subdivided, which is most unusual. There are 22 named star pointers.

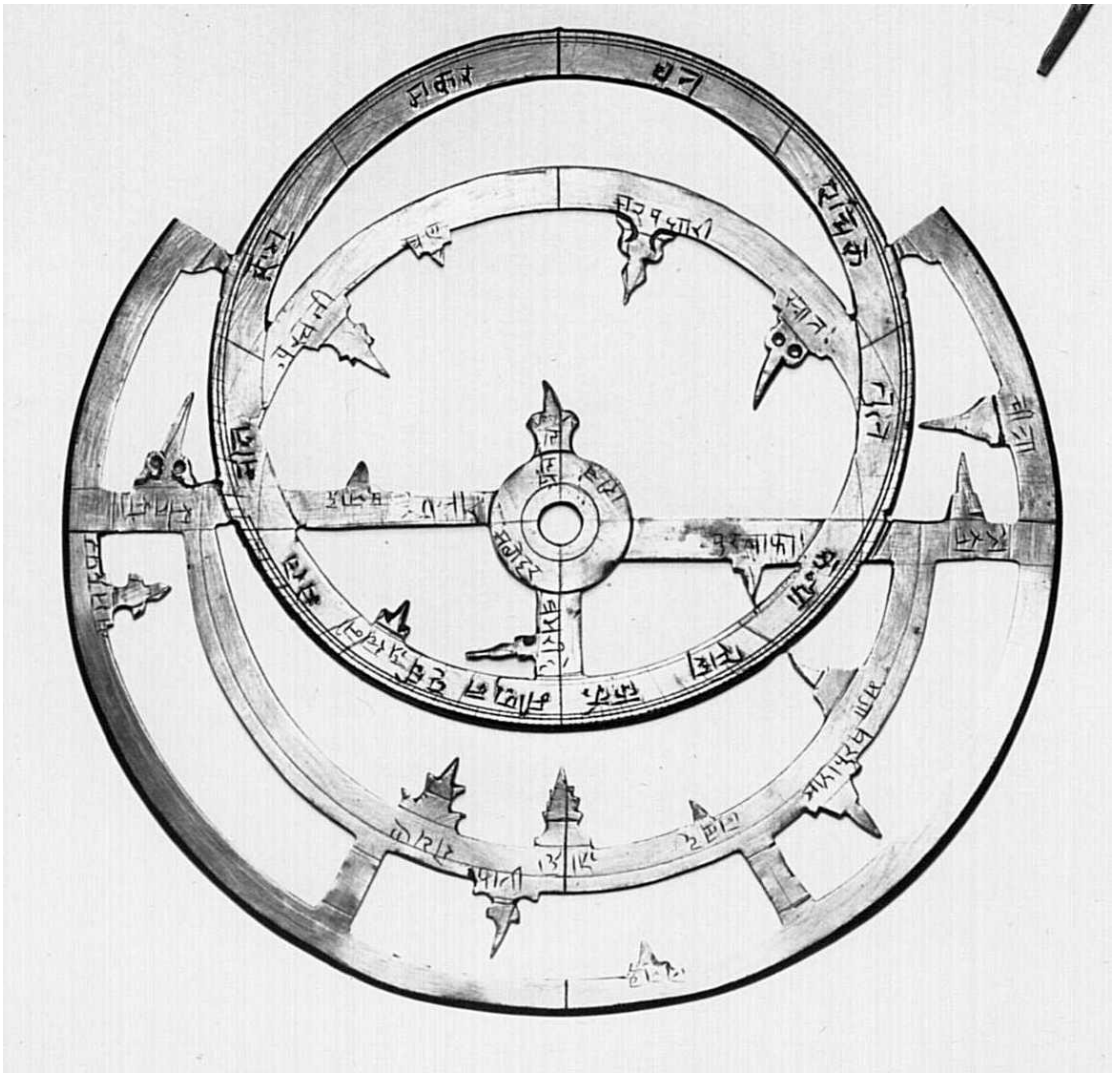


Figure D033.3 – Rete of the astrolabe (photo courtesy the owner)

Table D033-2 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samadrapara*	*Samudrapakṣī*	β Ceti
2	*Machodara*	*Matsyodara*	β Andromedae
3	*Asvanī*	*Aśvinī*	β Arietis
4	*Royaṇa*	*Rohiṇī*	α Tauri
5	*Bramarīde*	*Brahmahṛdaya*	α Aurigae
6	*Pātī*	*Mithuna-vāma-pāda*	β Orionis
7	*Ādrā*	*Ārdrā*	α Orionis

	Star Name as engraved	Full/Correct Form	Identification
8	(indecipherable)	*Lubdhaka*	α Canis Majoris
9	*Lubada*	*Lubdhakabandhu*	α Canis Minoris
10	*Māhāpuraṣa*	*Mahāpuruṣa*	α Hydrae
11	*Magā*	*Maghā*	α Leonis
12	*Purabāphā*	*Pūrva-phālgunī*	δ Leonis
13	*Harasta*	*Hasta*	δ Corvi
14	*Cītrā*	*Citrā*	α Virginis
15	*Svātaḥ*	*Svāti*	α Bootis
16	*Marīca*	*Marīci*	η Ursae Majoris
17	*Sarapadhārī*	*Sarpadhārīśira*	α Ophiuchi
18	*Abhaca*	*Abhijit*	α Lyrae
19	*Svaṇa*	*Śravaṇa*	α Aquilae
20	*Asvanī*	*Aśvanābhi*	δ Pegasi
21	*Pūbhādra*	*Pūrva-bhādrapada*	β Pegasi
22	*Satasā*	*Śatabhiṣā*	λ Aquarii

BACK

On the back, the rim of the upper half carries the altitude scales which are divided in 1° and in 6°. Groups of 6° are numbered from 6 to 90, separately for each quadrant, starting from the east and west points and reaching up to the south point.

In the upper left quadrant are projected five lines of unequal hours which are numbered as 6, 12, 18, 24, 30 (?). The upper right quadrant contains a sine-cosine graph with 30 horizontal and 30 vertical parallels. Two quarter circles are drawn at 7 and 12 divisions; the latter represents the obliquity of the ecliptic.

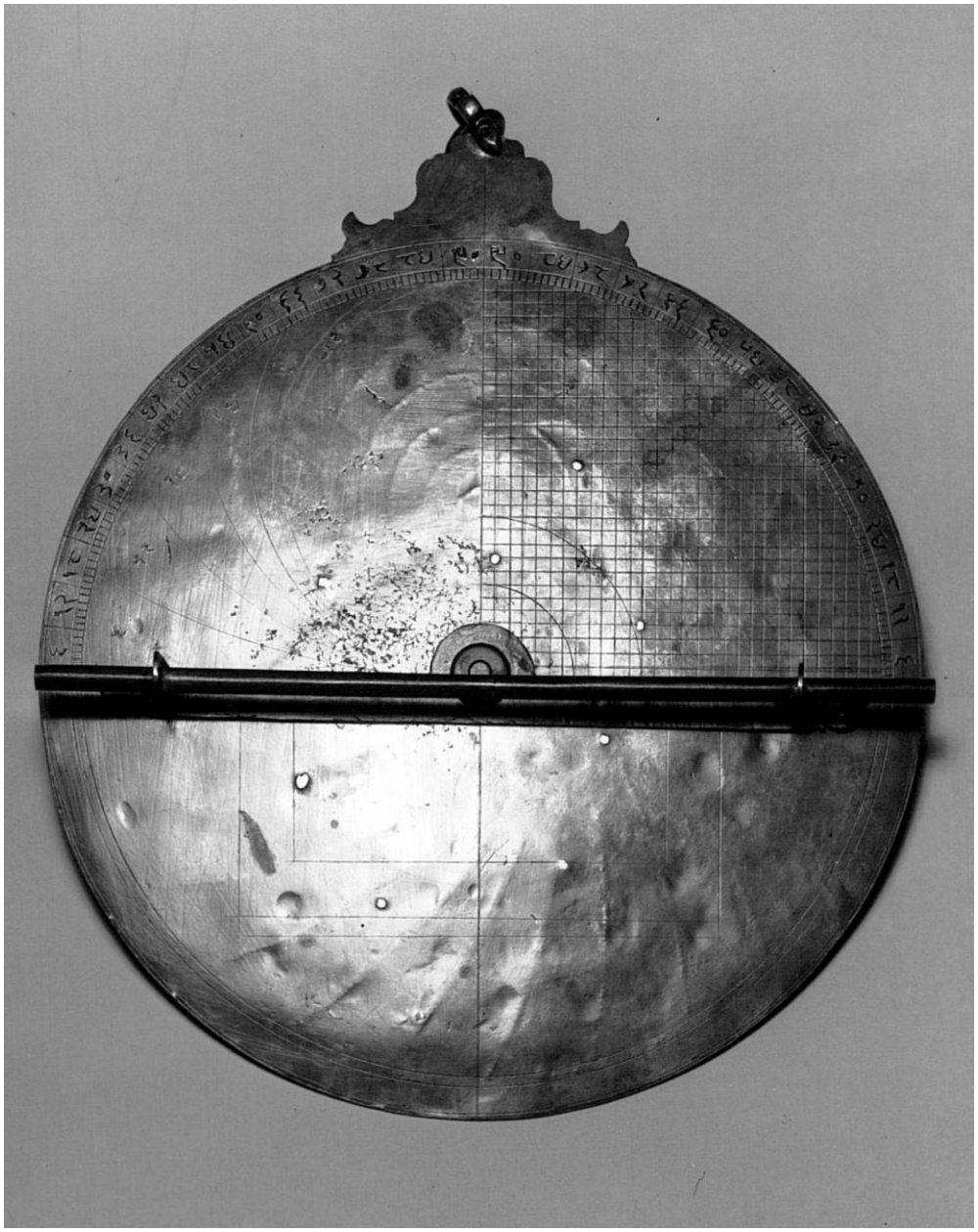


Figure D033.4 – Back of the astrolabe (photo courtesy the owner)

In the lower half, outlines are drawn for two shadow squares, but these are left incomplete, without dividing the scales.

The alidade is equipped with a sighting tube.

D034⊙ ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED[883]

Early 19th century, before 1828, Kuchaman

Diameter 173 mm

London, Victoria & Albert Museum (# IM 409 1924);

CCA 92

This is the first Sanskrit astrolabe to be studied by modern scholarship. William H. Morley described it in his classic work *Description of a Persian Astrolabe constructed for Sháh Husain Safawí* in 1856.[884] Robert H. Gunther treated it as the first Hindu astrolabe in his *Astrolabes of the World,* where he assigned it the number 92.[885] Consequently it bears the CCA no. 92. Morley states that the astrolabe belonged originally to a certain Mrs. Furlong around 1828 and was deposited in the Museum of the Royal Asiatic Society in August 1829 'and about that time submitted to the late Dr. Rosen's inspection, who translated the inscriptions.' After the dissolution (?) of the Museum of the Royal Asiatic Society, the astrolabe was transferred to the Victoria and Albert Museum.

It is a beautifully crafted astrolabe; the crown is reticulated in the form of an inverted lotus flower. This became the characteristic feature of many astrolabes produced subsequently at Kuchaman, although it is nowhere delinately as elegantly as here. The lines and circles are drawn very neatly. Good and generally correct calligraphy of numbers and letters.

COMPONENTS

Plate with crown (d. 173, h. 214, t. 3), shackle and ring, rete (d. 152, t. 2) for 23 stars, alidade with a sighting tube, washer, pin, horse.

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883 Victoria and Albert Museum wrote to say that they do not permit the publication of private photography of their objects. Therefore, this entry is regretfully without my photos of this beautiful astrolabe. Gunther 1932, no. 92, pp. 221-222.

884 Morley 1856, pp. 41-42, plate xxi, fig. 44.

885 Gunther 1932, no. 92, pp. 221-222.

FRONT

The ring and shackle are small and plain. The crown is reticulated in the form of an inverted lotus which encloses an upright flower with five petals, with decorative lines on both sides. The degree scale on the rim is divided in 1° and 6° and numbered in 6s separately for each quadrant as 1-90; 90-1; 1-90; 90-1. Altitude circles are drawn for each 2°, with every fifth (i.e. 10°) highlighted with dots. Azimuth arcs are traced for every 6° below the horizon. In the lower half are the lines for unequal hours. But none of these sets is numbered. The arrangement of the altitude circles shows that the plate is deigned for the latitude of 27° which is the latitude of Kuchaman.[886]

RETE

The rete is rather plain. The three bands of Capricorn, equator and ecliptic held together by the east-west equinoctial bar without any counter-change. The equator ring is counterchanged at its intersection with the ecliptic ring. The ecliptic is divided into 12 signs and labelled as *Meṣa, Vṛṣa, Mithuna, Karka, Siṃha, Kanyā, Tulā, V*[*ṛ*]*ścika, Dhana* (*Dhanus*), *Makara, Kumbha, Mīna.* Each sign is subdivided into 5 units and numbered anticlockwise as 6, 12, .. 30. The rim of the ecliptic ring is divided into single degrees.

There are 23 star pointers (11 outside and 12 inside the ecliptic), generally dagger-shaped; two have the shape of tiger's claw. The stars are listed below in the order of increasing right ascension, starting from the vernal equinox.

Table D034-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Matsyodara*		β Andromedae
3	*Nahari*		γ Eridani
4	*Pretaśira*		β Persei

886 Morley, following him Gunther, states that the plate is calibrated for the latitude of 24° which is not correct.

	Star Name as engraved	Full/Correct Form	Identification
5	*Rohiṇī*		α Tauri
6	*Brahmahṛda*	*Brahmahṛdaya*	α Aurigae
7	*Mithunavāmapāda*		γ Orionis
8	*Ārdrā*		α Orionis
9	*Lubdhaka*		α Canis Majoris
10	*Lubdhakavadhu*	*Lubdhakabandhu*	α Canis Minoris
11	*Mahāpuruṣa*		α Hydrae
12	*Maghā*		α Leonis
13	*Citrā*		α Virginis
14	*Svātī*	*Svāti*	α Bootis
15	*Vi.mātṛmaṇḍala*	*Viśākhā mātṛmaṇḍala*	α Coronae Borealis
16	*Sarpadhārīśira*		α Ophiuchi
17	*Abhijit*		α Lyrae
18	*Śravaṇa*		α Aquilae
19	*Kurkuṭapu*	*Kukkuṭapuccha*	α Cygni
20	*Aśvamukha*		ε Pegasi
21	*Śatajivā*	*Śatabhiṣā*	λ Aquarii
22	*Pūrvābhādrapada*	*Pūrvā Bhādrapadā*	β Pegasi
23	*Uttarābhā*	*Uttarā Bhādrapadā*	γ Pegasi

BACK

The degree scale on the rim is divided and numbered as in the front. The upper left quadrant bears the sine-cosine grid with 30 horizontal and 30 vertical parallels. The arc of obliquity is drawn at the 12th division. The 30 horizontal lines are extended into

the upper right quadrant to form declination circles there. The realted signs are labelled, starting from the centre, along the vertical radius, as *Ka[r]ka, Siṃha, Kanya* (*Kanyā*), *Tula* (*Tulā*), *Vṛśca* (*Vṛścika*), *Dhana* (*Dhanuḥ*), along the horizontal radius as *Mithuna, Vṛṣa, Meṣa, Mīna, Kuṃbha, Maka*[*ra*].

Shadow squares are drawn in the two lower quadrants. On the left for the shadows cast by a gnomon of 7 feet; the 7 divisions are numbered and each division is subdivided into 5 units; the vertical scale carries the label *saptāṃgula-śaṃkoḥ viloma-chāyā* (reverse shadow of the gnomon of 7 digits) and the horizontal scale the label *saptāṃgula-śaṃkoḥ sama-chāyā* (direct shadow of the gnomon of 7 digits). The square on the right is for shadows cast by a gnomon of 12 digits; the 12 divisions are numbered and each division is subdivided into 3 units; here the horizontal scale is accompanied by the label *dvādaśāṃgula-śaṃkoḥ sama-chāyā* (direct shadow of the gnomon of 12 digits) and the vertical scale *dvādaśāṃgula-śaṃkoḥ viloma-chāyā* (reverse shadow of the gnomon of 12 digits).

The alidade is divided into 26 (?) parts on each side; it is fitted with a sighting tube. The wedge is made in form of a small neat horse with its eye clearly marked.

D035⊙ ASTROLABE FOR LATITUDE 27°/18°, DESIGNED BY JAYAKṚṢṆADĀSA, MADE BY LAKṢMĪNĀRĀYAṆA

1887, Kuchaman, Rajasthan

Diameter 220 mm

Jaipur, Shri Sanjay Sharma Museum & Research Institute



Figure D035.1 – Front of the astrolabe (photo by S. R. Sarma)

The iscription on the back informs that this astrolabe was designed by Jayakṛṣṇadāsa and made by Lakṣmīnārāyaṇa at Kuchaman in 1887 for Acaleśvara. Calligraphy is good, but the labels are full of errors. The next three astrolabes are also produced by this Lakṣmīnārāyaṇa and display many common traits.

Components

Plate with crown (d. 220), shackle, ring, rete for 18 stars, alidade with a sighting tube, pin and wdge.

Front

The crown is crudely shaped like an inverted lotus. It is partly broken and attached to the main plate with a supporting strip. The ring and shackle are plain. The degree scale on the rim is divided in 1° and 6° and numbered in 6s clockwise from 1 to 60. Altitude circles are drawn for each 3°; every third line is highlighted with dots. Azimuth arcs are drawn above and below the horizon for every 6°. Unequal hour lines are drawn in the lower half. None of these lines is numbered. The plate is calibrated for the latitude of Kuchaman at 27° but is not so marked.

Rete

The three almost complete rings of the Tropic of Capricorn, celestial equator and the ecliptic are held together by the east-west equinoctial bar with one counter change at the centre. The equator ring is counterchanged at its intersection with the ecliptic ring. In the south the rings of the equator and the ecliptic are connected by an ornate U-shaped bridge. The same shape is joined top to top to form an ornate X-shaped bridge, which is used three times to connect the rings of the celestial equator and the Tropic of Capricorn in the north. The ecliptic ring is much wider than the other rings. It is divided into the 12 signs of the zodiac and labelled but not always correctly. Thus *Tula* (instead of *Tulā*), *Vṛści* (instead of *Vṛścika*) and *Dhana* (instead of *Dhanuḥ*). Each sign is divided into units of 6°, and labelled 6, 12, 18, 24 and 30. The bevelled edge of the ecliptic ring is graduated in single.

There are 18 dagger-shaped (some straight and some curved) star pointers. These are arranged below in the order of increasing right ascension, starting from the vernal equinox.

Table D035-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samurapakṣī*	*Samudra-pakṣī*	β Ceti
2	*Machodara*	*Matsyodara*	β Andromedae
3	(not named)	*Pretaśira*	β Persei
4	*Rohiṇī*		α Tauri
5	*Ārśa*	*Ārdrā*	α Orionis
6	*Lubdhaka*		α Canis Majoris
7	*Lubdhabadhu*	*Lubdhaka-bandhu*	α Canis Minoris
8	*Hasta*		δ Corvi
9	*Cittarā*	*Citrā*	α Virginis
10	*Masvī*	*Marīci*	η Ursae Majoris
11	*Svātī*	*Svāti*	α Bootis
12	*Rāpedhārīśira*	*Sarpadhārīśira*	α Ophiuchi
13	*Abhijit*		α Lyrae
14	*Avaṇa*	*Śravaṇa*	α Aquilae
15	*Kukuṭapuccha*	*Kukkuṭapuccha*	α Cygni
16	*Asamuṣa*	*Aśvamukha*	ε Pegasi
17	*Śatabhiṣā*		λ Aqurii
18	*Pubhāda*	*Pūrva-bhādrapadā*	β Pegasi

BACK

The entire rim is covered by the degree scale which is divided in 1° and 6°. In the upper half, groups of 6° are numbered, separately for each quadrant, from 6 to 90. In the lower half the divisions are not numbered.

The instrument maker first drew altitude circles on this side at intervals of 3° for the latitude of 18°. Abandoning these, he drew altitude circles once again on the other side of the plate for the latitude of 27° and treated that side as the front of the astrolabe. Consequently the upper half of what is now the back contains non-functional altitude circles.

In the lower half are drawn shadow squares, on the left for the gnomon of 12 digits and on the right for the gnomon of 7 digits. The vertical and horizontal parts of the left-hand side square are divided into 12 parts each and numbered accordingly. These carry the following labels:
dvādaśāṃgulasaṃkuvilomachā (sic! *dvādaśāṅgula-śaṅku-vilomachāyā*, 'reverse shadow of the gnomon of 12 digits') and
dvādaśāṃgulasaṃkulomachā (sic! *dvādaśāṅgula-śaṅku-samachāyā*, 'direct shadow of the gnomon of 12 digits').

The vertical and horizontal scales of the square on the right are divided into 7 parts each and numbered accordingly. These are accompanied by the following labels:
saptāṃgulasaṃkuvilomachā (sic! *saptāṅgula-śaṅku-viloma-chāyā*, 'reverse shadow of the gnomon of 7 digits') and
saptāṃgulasaṃkulomachā (sic! *saptāṇgula-śaṅku-sama-chāyā,* direct shadow of the gnomon of 7 digits).[887]

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[887] While the inverse shadow or umbra verse is *viloma-chāyā,* the direct shadow is not *loma-chāyā,* but *sama-chāyā.*



Figure D035.2 – Inscription at the back (photo by S. R. Sarma)

INSCRIPTION

Within the shadow box and below it is engraved the maker's signature which runs thus in 5 lines:

josī jayakṛṣṇadāsajī kṛtaṃ.

uratā (sic! read: *ustā[da]*) *lakṣmīnārāyaṇena yu* (sic! read: *su*) *saṃpāditaṃ.*

paṃ. jyotirvid audīcya mahādevastanu (sic! read: *˚sūnu*)

acaleśvarakasya yaṃtrarāja.

kucāmaṇi.

'Designed (*kṛta*) by the astrologer Jayakṛṣṇadāsa-jī,

well executed (*susaṃpādita*) by the master artisan (*ustād*) Lakṣmīnārāyaṇa.[888]

This *yantrarāja* belongs to Acaleśvara, son of the Audīcya Brahmin, Pandit *Jyotirvid* Mahādeva. [The astrolabe was made in the city of] Kuchaman.'

On the left of the shadow box is written *Saṃ. 1944*, which corresponds to AD 1887-88.

There is an alidade to which a sighting tube was attached; it is somewhat longer than the diameter of the astrolabe.

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888 On this astrolabe maker, see Sarma 2010, s.v. Lakṣmīnārāyaṇa.

D036⊙ ASTROLABE FOR LATITUDE 27°/18° DESIGNED BY JAYAKṚṢṆADĀSA, MADE BY LAKṂĪṆĀRĀYAṆA

1902, Kuchaman, Rajasthan

Diameter 219 mm

Paris, PC



Figure D036.1 – Front of the astrolabe (photo by S. R. Sarma)

Like the previous astrolabe, this one also is designed by the same Jayakṛṣṇadsa and fabricated by the same Lakṣmīnārāyaṇa for the same patron Acaleśvara, but after a gap of 15 years.

COMPONENTS

Plate with crown (d. 219, h. 258, t. 1.5), shackle and ring, rete (d. 200) for 19 stars, alidade with a sighting tube, pin, washer. The wedge is missing; a crude piece of iron is used in its place.

FRONT

The reticulated crown is similar to the crown in the previous astrolabe D035. The shackle and ring are plain. The degree scale on the rim is divided in 1° and 6° and numbered in 6s serially from 1 to 60. Altitude circles are drawn for every 2°; alternate lines are dotted. Azimuth arcs are traced for every 6 above and below the horizon. There are lines for unequal hours in the lower half. But none of these is numbered. The equator and the tropic of Cancer are shown as dotted lines above the horizon, but plain below. The prime vertical is also dotted. The plate is designed for the latitude of 27° and but this is not stated on the plate.

RETE

The three rings of the Tropic of Cancer, the ecliptic and the Tropic of Cancer and an almost complete ring of equator, which is counterchanged at its intersection with the ecliptic ring, are held together by the east-west equinoctial bar, which has a counter-change at the centre. The rings of the ecliptic and the equator are connected in the south by an ornate U-shaped bridge (of the same design as in D035). In the north, the equator ring and the Capricorn ring are joined by three ornate X-shaped bridges which are formed by joining two U-shaped pieces, one upright and the other inverted.

The ecliptic ring is much wider than the other two rings. It is divided into the 12 signs and labelled with their names. Each sign is divided into 5 units and labelled anticlockwise as 6, 12,…30.



Figure D036.2 – Rete of the Astrolabe (photo by S. R. Sarma)

Table D036-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samurapakṣī*	*Samudra-pakṣī*	β Ceti
2	*Machodara*	*Matsyodara*	β Andromedae
3	(not named)	*Pretaśira*	β Persei
4	*Rohiṇī*		α Tauri
5	*Ārdrā*		α Orionis
6	*Lubdhaka*		α Canis Majoris

	Star Name as engraved	Full/Correct Form	Identification
7	*Lubdha.badhu*	*Lubdhaka-bandhu*	α Canis Minoris
8	*Hastā*		δ Corvi
9	*Citrārā*	*Citrā*	α Virginis
10	*Masvī*	*Marīci*	η Ursae Majoris
11	*Svātī*	*Svāti*	α Bootis
12	(not named)	*Sarpagrīvā*	α Serpentis
13	*Rāpedhārīśira*	*Sarpadhārīśira*	α Ophiuchi
14	*Abhejit*	*Abhijit*	α Lyrae
15	*Śravaṇa*		α Aquilae
16	*Ku pucha*	*Kukkuṭapuccha*	α Cygni
17	*Asamuṣa*	*Aśvamukha*	ε Pegasi
18	*Śatabhiṣā*		λ Aquarii
19	*U.bhāda*	*Uttara-bhādrapadā*	γ Pegasi

BACK

The degree scale on the entire rim is divided in 1° and 6°, but groups of 6° are numbered only in the two upper quadrants for measuring the altitude, as 6—90; 90—6. As in D035, here also a full set of altitude circles are drawn at intervals of 3° for the latitude of 18°. The prime vertical is shown as a dotted line above the horizon; below the horizon it is discontinued.



Figure D036.3 – Back of the Astrolabe (photo by S. R. Sarma)

In the two lower quadrants, there are shadow squares, on the left for shadows cast by the gnomon of 12 digits and on the right for shadows thrown by the gnomon of 7 feet. The labels on the four scales have several errors; the correct forms are given in brackets:

Vertical scale on the left: *dvādaśāgulaśaṃkuvilomachā* (*dvādaśāṅgula-śaṅku-viloma-chāyā*), 'umbra versa of the 12-digit gnomon'

Horizontal scale on the left: *dvādaśāgulaśaṃkulāma* (*dvādaśāṅgula-śaṅku-sama-chāyā*), 'umbra recta of the 12-digit gnomon'

Horizontal scale on the right: *saptāgulasakulomachā* (*saptāṅgula-śaṅku-sama-chāyā*), 'umbra recta of the 7-digit gnomon'

Vertical scale on the right: *saptāgulaśakuvilomachā* (*saptāṅgula-śaṅku-viloma-chāyā*), 'umbra versa of the 7-digit gnomon'.

The alidade (length 200 m) carries a slighting tube (slightly bent) of 220 mm length. The tube is supported by triangular uprights of 30 mm height. There is a pin.

INSCRIPTION

There is an inscription mentioning the designer, maker and the owner in five lines; the first two lines are inside the shadow square, the rest are below. The inscription reads thus:

jośī jayakṛṣṇadāsajī kṛtaṃ
ustāda lakṣmīnārayaṇena susaṃpāditaṃ |
paṃ. jyotirvida audīcya mahādevasūnu-acaleśvara-
kasya yaṃtrarāja
kūcamaṇi

'Designed by the astrologer (*joṣī*) Jayakṛṣṇadāsa-jī, well executed by the master artisan (*ustād*) Lakṣmīnārāyaṇa, this astrolabe belongs to Acaleśvara, son of the Audīcya Brahmin, Pandit, *Jyotirvid* Mahādeva. [The astrolabe was made in the city of] Kuchaman.'

To the left of the shadow squares is engraved the date of manufacture of the astrolabe as *saṃvat 1959,* which translates as AD 1902.

PROVENANCE

Formerly of Jean Lagarde; came for auction at Christie's on 9 April 1975, lot no. 88.

D037 ASTROLABE FOR LATITUDE 27°/ 18°, DESIGNED BY HARIDATTA, MADE BY LAKṢMĪNARAYAṆA[889]

1903, Kuchaman, Rajasthan

Diameter 244 mm

Hastings-on-Hudson, Tesseract



Figure D037.1 – Front of the astrolabe (photo courtesy Dr David Coffeen)

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[889] Entry based on the notes kindly provided by Professor David Pingree and Dr Clemency Montelle who read the astrolabe for the auction house of Skinner, and detailed photos from Tesseract.

This astrolabe was made by the same Lakṣmīnārāyaṇa as in the previous two cases, but was designed not by Jayakṛṣṇadāsa, but by son Haridatta.

COMPONENTS

Plate with crown (d. 244, h. 283), shackle and ring, rete for 18 stars, alidade with a sighting tube; original pin and wedge are lost; the parts are held together now by a modern bolt and nut.

FRONT

The astrolabe bears a high crown on which the outlines of an inverted lotus are engraved but not cut *à jour*. Probably the artisan wanted to cut off some portions and create a perforated crown as in his three other extant astrolabes, but failed to do so. The astrolabe is suspended by a small shackle and a large ring.

The degree scale on the rim is divided in 1° and 6°; groups of 6° are numbered serially from 1 to 60, starting at the topmost point and proceeding clockwise.

On the plate are drawn the south-north and east-west lines, and the concentric circles representing the tropic of Capricorn, the celestial equator, and the tropic of Cancer. Altitude circles are drawn for each 2° where every third circle is highlighted with dots. Azimuth arcs are both above and below the horizon for each 6° and the prime vertical is highlighted with dots. However, neither of these two sets of lines is labelled. No hour lines are drawn in the lower half. The plate is calibrated for the terrestrial latitude 27° but there is no label displaying this value.

RETE

In the rete, three broad rings representing the tropic of Capricorn, the celestial equator and the ecliptic are held together by the east-west equinoctial bar, with a counter-change at the centre, and by a small part of the vertical bar which connects a small ring at the centre with the ecliptic ring. As in the preceding two astrolabes (D035 and D036), here also an ornate U-shaped bridge connects the equator ring with ecliptic ring in south and three ornate X-shaped bridges join the lower half of the equator ring with the Capricorn ring. The ecliptic is divided into 12 signs of the zodiac and labelled with their names. Each sign is divided into five units of 6° and labelled in an anticlockwise direction. Single degrees are marked on the sloped edge of the ecliptic ring.

There are 18 dagger-shaped star pointers. Ten of these are outside (i.e. south of) the ecliptic and 8 inside (north of) the ecliptic. Star names in Sanskrit are engraved on all pointers, except no. 11. The names are sometimes abbreviated, sometimes engraved incorrectly. They are listed below according to the increasing right ascension.



Figure D037.2 – Rete of the astrolabe (photo courtesy Dr David Coffeen)

Table D037-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣā*	*Samudrapakṣī*	β Ceti
2	*Matsyodara*		β Andromedae
3	*Rohiṇī*		α Tauri

	Star Name as engraved	Full/Correct Form	Identification
4	*Ārdrā*		α Orionis
5	*Lubdhaka*		α Canis Majoris
6	*Lubdhavadhu*	*Lubdhaka-bandhu*	α Canis Minoris
7	*Hasta*		δ Corvi
8	*Marī*	*Marīci*	η Ursae Majoris
9	*Citrā*		α Virginis
10	*Svāti*		α Bootis
11	(not named)	*Viśākhāmāṛmaṇḍala*	α Coronae Borealis
12	*Sarpadhārīśara*	*Sarpadhārīśira*	α Ophiuchi
13	*Abhijita*	*Abhijit*	α Lyrae
14	*Śravaṇa*		α Aquilae
15	*Ku.pu.*	*Kukkuṭa-puccha*	α Cygni
16	*Aśvamukha*		ε Pegasi
17	*Śatabhiṣā*		λ Aquarii
18	*Pūvābhādra*	*Pūrva-bhādrapadā*	β Pegasi

BACK

The degree scale on the rim is divided in 1° and 6°. Groups of 6° are numbered only in the upper half, separately for each quadrant, as 6—90; 90—6 for measuring the altitudes. As in the preceding two astrolabes, here also altitude circles are drawn at intervals of 3° for the latitude of 18°.

In the lower half, shadow squares are engraved, on the left for the gnomon of 7 digits and on the right for the gnomon of 12 digits. The vertical and horizontal scales on the left carry 7 divisions, which are further subdivided into two units each. On the right, likewise the 12 divisions are further subdivided into two units each. In all the four scales,

only the first and the last divisions are numbered. The scales are accompanied by the following labels:

Vertical scale on the left: *saptāṃgulaśāṃ[ku]vilomachā[yā],* ‘umbra versa of the gnomon of seven digits’,

Horizontal scale on the left: *saptāṃgulaśāṃku-loma*(sic! read -*sama*)*chāyā,* ‘umbra recta of the gnomon of seven digits’,

Horizontal scale on the right: *dvādaśāṃ[gula]śāṃku-loma*(sic! read -*sama*)*chayā,* ‘umbra recta of the gnomon of twelve digits’,

Vertical scale on the right: *dvādaśaṃ* (sic! read ˚*śāṃ*)*[gulaśāṃku] vilomachayā,* ‘umbra versa of the gnomon of twelve digits’.

The alidade is fitted with a slightly longer sighting tube. The original pin and wedge are missing. These are replaced by a modern bolt and nut.



Figure D037.3 – Back of the astrolabe (photo courtesy Dr David Coffeen)

INSCRIPTION

Inside the shadow squares is an inscription in four lines:

rāvabahādura-mahārāja-śrī-serasiṃhajī-rājye jyo
tirvij[j]ayakṛṣṇātmaja-haridatta-kṛtaṃ saṃ 1960 |
kārtika śukrā 6 cāṃdravāsare ustā[da] lakṣmīnārā
yaṇa kucāmaṇamadhye ||

> ‘In the kingdom of Rao Bahadur Mahārāja the glorious Serasiṃha (Sher Singh), this astrolabe was designed by Haridatta, son of astronomer Jayakṛṣṇa, [and was made] by the master artisan Lakṣmīnārāyaṇa. Saṃvat 1960, Monday, the sixth day of the bright half of Kārtika (= Monday 26 October 1903) in Kuchaman.’

‘Rao Bahadur’ was a title conferred by the colonial government on Hindus of high social standing, but not on princes or Mahārājas. The chiefs of Kuchaman were of lower nobility and carried the title Thākur, but they were not Mahārājas. In the inscription on the astrolabe C034, also designed by Haridatta and fabricated by Lakṣmīnārāyaṇa, the title ‘Rao Bahadur’ was scratched out and replaced ‘Mahārāja’. Probably the chiefs were aspiring for this elevated status or the instrument designer Haridatta was trying to flatter them.

PROVENANCE

The astrolabe was formerly with the auction house of Skinner, Bolton. The late Professor David Pingree and his student Dr Clemency Montelle read the astrolabe for Skinner. Tesseract acquired it from Skinner in the sale 2133 on 13 April 2002.

BIBLIOGRAPHY

Skinner 2002, no. 239, p. 37.

D038⊙ ASTROLABE FOR LATITUDE 27°/18°, DESIGNED BY JAYAKṚṢṆADĀSA, MADE BY LAKṢMĪNĀRĀYAṆA, NOT DATED[890]

Late 19th century, Kuchaman, Rajasthan

Diameter 309 mm

Hamburg, PC

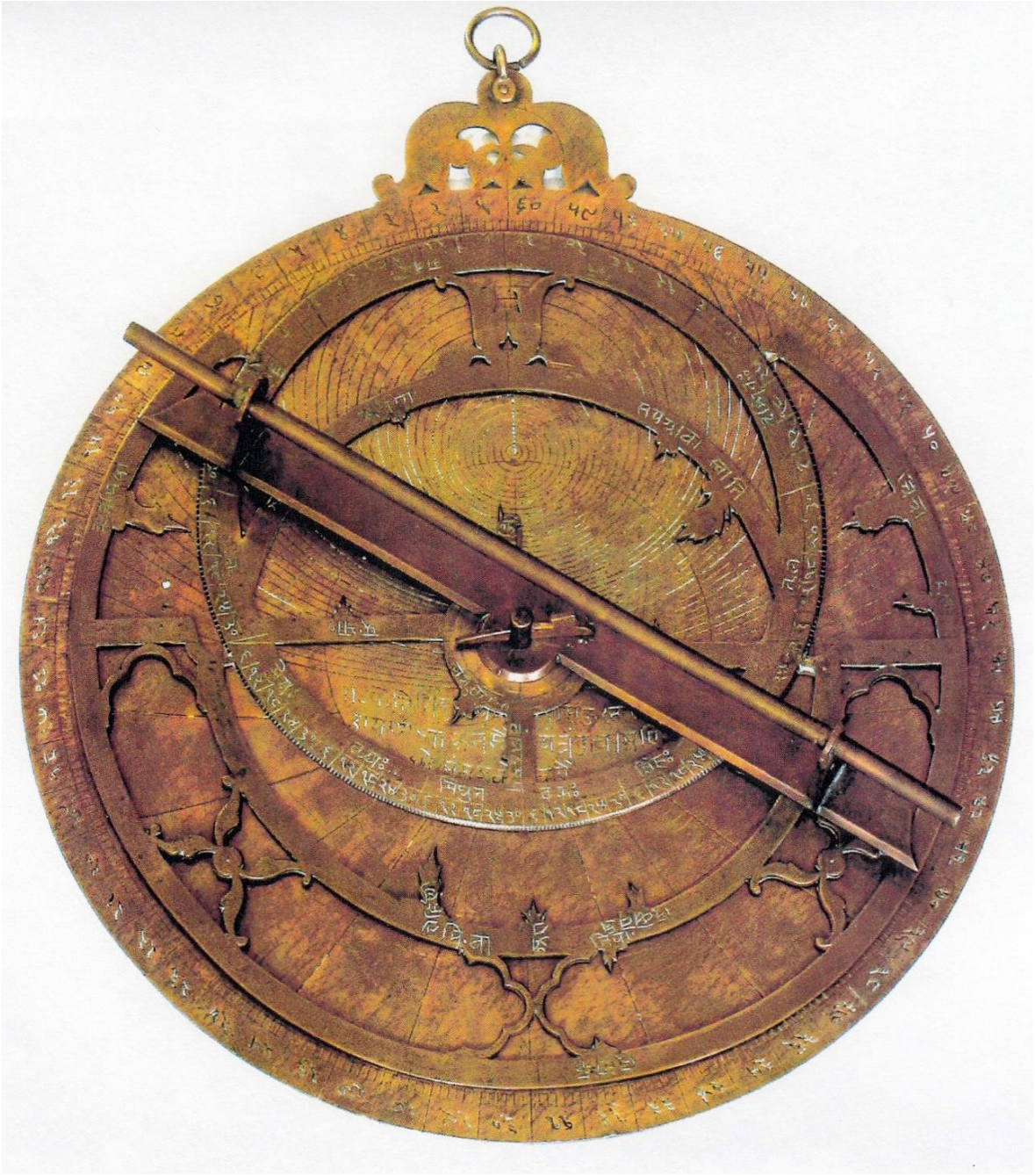


Figure D038.1 – Front of the astrolabe (photo by the owner)

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890 Entry based on personal examination and photos kindly provided by the owner.

Like the preceding three astrolabes, this one is also fabricated by the master artisan Lakṣmīnārāyaṇa and displays common features. However, unilike in the preceding astrolabes, on the reverse side the projections for latitude 18° are completed in the lower half as well. Therefore, the plate can be used for observations at latitude 18° as well as at latitude 27°, but the scale on the reverse side is not correctly numbered for altitude measurements. On the obverse side calibrated for latitude 27°, names of different localities are engraved in the spaces between the azimuth arcs, which is most unusual.

COMPONENTS

Plate with crown (d. 309, h. 352), shackle and ring, rete for 20 stars, alidade with a sighting tube, pin and wedge.



Figure D038.2 – Crown of the astrolabe (photo by the owner)

FRONT

The crown is elegantly crafted. It is cut *à jour* in the form of an inverted stylized lotus. In the front decorative lines are engraved on the surface of the crown to indicate the individual petals. This was not done on the back.

The degree scale on the sim is divided in 1° and 6° and numbered in 6s separately for each quadrant as 1—90; 90—1; 1—90; 90—1.



Figure D038.3 – Obverse side of the plate (photo by the owner)

Altitude circles are drawn for each 2° and every third circle (i.e. 6°) is highlighted by dots. Azimuth arcs are drawn for each 6° above and below the horizon. Below the horizon are the unequal hour lines. Neither the almucantars, nor the azimuths, nor the hour lines are numbered. The plate is designed for the latitude of 27°, but this value is not engraved on the plate. However, under the eastern horizon is written *pūrva kṣitija* (eastern horizon) and under the western horizon *paścima kṣitija* (western horizon).

Most unusually, in the lower half of the plate, between the azimuth lines, there are six inscriptions; five of these can be identified as the names of towns. Starting from the meridian and proceeding towards the east, the following are the inscriptions:

Between the azimuth lines for

24° and 30°: *kucāmaṇi*	(= Kuchaman)
66°-72°: *kṛṣg*<read *ṇ*>*gaṭha*	(= Kishangarh 26:34° N; 74;52° E)
72°-78°: *ajamera*	(= Ajmer 26;27° N; 74;38° E)
78°-84°: *navānagara*	(= Jamnagar 22;27° N; 70;07° E)
84°-90°: *devagaṭha*	(= Daulatabad 19;57° N; 75;15° E)
108°-114°: *carapara*	(??)
ma 2| 9 | 45	(??)

The first five are the names of towns in the Gujarat, Rajasthan and Maharashtra. But they have absolutely no connection with the azimuth lines on the plate. It is quite intriguing why they are engraved here.

RETE

The rete is elegantly crafted, with a lotus-like floral ornament between the circles of the ecliptic and equator at the top, which provides a counterpoise to the floral pattern of the crown. The retes in the other astrolabes are fashioned similarly. This seems to be the hall mark of the artisan of Lakṣmīnārāyaṇa. The tropic of Capricorn, the equator and ecliptic are represented by three rings. The ecliptic ring is slightly wider. The three rings are held together by the east-west equinoctial bar which is counter-changed once at the centre. The equator ring is counterchanged at its intersection with the ecliptic ring. The two rings of equator and ecliptic are connected at the top by lotus-like floral ornament already mentioned. The two rings of the equator and the Tropic of Capricorn are held together in the north by three ornate bridges in the form of the letter X. Below the east-west bar in the east and in the west, there are arch-like patterns with three lobes. At the north point, two of such arch patterns are joined together back to back.

The four slender joints connecting the ecliptic ring to the rest broke at some point and the ecliptic ring became detached from the rest of the rete. Subsequently the ecliptic ring was joined carefully to the rest of the rete by soldering at two places and adding a thin strip of brass at the back at two other places. Thus the north-eastern tip of the Capricorn ring was joined to the ecliptic ring in the region of Aquarius by soldering; so too the equator ring and a segment of the east-west bar to the ecliptic ring in the region of Aries. The north-western tip of the Capricorn ring was joined to the ecliptic ring in

the region of Scorpio by a strip of brass; so also the equator ring and a segment of the east-west bar to the ecliptic ring in the region of Virgo.

The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names. The signs are subdivided into units of 6° each; these are numbered as 6, 12, …30, in an anti-clockwise direction. The bevelled edge of the ecliptic ring is divided in single degrees.

There are 20 named star pointers, but these have different shapes from those in the other astrolabes made by Lakṣmīnārāyaṇa.

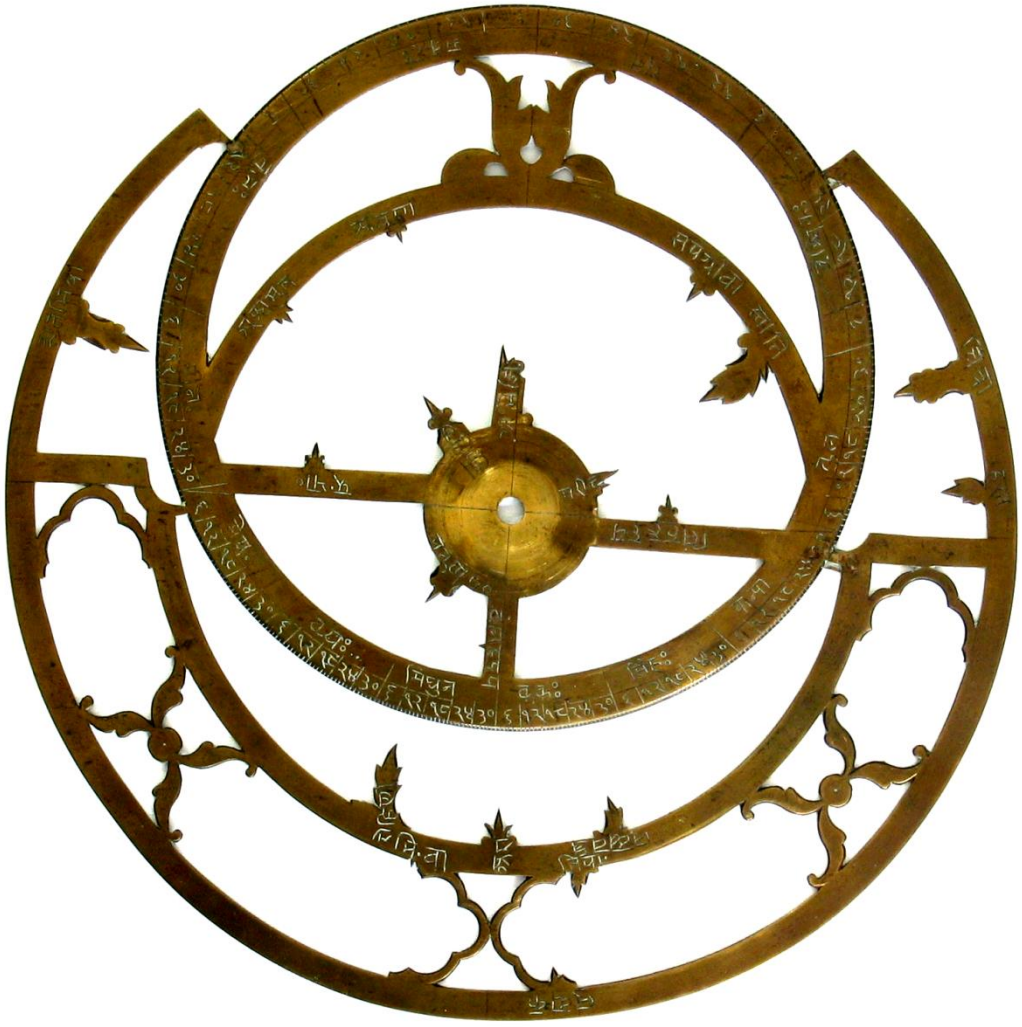


Figure D038.4 – Rete of the astrolabe (photo by the owner)

Table D038-1 Stars on the Rete

	Star Names as engraved	Full/Correct Form	Identification
1	*Manuṣya pā*	*Manuṣya-pārśva*	α Persei

	Star Names as engraved	Full/Correct Form	Identification
2	*Rohiṇī*		α Tauri
3	*Vaṃhmahṛdaya*	*Brahma-hṛdaya*	α Aurigae
4	*Mi.vā.*	*Mithuna-vāma-pāda*	β Orionis
5	*Ārā*	*Ārdrā*	α Orionis
6	*Mi.pā*	*Mithuna-dakṣina-pāda*	κ Orionis
7	*Lubdhaka*		α Canis Majoris
8	*Lubdhakavaṃdhu*	*Lubdhaka-bandhu*	α Canis Minoris
9	*Siṃhahṛdaya*		α Leonis
10	*Hasta*		δ Corvi
11	*Citrā*		α Virginis
12	*Marīca*	*Marīci*	η Ursae Majoris
13	*Svāti*		α Bootis
14	*Sarpagrīvā*		α Serpentis
15	*Abhiji*	*Abhijit*	α Lyrae
16	*Śravaṇa*		α Aquilae
17	*Ku.pucha*	*Kukkuṭapuccha*	α Cygni
18	*Aśvamuṣa*	*Aśvamukha*	ε Pegasi
19	*Śatabhiṣā*		λ Aquarii
20	*Pū.bhā.*	*Pūrva-bhādrapada*	β Pegasi

BACK

The entire rim is covered by a degree scale, consisting of the narrow inner band of single degrees and the broader outer band divided into groups of 6°. These are

numbered serially, but anti-clockwise starting from the south point. This is most unusual. Therefore this scale cannot be used to measure the altitude of the heavenly bodies. As in the front, there are also the concentric circles of Capricorn, equator and Cancer. As in the preceding astrolabes, here also a full set of altitude circles are drawn for the latitude of about 18° at intervals of 2°. However, unlike in the preceding astrolabes, shadow squares are not drawn in the lower half , but the projections for the latitude of 18° are completed by drawing the lines of unequal hours, but not the azimuth arcs. The altitude circles and the hour lines are not numbered, nor is the latitude value of 18° recorded.



Figure D038.5 – Back of the astrolabe (photo by the owner)

ALIDADE

There is a 281 mm long straight-bar alidade with ornate terminals, to which a long sighting tube (length 294 mm; diameter 7.3 mm) is attached. The tube is made by rolling a sheet of brass. A slit at the joint is still visible. There are no graduation marks on the alidade.

The whole ensemble of the astrolabe is held together by a broad-headed pin. The pin is made fast by a pretty wedge. Instead of the usual shape of horse's head, the artisan prepared modernistic wedge, by attaching a small rectangle to an arc of a circle.



Figure D038.6 – Alidade with the sighting tube, washer, pin and wedge (photo by the owner)

INSCRIPTION

In the space between the horizon and the circle of Cancer is engraved the following inscription in three lines.

jyotirvid jayakṛṣṇadāsa ūstā[d] lakṣmīnā-
rāyaṇābhyāṃ kataṃ <read kṛtam> saumyayantraṃ kucāmaṇima-
dhye muṃmaï ko yaṃtra hai/chai (?)

'[This] northern instrument (i.e. northern astrolabe) was made by the astronomer (*jyoirvid*) Jayakṛṣṇadāsa and the master artisan (*ustād*) Lakṣīnārāyaṇa at Kuchaman. …'

Underlined parts appear to be in Rajasthani dialect.

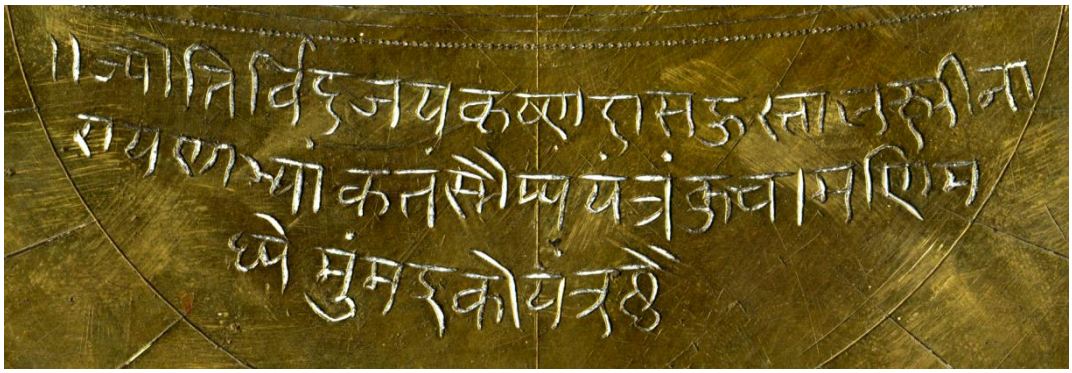


Figure D038.7 – Inscription on the back (photo by the owner)

The Sanskrit astrolabes were usually designed by high-caste Brahmin astronomers and fabricated by low-caste artisans. This distinction is maintained in the inscriptions on the preceding three astrolabes where it was clearly stated that the astrolabe was designed (*kṛta*) by the astronomer Jayakṛṣṇadāsa or by his son Haradatta and that it was well executed (*susaṃpādita*) by the master artisan (*ustād*) Lakṣmīnārāyaṇa. In the present inscription, which was naturally composed by Jayakṛṣṇadāsa and engraved by Lakṣīnārāyaṇa, this distinction was removed and the two names of Jayakṛṣṇadāsa and of Lakṣīnārāyaṇa are mentioned together in a single compound in instrumental dual.

PROVENANCE

The present owner acquired it in early 2011 at ebay where it was offered as a kind of sextant!

D039 ASTROLABE FOR LATITUDE 27°/18°, NOT SIGNED, NOT DATED[891]

19th century, Kuchaman, Rajasthan

Diameter 280 mm

PLU



Figure D039.1 – Front of the astrolabe (courtesy Professor David Pingree)

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[891] Entry based on the notes and photos kindly provided by Professor David Pingree, who read this astrolabe for for the auction house of Skinner.

Stylistically it is close to the Kuchaman astrolabe of 1903 (C037). The crown is exactly alike; and the back has projection for the latitude of 18° as in the four other astrolabes made at Kuchaman between 1887 and 1903. But the rete does not have ornate bridges as in the other Kuchaman astrolabes. The workmanship is good.

COMPONENTS

Plate with crown (d. 280), shackle and ring, rete (d. 260) for 25 stars, alidade with a sighting tube, pin and a bird-shaped wedge.

FRONT

The crown is low and plain. The degree scale on the rim is divided in 1° and 6°; the latter are numbered serially from 1 to 60. Altitude circles for 2°, azimuth arcs above and below the horizon for 6°; lines for seasonal hours. None of these lines appear to have been numbered. The plate is calibrated for 27° but this is not mentioned on the plate.

RETE

The three rings of Capricorn, equator and ecliptic are held together by the east-west equinoctial bar which has a counter change at the centre. The equator ring is also counterchanged at its intersections with the ecliptic ring. Unlike in the other Kuchaman astrolabes, the equatorial ring and that of the Capricorn ring are not joined by ornate bridges, but by two plain straight bars in the north. A segment of the solstitial bar joins the central disc with the ecliptic ring below. There is no bridge connecting the equator ring with the ecliptic ring in the south.

The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names; each sign is further divided into units of 6° and numbered accordingly. These units are divided into single degrees on the sloped edge of zodiac ring. There are 24 named star pointers, mainly of the dagger sahpe.

Table D039-1 Stars on the Rete

	Star Name as engraved	Full /Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Matsyodara*		β Andromedae
3	*Manuṣyapakṣī*	*Manuṣyapārśva*	α Persei
4	*Aśvinī*		γ Arietis
5	*Rohiṇī*		α Tauri
6	*Vrahmahṛdaya*	*Brahmahṛdaya*	α Aurigae
7	*Mi. vā. pā.*	*Mithuna-vāma-pāda*	β Orionis
8	*Ārdrā*		α Orionis
9	*Lubdhaka*		α Canis Majoris
10	*Tipā*	*Prajāpati ?*	δ Aurigae
11	*Lu. baṃdhu*	*Lubdhaka-bandhu*	α Canis Minoris
12	*Mahāpuruṣa*		α Hydrae
13	*Maghā*		α Leonis
14	Pu. phā.	Pūrva-phālgunī	δ Leonis
15	*Hasta*		δ Corvi
16	*Citrā*		α Virginis
17	*Marīci*		η Ursae Majoris
18	*Svāti*		α Bootis
19	*Sarpagrīvā*		α Serpentis
20	*Abhijit*		α Lyrae
21	*Śravaṇa*		α Aquilae
22	*Kurkkuṭapucha*	*Kukkuṭa-puccha*	α Cygni
23	*Aśvamukha*		ε Pegasi

	Star Name as engraved	Full /Correct Form	Identification
24	*Śatabhiṣā*		λ Aquarii
25	*Pūrvā Bhādrapadā*		β Pegasi

BACK

The rim carries a degree scale which is divided in 1° and 6°. In the upper half groups of 6° are numbered in 6s separately for each quadrant as 6—90; 90—6. In the lower half the scale is not numbered. As in the front, here also the concentric circles of the Tropic of Capricorn, the celestial equator and the Tropic of Cancer are drawn and upon these altitude circles are traced at intervals 2° for the latitude of 18°.



Figure D039.2 – Back of the Astrolabe (courtesy Professor David Pingree)

In the lower half there are shadow squares, on the left for the gnomon of 12 digits and on the right for the gnomon of 7 digits. The labels on the four scales are as follows:
Vertical scale on the left: *dvādaśāṃgulaśaṃku-vilomachāyā* (umbra versa of the 12-digit gnomon)
Horizontal scale on the left: *dvādaśāṃgulaśaṃku-loma* (sic! *-sama*)*chāyā* (umbra recta of the 12-digit gnomon),
Horizontal scale on the right: *saptāṃgulaśaṃku-loma* (sic! *-sama*) *chāyā* (umbra recta of the 7-digit gnomon),

Vertical scale on the right: *saptāṃgulaśaṃkuvilomachāyā* (umbra versa of the 7-digit gnomon).

PROVENANCE

Ex-Tesseract C73.4 (catalog 73, item no. 4); ex-Skinner, sale 21333, 13 April 2002.

BIBLIOGRAPHY

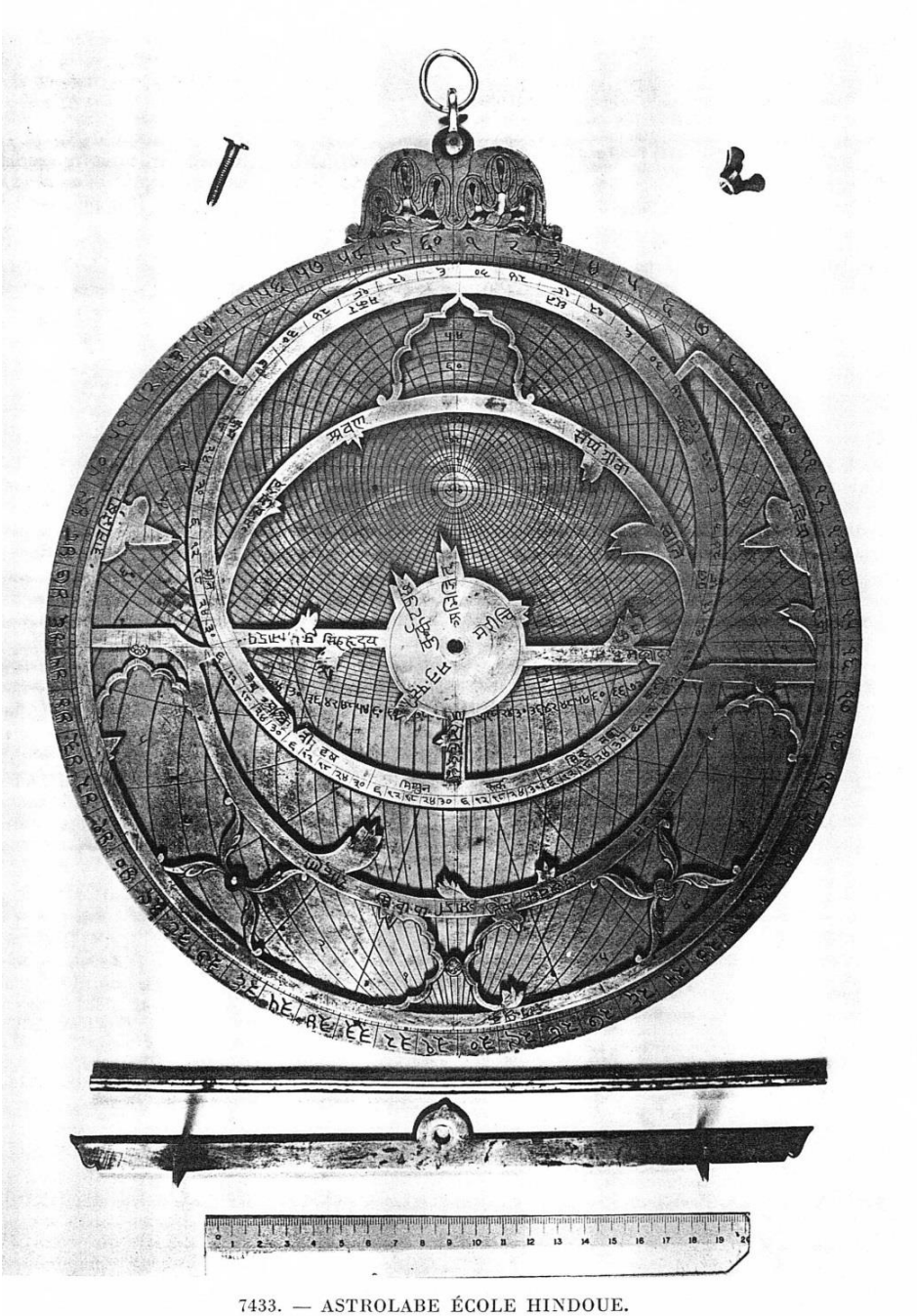
Skinner 2002, no. 242, p. 38.

D040 ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED[892]

19th century, Kuchaman, Rajasthan

Diameter 370 mm

PLU



7433. — ASTROLABE ÉCOLE HINDOUE.

Figure D040.1 – Front of the astrolabe (photo by Alain Brieux)

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892 Entry based on a photo published in the catalogue of Alain Brieux, *Histoire des sciences, livres, instruments,* Paris 1973, p. 106, no. 7433.

A very large astrolabe, with the characteristic crown and rete of the astrolabes made at Kuchaman. It is not known whether there is any inscription at the back. The workmanship and the orthography are good.

COMPONENTS

Plate with crown (d. 370), shackle and ring, rete for 25 stars, alidade with a sighting tube; these are held together by a modern bolt and nut.

FRONT

An elaborate pattern of an inverted lotus is engraved upon the front of the crown which is cut out. The shackle is small, but the ring is large. The degree scale on the rim is divided in 1° and 6° and numbered from 1 to 60. Altitude circles are drawn for every 2° and numbered in 6s along the periphery of the plate. Azimuth arcs are traced above and below the horizon for each 6° and numbered along the horizon line below. Lines for seasonal hours are numbered from the western horizon from 1 to 6 up to the meridian and again from 1 to 6 up to the eastern horizon. The plate is designed for the latitude of 27°, but no label to the effect can be seen in the available photo.

RETE

The rete consists of the peripherical ring of the Tropic of Capricorn, a much wider ecliptic ring and almost complete equator ring with counter changes at its intersections with the ecliptic ring. The three rings are held together by the east-west equinoctial bar with a counter change at the centre. The equatorial ring is joined to the ecliptic ring in the south by an arch-like bridge. In the north the equator ring and the Capricorn ring are joined by three ornate X-like bridges. The middle one is formed by two arch-like figures joined back-to-back with a circle in the middle. The same arch-like figures with a circle at the pinnacle are added to the east-west bar at its eastern and western extremities, thus forming two elegant cartouches on either side of the meridian between the rings of equator and Capricorn. Thus in the lower half, the rete resembles the rete of D038.

The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names. Each sign is divided in groups of 6° and numbered accordingly.

There are 25 dagger-shaped star pointers, some of which are straight and some others curved.

Table D040-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	(not named)	*Samudrapakṣī*	β Ceti
2	*Siṃhahṛdaya*!	*Matsyodara*[893]	β Andromedae
3	*Aśvinī*		β Arietis
4	*Manu.pakṣī*	*Manuṣyapārśva*	α Persei
5	*Rohiṇī*		α Tauri
6	*Vrahmahṛdaya*	*Brahmahṛdaya*[894]	α Aurigae
7	*Mi.vā.pā*	*Mithuna-vāma-pāda*	β Orionis
8	*Ārdrā*		α Orionis
9	*Ludhvaka*	*Lubdhaka*	α Canis Majoris
10	*Tipā*	*Prajāpati*?	δ Aurugae
11	*Luddhavaka--*	*Lubdhaka-bandhu*	α Canis Minoris
12	*Mahāpuruṣa*		α Hydrae
13	*Matsyodara*!	*Siṃhahṛdaya*	α Leonis
14	*Hasta*		δ Corvi
15	*Pū.phā.*	*Pūrva-phālgunī*	δ Leonis
16	*Citrā*		α Virginis
17	*Marīci*		η Ursae Majoris
18	*Svāti*		α Bootis
19	*Sarppagrīvā*	*Sarpagrīvā*	α Serpentis
20	*Abhijit*		α Lyrae

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893 The names of 2 (*matsyodara*) and 13 (*siṃhahṛdaya*) are interchanged by mistake.

894 The relative positions of 6 and 7 are slightly reversed.

	Star Name as engraved	Full/Correct Form	Identification
21	*Śravaṇa*		α Aquilae
22	*Kurkkaṭapucha*	*Kukkuṭapuccha*	α Cygni
23	*Aśvamukha*		ε Pegasi
24	*Śatabhiṣā*		λ Aquarii
25	*Pū.bhādrapa.*	*Pūrva-bhādrapadā*	β Pegasi

BACK

No information is available.

D041 ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED

19th century, Kuchaman, Rajasthan

Diameter 291 mm

Qatar, Doha, Museum of Islamic Art (# MW.380.2007), ex-Point Lookout, ex-Alain Brieux

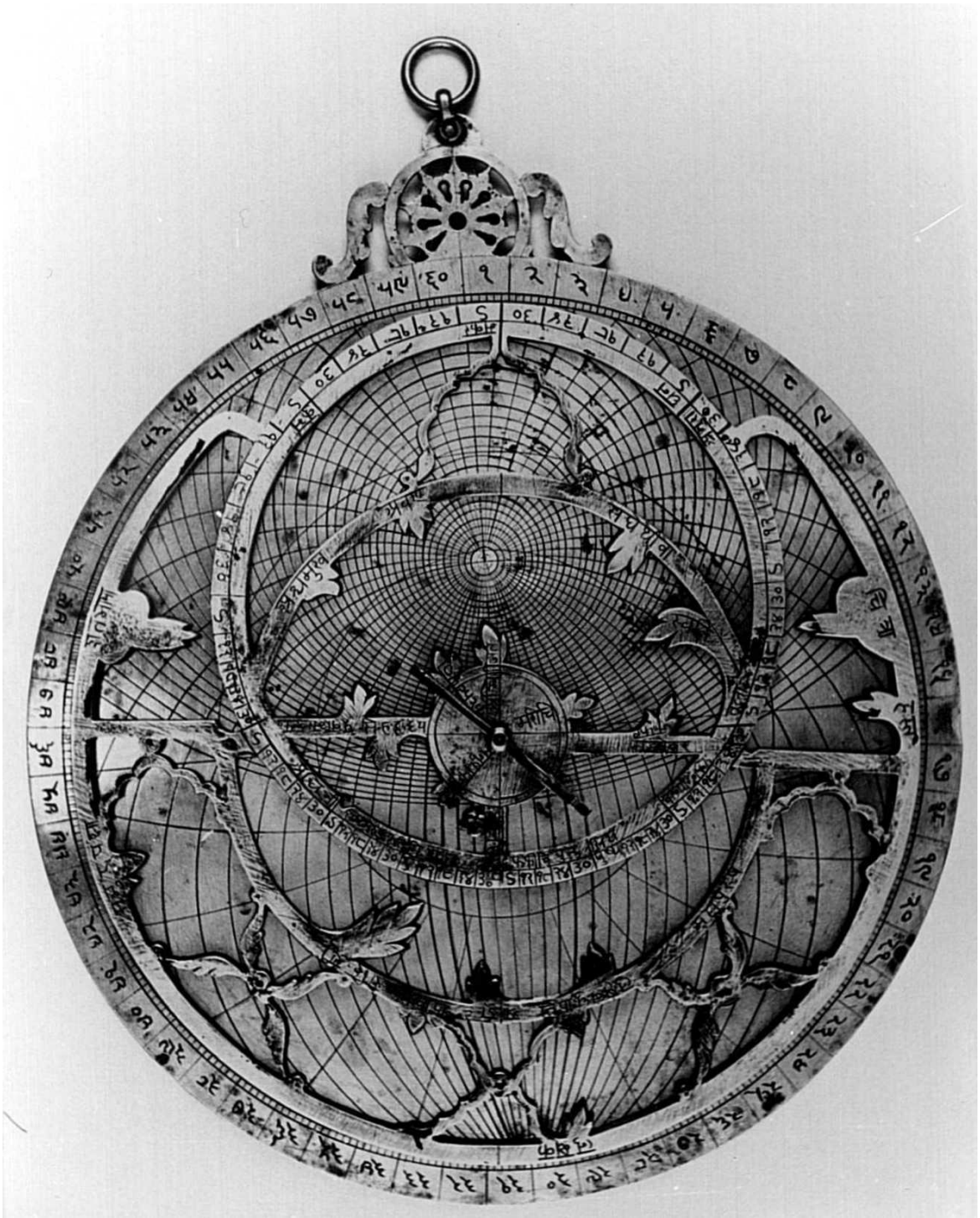


Figure D041.1 – Front of the astrolabe (courtesy Anthony Turner)

Linton 1980, no. 180, p. 124, contains a brief description of a single plate astrolabe but provides no photo. Anthony Turner gave me two photos and some photocopies of photos from the collection of Alain Brieux. The photos carry a label 'Linton Collection'. These photos must have been prepared for the Linton Catalogue but were not included there. It is possible that these photos refer to the astrolabe listed under no. 180. The crown does not have the inverted lotus pattern which is characteristic of the Kuchaman astrolabes, but the rete shows another feature of the Kuchaman astrolabes, viz., the ornate bridges that connect the equatorial ring with the other rings. In fact, the rete here displays such close similarity with the rete in the previous astrolabe that it makes the same errors in star names.

COMPONENTS

Plate with crown (d. 291), shackle and ring, rete for 25 stars; alidade is missing; pin and washer are replacements.

FRONT

The rete consists of a ring enclosing an ornate wheel worked *à jour*. To the left and right of the ring are two pieces in foliate pattern. The scale on the rim of the plate is divided in 1° and 6° and numbered serially from 1 to 60. Altitude circles are drawn for every 2° and azimuth arcs above and below the horizon line for every 6°. In the lower half there are lines for unequal hours. None of these three families of lines is numbered. The plate is calibrated for the latitude of ca. 27°.

RETE

The rete here closely resembles the rete in the previous astrolabe (D040), including the interchange of the labels of *Matsyodara*) and *Siṃhahṛdaya*. Here also there are three rings representing the Tropic of Capricorn, a much broader ecliptic ring, almost complete equator ring with counter changes at the intersections with the ecliptic ring. The three rings are held together by the east-west equinoctial bar with a counter change at the centre. The ecliptic ring and the equator ring are joined in the south by an arch-like bridge. The equator ring and the ring of the Tropic of Capricorn are joined in the north, by two ornate X-like supports on either side of the meridian and by a third support at the meridian which is also X-shaped but matches with the two arch-like figures joined back-to-back with a circle in the middle. The same arch-like figures with

a circle at the apex are added to the east-west bar at its eastern and western extremities, forming a cartouche with the lower halves of the rings of the equator and Tropic of Capricorn.

The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names. Each sign is divided in groups of 6° and numbered accordingly.

As in the previous astrolabe (D040) here also there seem to be 25 leaf-shaped star pointers, some of which are straight and some others curved.

Table D041-1 Stars on the Rete

	Star Name as engraved	Full/ Correct Form	Identification
1	*Samudrapakṣā*	*Samudrapakṣī*	β Ceti
2	*Siṃhahṛdaya*!	*Matsyodara*[895]	β Andromedae
3	*Aśvinī*		γ Arietis
4	*Manuṣyapā-*	*Manuṣya-pārśva*	α Persei
5	*Rohiṇī*		α Tauri
6	illegible	*Brahma-hṛdaya*	α Aurigae
7	*Mi.vā.pā*	*Mithuna-vāma-pāda*	β Orionis
8	*Ārdrā*		α Orionis
9	*Ludhvaka*	*Lubdhaka*	α Canis Majoris
10	*Tiṣāḥ*	*Prajāpati?*	δ Aurigae
11	*Ludhabaṃdhu*	*Lubdhaka-bandhu*	α Canis Minoris
12	*Mahāpuruṣa*		α Hydrae
13	*Matsyodara*!	*Siṃhahṛdaya*	α Leonis
14	*Hasta*		δ Corvi

[895] The names of 2 (*Matsyodara*) and 13 (*Siṃhahṛdaya*) are wrongly interchanged.

	Star Name as engraved	Full/ Correct Form	Identification
15	*Pū.phā.*	*Pūrva-phālgunī*	δ Leonis
16	*Citrā*		α Virinis
17	*Marīci*		η Ursae Majoris
18	*Svāti*		α Bootis
19	*Sadyathīvā*	*Sarpagrīvā*	α Serpentis
20	*Abhijit*		α Lyrae
21	*Śravaṇa*		α Aquilae
22	*Kurkkaṭapucha*	*Kukkuṭa-puccha*	α Cygni
23	*Aśvamukha*		ε Pegasi
24	*Śatabhiṣā*		λ Aquarii
25	*Pūrvābhādrapa*	*Pūrvabhādrapdā*	β Pegasi

BACK

The scale on the rim of the back is divided in 1° and 6°; in the upper two quadrants, groups of 6° are numbered from 6 to 90, separately for each quadrant, starting from the east or west points and reaching the south point. In the lower half these are not numbered. The east-west and south-north diameters are drawn and also the circles of the equator and the Tropic of Cancer. Otherwise the two upper quadrants are empty.

In the lower half there are shadow squares. On the right for the gnomon of 7 digits. The two scales are accordingly divided into 7 units; each unit is halved. The label along the horizontal scale reads *saptāṃgulaśaṃku-lomachāyā* and that along the vertical scale *saptāṃgulaśaṃkuvilomachāyā.* This incorrect expression *lomachāyā* instead of *samachāyā* for umbra recta is again a feature of the Kuchaman astrolabes. In the photocopy of the photo of back that is available to me, the left half is completely dark and the details of the shadow square on the left (presumably it has the base of 12) are not visible.

D042 ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED[896]

19th century, Kuchaman, Rajasthan

Diameter 211 mm

Vicenza, Italy, PC of Mr Giancarlo Beltrame (# 224)

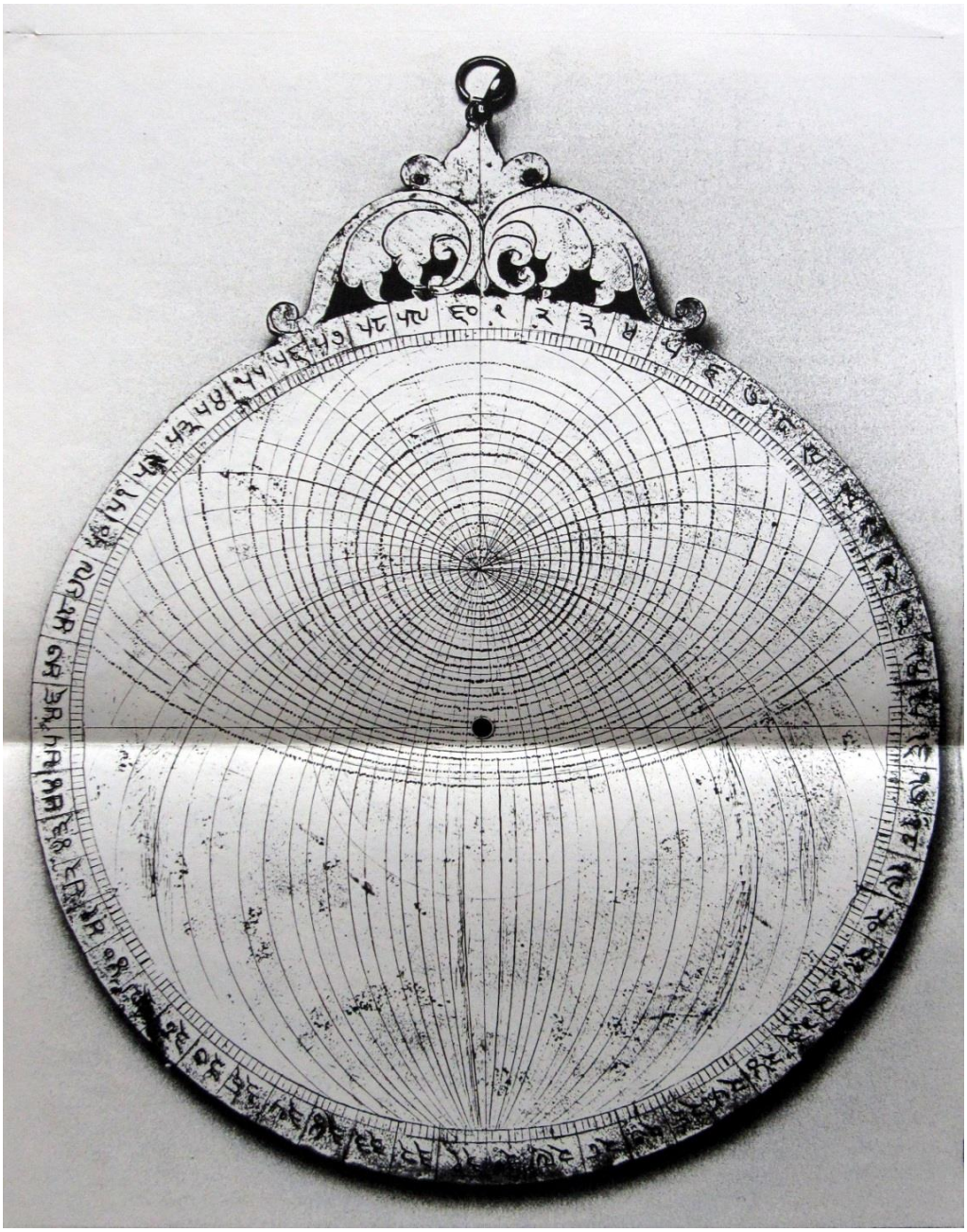


Figure D042.1 – Front of the astrolabe (courtesy Anthony J. Turner)

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[896] This entry is based on the notes and photos kindly provided by Anthony J. Turner. The Beltrame collection is catalogued by Anthony Turner and others; cf. Brenni 1996, p. 16.

The strylised lotus-like crown suggests that this astrolabe too may have been made in Kuchaman. These leaf-shaped star pointers resembles those in the two precediong specimens (D040, D041).

COMPONENTS

Plate with crown, shackle, rete for 11 stars, alidade with a sighting tube.

FRONT

The crown is worked *à jour* and engraved on the front with lines to produce a symmetrical floral patten. The degree scale on the rim is divided in 1° and in 6°; groups are 6° are numbered serially from 1 to 60. Altitude circles (alternately straight and dotted lines) are drawn for every 3 degrees. Azimuth arcs are drawn for every 6° above and below the horizon. There are no hour lines. The plate is calibrated for the latitude of 27° although this is not stated. Nor are the altitude circles and azimuth arcs numbered.

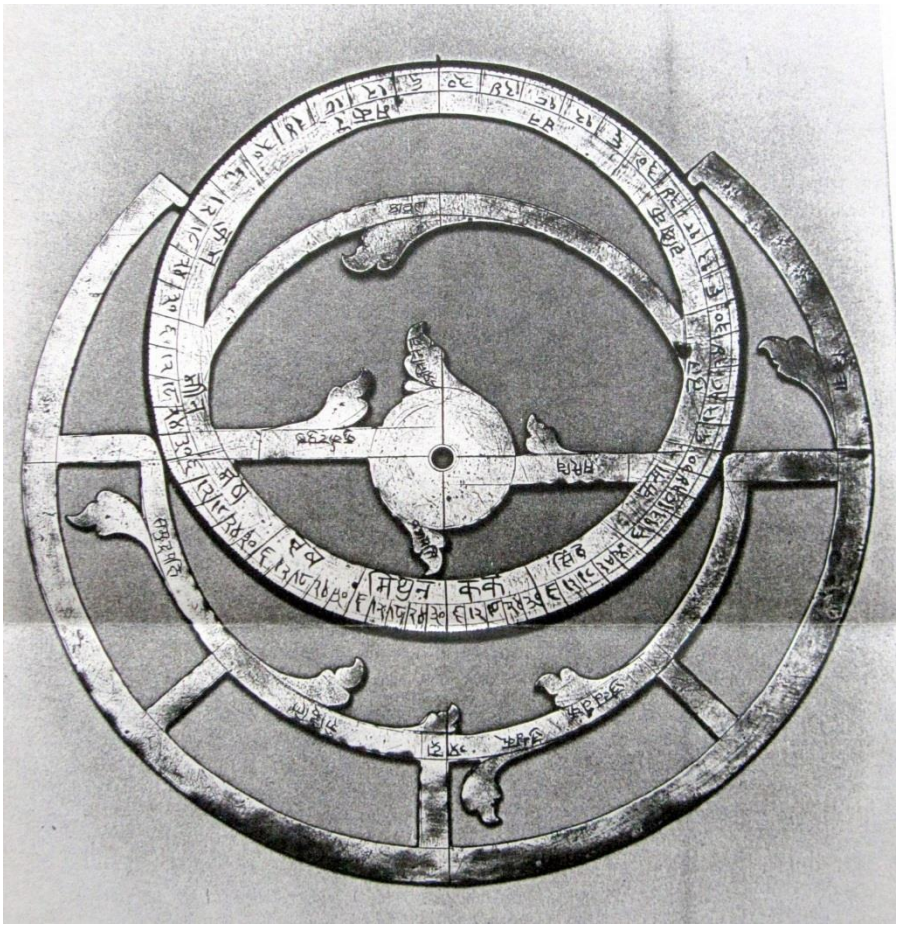


Figure D042.2 – Rete of the Astrolabe (courtesy Anthony J. Turner)

RETE

The rete consists of the three rings of the Tropic of Capricorn, the equator and much wider ecliptic held together by the equinoctial bar which has a counter change at the centre. In the lower half, the rings of the equator and the Tropic of Capricorn are connected by a segment of the solstitial bar and two more bars placed symmetrically on either side of the solstitial bar. The much wider ecliptic ring is divided into the 12 signs of zodiac and labelled with their names. Each sign is subdivided in groups of 6° and labelled accordingly.

It is remarkable that the number of star pointers is very small in comparison to the other astrolabes. The 11 star pointers are leaf-shaped.

Table D042-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣi*	*Samudrapakṣī*	β Ceti
2	*Rohiṇī*		α Tauri
3	*Prajāpati*		δ Aurigae
4	*Ārdrā*		α Orionis
5	*Ludhvaka*	*Lubdhaka*	α Canis Majoris
6	*Ludhavaka*	*Lubdhaka-bandhu*	α Canis Minoris
7	*Citrā*		α Virginis
8	*Marici*	*Marīci*	η Ursae Majoris
9	*Abhijit*		α Lyrae
10	*Śravaṇa*		α Aquilae
11	*Kurkurapucha*	*Kukkuṭapuccha*	α Cygni

BACK

The scale on the rim is divided in 1° and in 6°. Groups of 6° are numbered only in the upper two quadrants, thus 6—90; 90—6. The upper two quadrants are blank. In

the lower half, there are shadow squares, on the left with 12 divisions and on the right with 7 divisions. The labels for the umbra recta and umbra versa are mixed up; the correct forms are given in brackets.

Vertical scale on the left: *dvādaśāṃgulaśaṃku-lomachāyā* (*dvādaśāṃgula-śaṃkuvilomachāyā*), 'umbra versa of the 12-digit gnomon ,

Horizontal scale on the left: *dvādaśāṃgulaśaṃku-vilomachāyā* (*dvādaśāṃgulaśaṃku-samamachāyā),* 'umbra recta of the gnomon of 12 digits',

Horizontal scale on the right: *saptāṃgulaśaṃku-vilomachāyā* (*saptāṃgulaśaṃku-samachāyā*), 'umbra recta of the 7-digit gnomon,

Vertical scale on the right: *saptāṃgulaśaṃku-lomachāyā* (*saptāṃgulaśaṃku-vilomachāyā*), 'umbra versa of the gnomon of 7 digits'.

As in many astrolabes produced at Kuchaman, this astrolabe also employs the non-existing term *loma* as the antonym of *viloma* in stead of the correct term *sama.*

D043 ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED[897]

19th century, Kuchaman, Rajasthan

Diameter ?

PLU

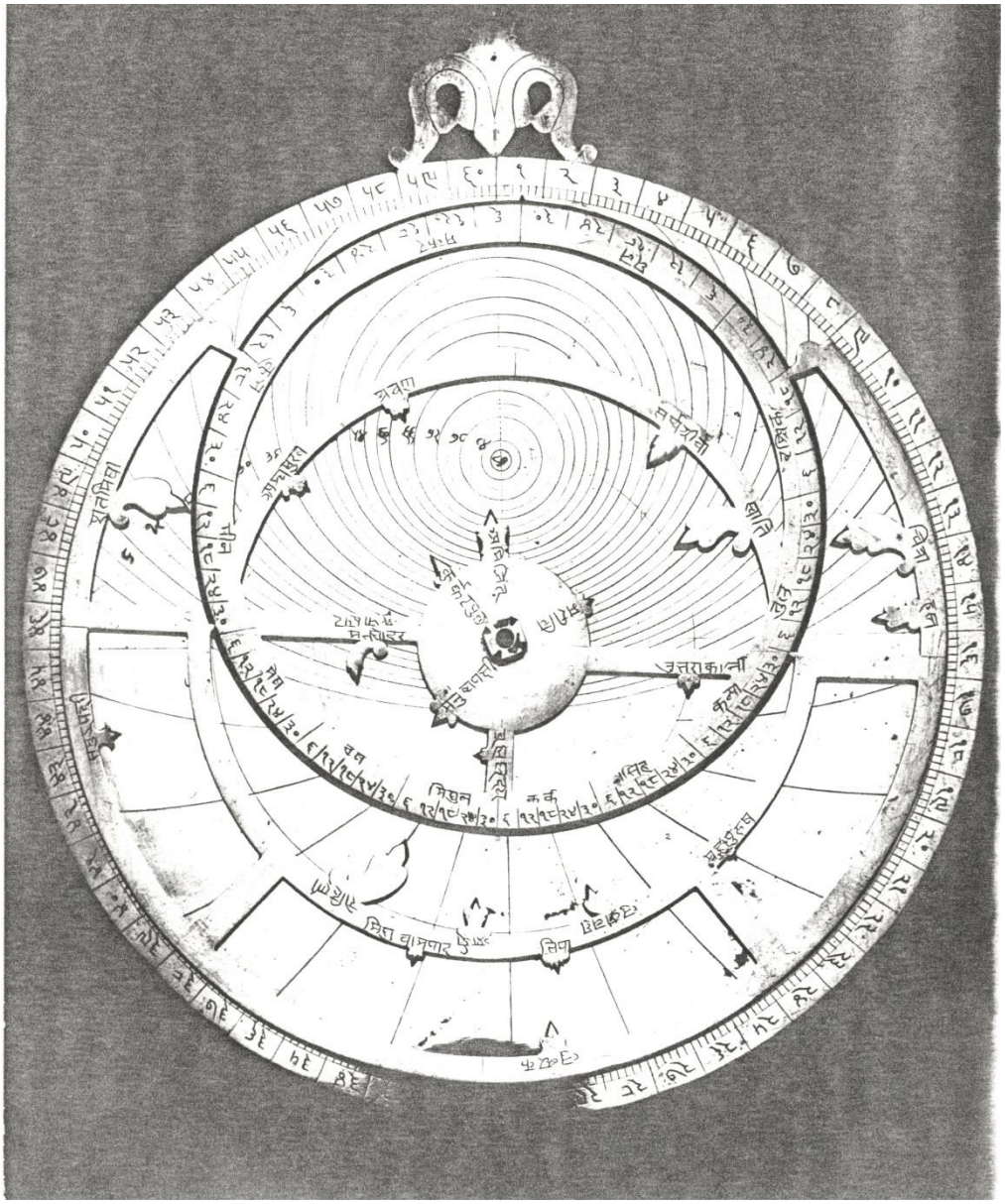


Figure D043.1 – Front of the astrolabe (courtesy Anthony J. Turner)

It is a well crafted astrolabe with neat and almost correct orthography. With its crown formed like a stylized inverted lotus, the astrolabe appears to have been produced in Kuchaman.

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[897] Entry based on a photocopy of a photo kindly provided by Anthony J. Turner.

COMPONENTS

Plate with crown, rete. The shackle and ring are missing. No information about alidade, pin and wedge.

FRONT

The crown is shaped as a stylized inverted lotus. The scale on the rim is divided in 1° and 6°; groups of 6° are numbered serially from 1-60. Altitude circles are drawn for every 3° and numbered in 6s. There are lines for seasonal hours, but no azimuth arcs. The plate appears to have been designed for the latitude of ca. 27.

RETE

The three rings of the Tropic of Capricorn, the equator and the ecliptic are held together by the east-west equinoctial bar which has one counter change. There are no other bridges connecting the different rings. The ring of equator has counter changes at its two intersections with the ecliptic ring. The ecliptic ring is divided in 12 signs and labelled with their names, and each sign is divided in units of 6° and numbered from 6 to 30. There are 23 star pointers, some shaped like small daggers and others like leaf-clusters.

Table D043-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Matsyodara*		β Andromedae
3	*Manuṣyapakṣī*	*Manuṣya-pārśva*	α Persei
4	*Rohiṇī*		α Tauri
5	*Mithunavāmapāda*		β Orionis
6	*Brahmahṛdaya*		α Aurigae
7	*Ārdrā*		α Orionis
8	*Lubdhaka*		α Canis Majoris
9	*lipā*	*Prajāpati ?*	δ Aurigae

	Star Name as engraved	Full/Correct Form	Identification
10	*Lubdhakabadha*	*Labdhaka-bandhu*	α Canis Minoris
11	*Mahāpuruṣa*		α Hydrae
12	*Uttarakāntā*	*Uttara-phālgunī*	β Leonis
13	*Hasta*		δ Corvi
14	*Citrā*		α Virginis
15	*Marīca*	*Marīci*	η Ursae Majoris
16	*Svāti*		α Bootis
17	*Sarpagrīvā*		α Serpentis
18	*Abhijit*		α Lyrae
19	*Śravaṇa*		α Aquilae
20	*Kurkarapuccha*	*Kukkuṭa-puccha*	α Cygni
21	*Aśvamukha*		ε Pegasi
22	*Śatabhiṣā*		λ Aquarii
23	*Pūbhādrapada*	*Pūrvabhādrapadā*	β Pegasi

BACK

No information is available about the back and about the alidade.

D044 ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED[898]

19th century, Kuchaman, Rajasthan

Diameter 290 mm

PLU

Linton 1980, no. 182, p. 124, has a brief description of a single plate astrolabe but no photo. There it is stated that the 'suspension piece is worked *à jour* as an inverted lotus'. Then this astrolabe must have been produced at Kuchaman. It cannot be identical with any of the astrolabes with similar crowns which are listed above because none of them have a diameter of 290 mm.

COMPONENTS

Plate with crown (d. 290), rete for 23 stars, alidade with a sighting tube. Original pin and wedge are missing; the parts are held in place by a nut and bolt. Shackle and ring are not mentioned.

FRONT

The degree scale on the rim is divided in 1° and in 6° and numbered from 1 to 60. Altitude circles are drawn for every 3° for the latitude of 27°. There are no azimuth arcs. Hour lines are not mentioned in the catalogue.

RETE

The equator circle is completely represented. The ecliptic circle is [divided into signs], into groups of 6° and into single degrees. 23 foliate star pointers.

BACK

Degree scale on the rim is divided in 1° and in 6°, and numbered from 6 to 90, separately for each quadrant. The upper two quadrants are presumably blank. In the lower half, shadow squares for 12 and 7 bases.

The alidade is equipped with a sighting tube.

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[898] Entry based on Linton 1980, no. 182, p. 124.

D045 ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED[899]

19th century, Kuchaman, Rajasthan

Diameter

PLU; ex-Saul Moskowitz, Marblehead



Figure D045.1 – Front of the astrolabe (courtesy Professor David Pingree)

The rete of this astrolabe displays bridges to connect the equatorial ring with the ecliptic ring in the south and with the Capricorn ring in the north, bridges which are characteristic of the astrolabes produced at Kuchaman. There are surprisingly very few (12) star pointers on the rete.

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899 Entry based on photos kindly provided by Professor David Pingree; he received these photos from Saul Moscowitz, a dealer in scientific instruments, Marblehead, Massachusetts, USA.

COMPONENTS

Plate with crown, shackle and ring, rete for 12 stars, alidade with a sighting tube, pin and wedge.

FRONT

The plate is rather thin, the impressions of the altitude circles drawn on the front are visible on the back. The crown is lobed, the shackle has a trifoliate form and the ring is large. The scale on the rim is graduated in 1° and 6°; groups of 6° are numbered serially from 1 to 60. Altitude circles for every 2°, every third circle is dotted; azimuth arcs for every 6° above and below the horizon. Neither set is numbered. No hour lines.

RETE

The rete consists of the three rings of Capricorn, equator and ecliptic which are held together by the east-west equinoctial bar which has one counter change at the centre. The equator ring is connected to the ecliptic ring in the south by an ornate bridge and to the Capricorn ring in the north by two bridges. The equator ring has counter changes at its two intersections with the ecliptic ring. The ecliptic ring is divided into the 12 signs and labelled with their names; each sign is divided into groups of 6° and numbered in 6s from 6 to 30.

There are 12 dagger-like star pointers.

Table D045-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Rohiṇī*		α Tauri
2	*Brahmahṛdaya*		α Aurigae
3	*Lubdhaka*		α Canis Majoris
4	*Lubdhavadha*	*Lubdhaka-bandhu*	α Canis Minoris
5	*Hasta*		δ Corvi
6	*Citrā*		α Virginis
7	*Marīca*	*Marīci*	η Ursae Majoris
8	*Svāti*		α Bootis

	Star Name as engraved	Full/Correct Form	Identification
9	*Abhijit*		α Lyrae
10	*Śravaṇa*		α Aquilae
11	*Kuṭapuccha*	*Kukkuṭa-puccha*	α Cygni
12	*Śatabhiṣā*		λ Aquarii

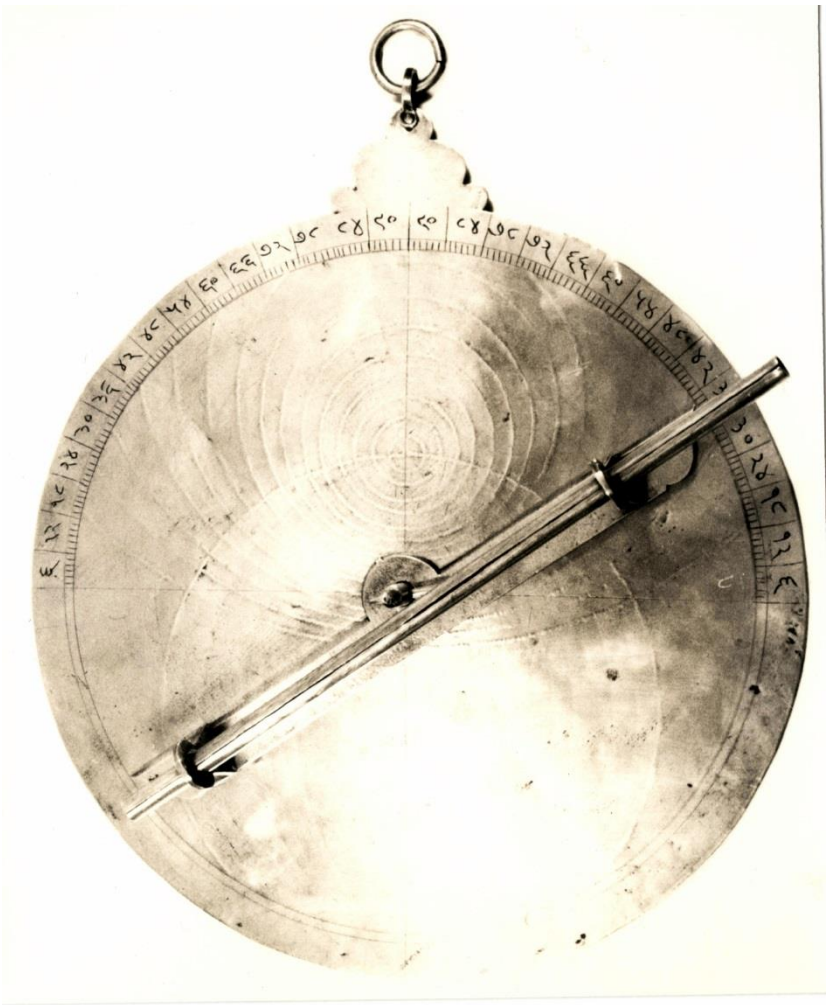


Figure D045.2 – Back of the astrolabe (courtesy Professor David Pingree)

BACK

On upper half of the rim on the back, there are two altitude scales divided in 1° and 6° and numbered in 6s as 6—90; 90—6. The rest is blank.

The alidade is equipped with a sighting tube which is slightly longer than the diameter of the astrolabe.

D046 ASTROLABE FOR LATITUDE CA. 27°, NOT SIGNED, NOT DATED[900]

19th century, Kuchaman, Rajasthan

Diameter ?

PLU



Figure D046.1 – Front of the astrolabe (courtesy Museum of the History of Science, Oxford)

COMPONENTS

Plate with crown, shackle and ring, rete for 17 stars; no information about alidade, pin and wedge.

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[900] Entry based on a photo in the archives of the Museum of the History of Science, Oxford.

FRONT

The crown is crudely reticulated. The degree scale on the rim is divided in 1° and in 6° and numbered from 1 to 60. Altitude circles for each 3° are arranged for ca. 27°. Azimuth arcs for each 6°. Lines for seasonal hours. None of these are numbered.

RETE

The rete exhibits the characteristic features of the astrolabes made by Lakṣmīnārāyaṇa of Kuchaman. The ring of the Tropic of Capricorn, the almost complete ring of equator, with counter changes at its intersections with the ecliptic ring, and the ecliptic ring are held together by the east-west equinoctial bar with one counter change at the centre. In the south, the equator ring is connected to the ecliptic ring by an ornate U-shaped bridge; in the north it is connected to the Capricorn ring by three ornate X-shaped supports.

The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names. Each sign is divided in groups of 6° and numbered accordingly.

There are 17 dagger-shaped star pointers, some straight and some curved.

Table D046-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samurapakṣī*	*Samudrapakṣī*	β Ceti
2	*Machodara*	*Matsyodara*	β Andromedae
3	*Rohiṇī*		α Tauri
4	*Ārdrā*		α Orionis
5	*Ludhvaka*	*Lubdhaka*	α Canis Majoris
6	*Lubdhabadhu*	*Lubdhakabandhu*	α Canis Minoris
7	*Hasta*		δ Corvi
8	*Citrārā*	*Citrā*	α Virginis
9	*Marvī*	*Marīci*	η Ursae Majoris
10	*Svātī*	*Svāti*	α Bootis

	Star Name as engraved	Full/Correct Form	Identification
11	*Rārpadhārīśira*	*Sarpadhārīśira*	α Serpentis
12	*Abhijit*		α Lyrae
13	*Śravaṇa*		α Aquilae
14	*--ṭapuccha*	*Kukkuṭa-puccha*	α Cygni
15	*Asamuṣa*	*Aśvamukha*	ε Pegasi
16	*Śatabhiṣā*		λ Aquarii
17	*Pū.bhāda*	*Pūrva-bhādrapadā*	β Pegasi

BACK

No information is available about the back.

D047 ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED

19th century, Kuchaman, Rajasthan

Diameter 295 mm

PLU; ex-Tesseract



Figure D047.1 – Front of the astrolabe (photo courtesy Dr David Coffeen)

This is a large astrolabe with a diameter of 295 mm. The crown has a rather unusual shape, but the two X-like bridges in the lower part of the rete suggest that the astrolabe was produced in Kuchaman.

COMPONENTS

Plate with crown (d. 295), shackle and ring, rete for 24 stars, alidade with a sighting tube, pin and wedge.

FRONT

The crown is shaped like a bow with recurved tips forming circular loops. It looks too flimsy to be able to support such a large astrolabe. The shackle and ring in a darker metal are small.

The scale on the rim of the plate is divided in 1° and 6°. Groups of 6° are numbered serially from 1 to 60. Altitude circles for every 2°, every third circle dotted. Azimuth arcs for every 6° above and below the horizon. Lines for seasonal hours. None of the sets is numbered. The plate is designed for the latitude of 27°, but this is not recorded either.

RETE

The three rings of the Tropic of Capricorn, equator and ecliptic are held together by the east west equinoctial bar which has a counter change at the centre. The equatorial ring has counter changes at its two intersections with ecliptic ring. It is joined to the ecliptic ring in the south by a trifoliate bridge and to the Capricorn ring in the north by two X-shaped bridges. The ecliptic ring is divided in the 12 signs and labelled with their names written very incorrectly. Each sign is divided into units of 6° and numbered from 6 to 30. The sloped edge of the ecliptic ring is divided in 1°.

There are 24 dagger shaped star pointers.

Table D047-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Matyodara*	*Matsyodara*	β Andromedae
3	(not named)	*Pretaśira*	β Persei
4	*Matapakṣī*	*Manuṣyapārśva*	α Persei
5	*Rohiṇī*		α Tauri

	Star Name as engraved	Full/Correct Form	Identification
6	*Vrahadapa*	*Brahma-hṛdaya*	α Aurigae
7	*Mi.vā.da*	*Mithuna-vāma-pāda*	β Orionis
8	*Ārdrā*		α Orionis
9	*Lugraka*	*Lubdhaka*	α Canis Majoris
10	*Tipā*	*Prajāpati ?*	δ Aurigae
11	*Luvadhu*	*Lubdhaka-bandhu*	α Canis Minoris
12	*Mahāpuruṣa*		α Hydrae
13	*Pūrvāphālgu*	*Pūrvaphālgunī*	δ Leonis
14	*Hasta*		δ Corvi
15	*Citrā*		α Virginis
16	*Marīci*		η Ursae Majoris
17	*Svāti*		α Bootis
18	*Sarpagrāvā*	*Sarpagrīvā*	α Serpentis
19	*Abhijita*	*Abhijit*	α Lyrae
20	*Śravaṇa*		α Aquilae
21	*Kukaṭapu*	*Kukkuṭa-puccha*	α Cygni
22	*Aśvamukha*		ε Pegasi
23	*Satabhiṣā*		λ Aquarii
24	*Pūrvābhādrapada Pūrvabhādrapadā*	β Pegasi	



BACK

The back is the astrolabe is completely blank, but for the altitude scales on the upper half of the rim which are divided in 1° and 6° and labelled as 6—90; 90—6.

The alidade is somewhat short, its tips barely reaching up to the altitude scale. A sighting tube is mounted on the alidade.

D048⊙ ASTROLABE FOR LATITUDE 27°, NOT SIGNED, NOT DATED

19th century, Kuchaman, Rajasthan?

Diameter 216 mm

Varanasi, Banaras Hindu University, Bharat Kala Bhavan (# 2/5133)

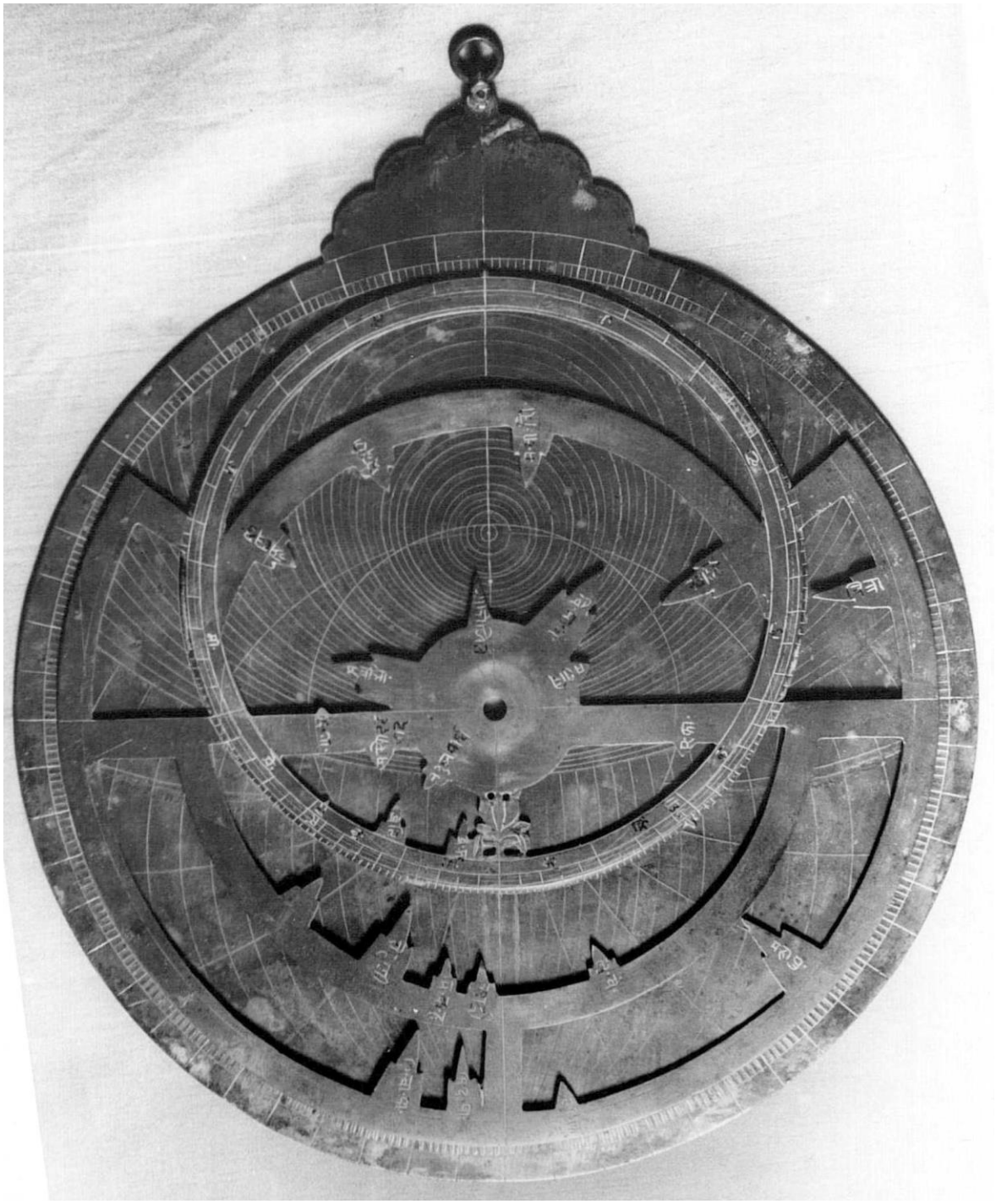


Figure D048.1 – Front of the astrolabe (courtesy Bharat Kala Bhavan)

On this astrolabe, altitude circles are drawn for the latitude of 27° on both sides. This fact and the motif of a lotus on the rete suggest that this astrolabe may have been made at Kuchaman. However, it is incomplete in many respects.

COMPONENTS

Plate with crown (d. 216, h. 248), shackle and ring, rete for 24 stars, alidade with a sighting tube, pin and wedge with horse's head.

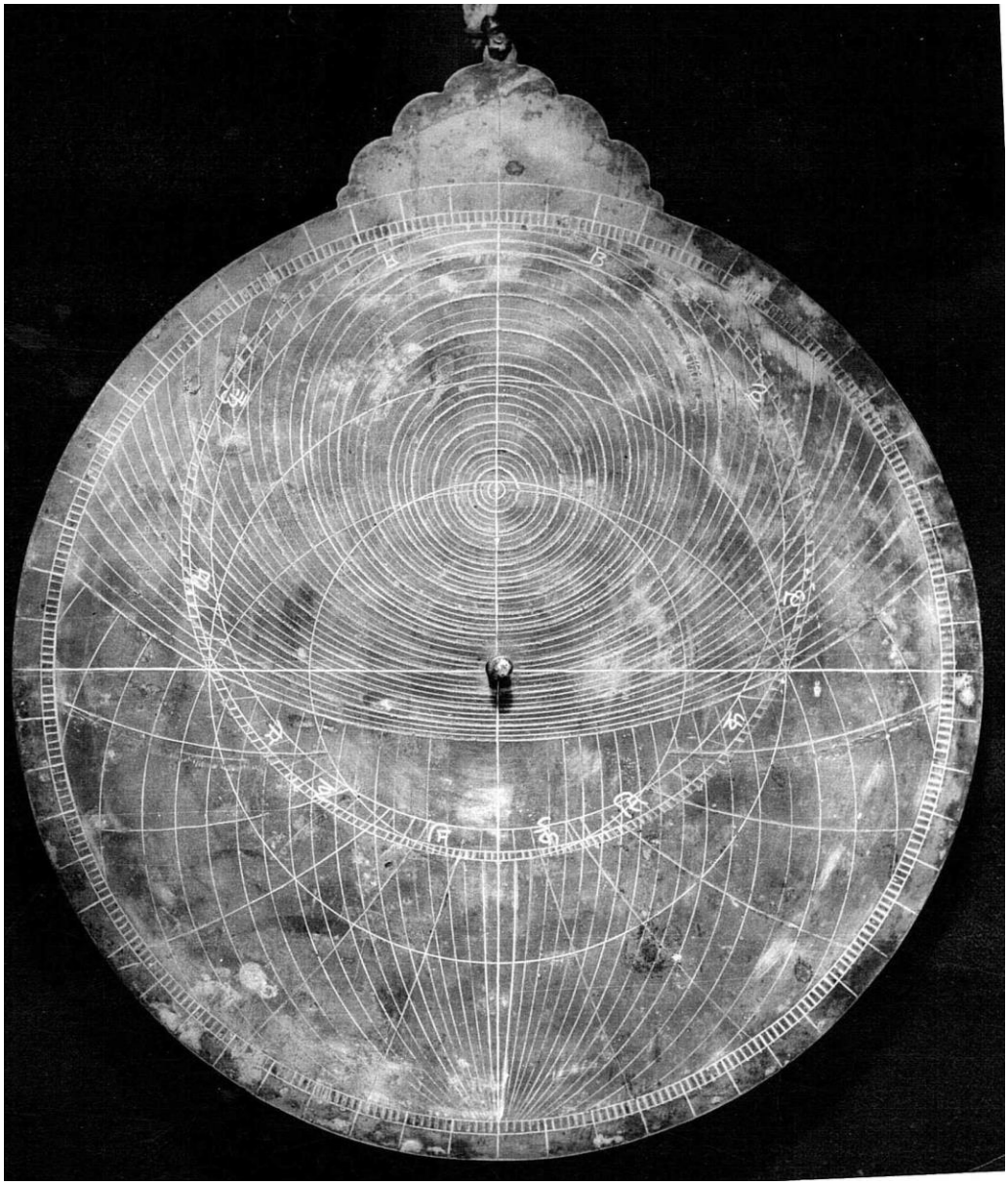


Figure D048.2 – Front of the plate (courtesy Bharat Kala Bhavan)

FRONT

The crown is high and lobed, the shackle and ring are small. The degree scale on the rim is divided in 1° and in 6° but not numbered. The circles of equator, Tropic of Cancer and the prime meridian are drawn. Altitude circles are drawn for every 2° and

each third line is highlighted with dots. Azimuth arcs are traced for every 6° below the horizon. In the lower half, lines for seasonal hours are drawn. But none of these is numbered. In addition to these projections, a wide ring of the ecliptic with three circles is drawn, which is unusual. The ecliptic is divided into the 12 zodiac signs and labelled with the initial syllables of their names. Each sign is divided into 12 parts.

The disposition of the altitude circles indicates that the plate is designed for the latitude of 27°. This value should have been engraved between the circle of horizon and the Tropic of Cancer, but this is not done.

RETE

The three rings of the Tropic of Capricorn, equator and ecliptic are held together by the equinoctial bar without counter change. In the lower half , the rings of the equator and the Tropic of Capricorn are joined by a segment of the solstitial bar. The central ring and the that of the ecliptic are joined in the lower half by a styled lotus flower. The ecliptic ring is divided into the 12 zodiac signs and labelled with the initial syllables of their names. Each sign is divided into 5 parts and each part is further subdivided into 3 units of 2° each. There are 24 dagger-shaped star-pointers.

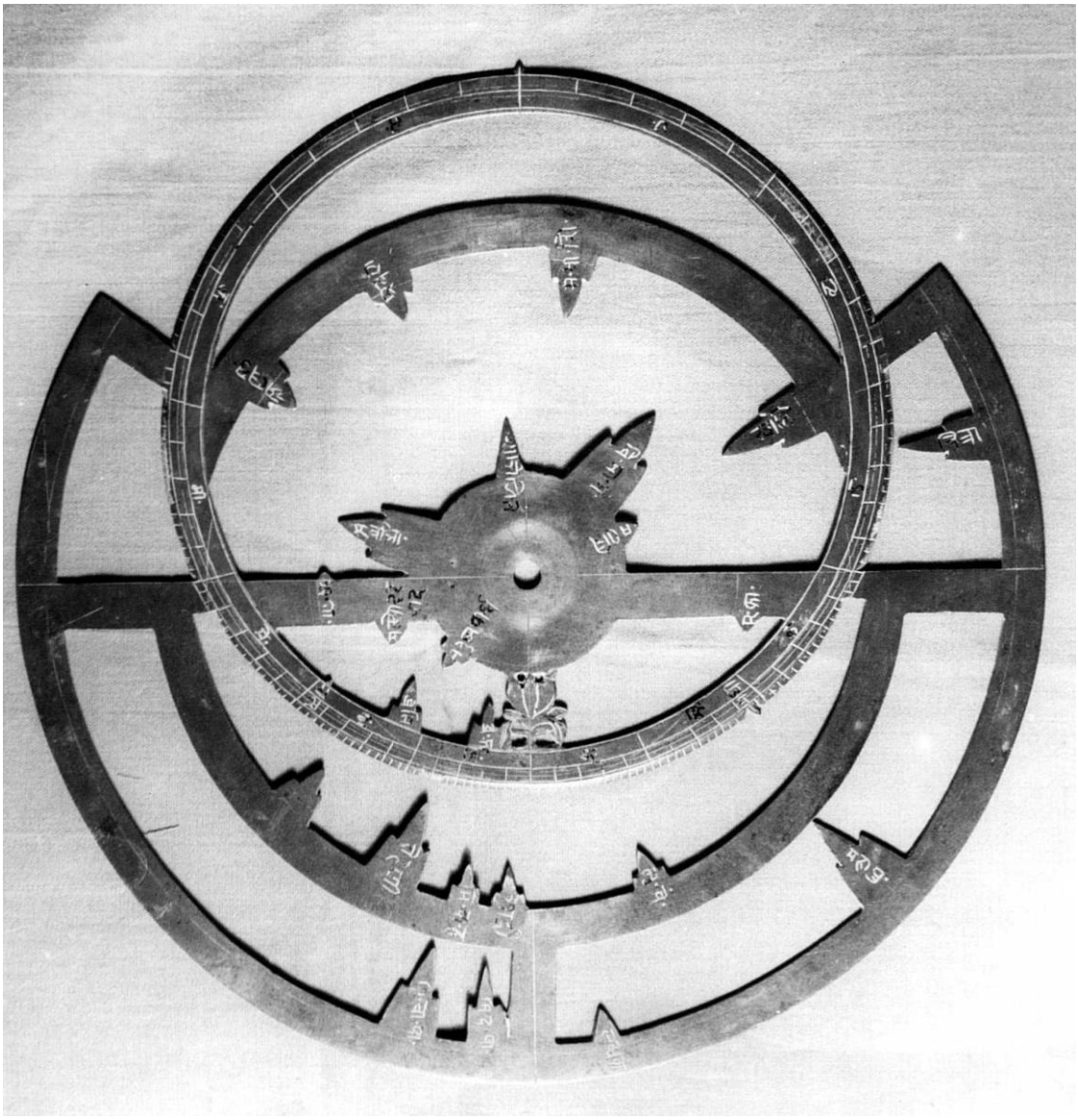


Figure D048.3 – Rete of the Astrolabe (courtesy Bharat Kala Bhavan)

Table D048-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Matsyodarapāda*		γ Andromedae
2	(not named)		
3	(not named)		
4	*Pra. śi.*	*Pretaśira*	β Persei
5	*Manuṣyapārśva*		α Persei
6	*Rohiṇī*	α Tauri	

	Star Name as engraved	Full/Correct Form	Identification
7	*Vra.hṛ.*	*Brahma-hṛdaya*	α Aurigae
8	*Mi.vā.pā*	*Mithuna-vāma-pāda*	β Orionis
9	*Mi.ka.ha*	*Mithuna-vāma-hasta*	γ Orionis
10	*Mi.da.pā.*	*Mithuna-dakṣiṇa-pāda*	κ Orionis
11	*Ārdrā*		α Orionis
12	*Lubdhaka*		α Canis Majoris
13	*Lu.va.*	*Lubdhaka-bandhu*	α Canis Minoris
14	*Mahāpu*	*Mahāpuruṣa*	α Hydrae
15	*Citrā*		α Virginis
16	*Marīci*		η UMa
17	*Svāti*		α Bootis
18	*Viśākhā*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
19	*Na.nī.si*	*Sarpadhārī-śira*	α Ophiuchi
20	*Abhijit*		α Lyrae
21	*Śravaṇa*		α Aquilae
22	*Aṣvamu*	*Aśvamukha*	ε Pegasi
23	*Pūrvabhā*	*Pūrva-bhādrapadā*	β Pegasi
24	*Utta.bhā*	*Uttara-bhādrapadā*	γ Pegasi

BACK

The degree scale on the entire rim is divided in 1° and in 6°, but only the upper half is numbered in 6s as 6—90; 90—6. Here also altitude circles, drawn for each 2°,

are arranged for the latitude of 27°. Circles of equator, Tropic of Cancer, prime meridian and ecliptic (rather faint) are drawn, but no azimuth arcs or hour lines. None of these arcs are labelled or numbered. On the lower right quadrant, a grid of 9 x 10 squares is drawn by horizontal and vertical parallels, but not filled in.

The alidade is fitted with a sighting tube.

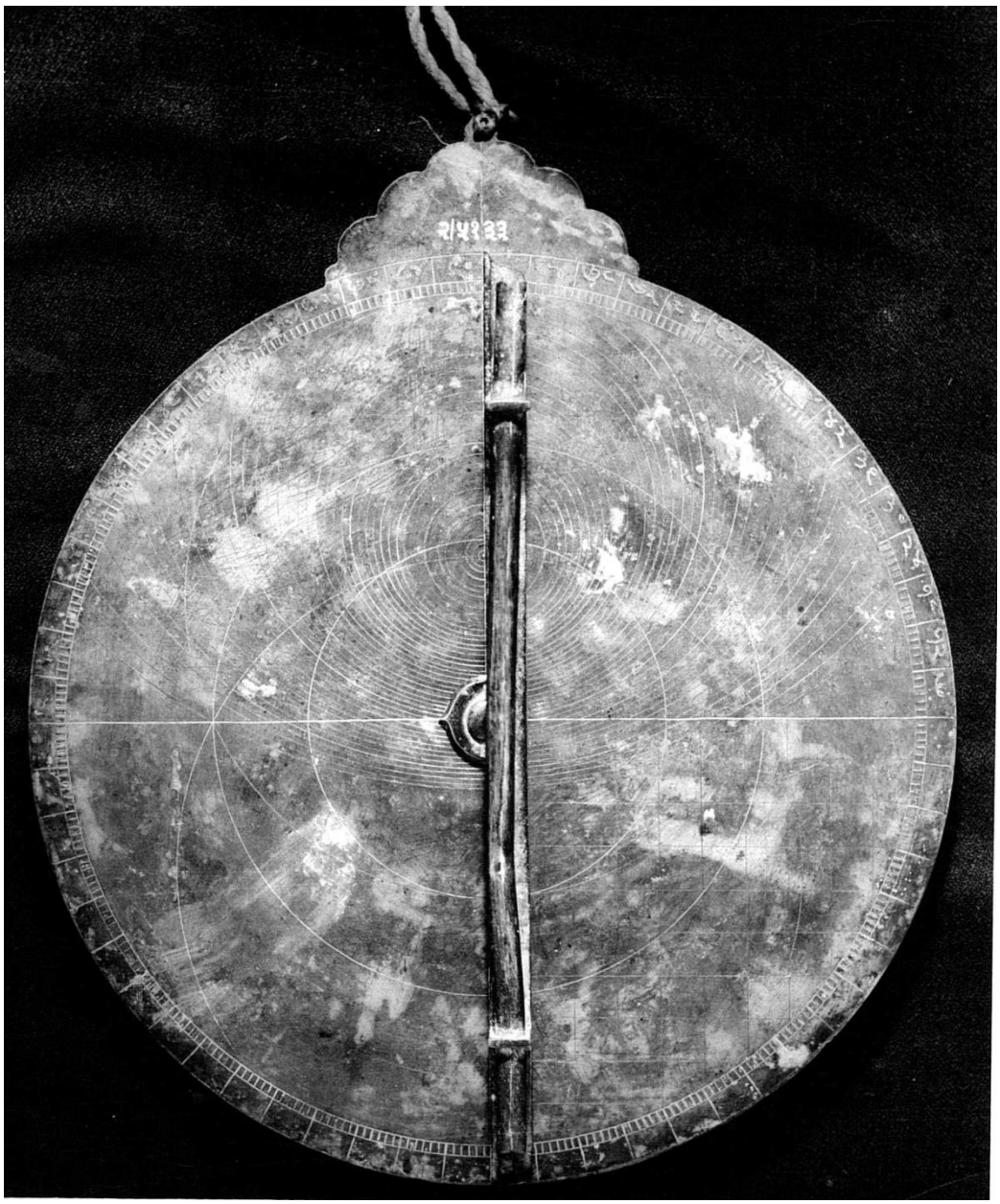


Figure D048.4 – Back of the astrolabe (courtesy Bharat Kala Bhavan)

ASTROLABES FOR LATITUDE 26° MADE AT JODHPUR

Three astrolabes are designed for the latitude of Jodhpur at 26°. Stylistically the first two belong together with similar crowns and must have been made by the same person around 1867. The third one displays a different workmanship.

D049⊙ ASTROLABE FOR LATITUDE 26°, NOT SIGNED

1867, Jodhpur, Rajasthan

Diameter 213 mm

Heidelberg, PC



Figure D049.1 – Front of the astrolabe (photo by Oskar Kober)

According to the inscription on the crown, this astrolabe was made in Jodhpur in Vikrama Saṃvat 1924 (= AD 1867-68). This astrolabe and the following specimen share a distinct form of crown. The workmanship and orthography are poor in both.

COMPONENTS

Plate with crown (d. 213, h. 249) shackle and ring, rete (d. 186) for 22 stars, alidade with a sighting tube, pin and bird-shaped wedge.

FRONT

The ring is heavy and the shackle has a trifoliate form. The crown has a distinctive form with tiger's claw like projections at the base on the left and the right. The degree scale on the rim is divided in 1° and 6° and numbered in 6s from the east point onwards as 6—90; 90—6; 6—90; 90—6. The digit 4 has a peculiar shape. Altitude circles are drawn for each 3° and every third line is emphasized by dots. These circles are labelled on the left as well on the right. Azimuth arcs drawn above and below the horizon for each 6° but not labelled. Dotted lines for unequal hours are numbered from 1 to 12 from the western horizon. Below the local horizon is engraved 26 in digits to declare that the plate is made for 26° latitude.

RETE

The rete is crudely made. The three rings of Tropic of Capricorn, equator and ecliptic are held together by the equinoctial bar. The ring of the equator is counterchanged where it intersects with the ring of the ecliptic. The ecliptic is divided into the 12 signs and labelled, not always correctly, with the names of the signs. There was an attempt to divide each sign into five units of 6°, further each of these into sub-units of 2°, but the divisions are not clearly drawn. Two star pointers (*Samudrapakṣī* and *Maghā*) were added later with copper pins and hammered. With these, there are altogether twenty-two dagger-shaped star pointers as shown in the following table.



Figure D049.2 – Rete of the astrolabe (photo by Oskar Kober)

Table D049-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣa*	*Samudrapakṣī*	β Ceti
2	*Machodara*	*Matsyodara*	β Andromedae
3	*Pretasira*	*Pretaśira*	β Persei
4	*Royaṇī*	*Rohiṇī*	α Tauri
5	*Bramarīpai*	*Brahmahṛdaya*	α Aurigae
6	*Pātī*	*Prajāpati*	δ Aurigae
7	*Ādrā*	*Ārdrā*	α Orionis

	Star Name as engraved	Full/Correct Form	Identification
8	*Lubadaka*	*Lubdhaka*	α Canis Majoris
9	*Ludabaṃda*	*Lubdhaka-bandhu*	α Canis Minoris
10	*Mahāpuruṣa*		α Hydrae
11	*Maghā*		α Leonis
12	*Purbā Phālugaṇa*	*Pūrva-phālgunī*	δ Leonis
13	*Hasta*		δ Corvi
14	*Cītrā*	*Citrā*	α Virginis
15	*Marīca*	*Marīci*	η Ursae Majoris
16	*Svāta*	*Svāti*	α Bootis
17	*Sarapadhārī*	*Sarpadhārīśira*	α Ophiuchi
18	*Abhijita*	*Abhijit*	α Lyrae
19	*Saravaṇa*	*Śravaṇa*	α Aquilae
20	*Aśvaī*	*Aśvamukha*	ε Pegasi
21	*Satabhīsa*	*Śatabhiṣā*	λ Aquarii
22	*Purvā Bhādrapada*	*Pūrva-bhādrapadā*	β Pegasi



Figure D049.3 – Back of the astrolabe (photo by Oskar Kober)

BACK

On the back, the rim of the upper half bears the altitude scale, divided in 1° and 6° and numbered as 6—90; 90—6 from the east point onwards. The same scale extends in the lower half also, but is not numbered.

In the upper left quadrant are drawn five equi-distant declination circles and 6 unequal hour curves. The upper right quadrant has a sine-cosine graph formed by 30 equi-distant horizontal and 30 equi-distant vertical parallels.

The lower half bears two shadow squares, both divided into 7 units. However, there are no numbers or labels in any of the four quadrants.

INSCRIPTION



Figure D049.4 – Crown with the Date (photo by Oskar Kober)

On the front side of the crown is the following inscription in two lines:

saṃ 1924 rā, jodhapuramadhye,

'[Made] in Vikrama Saṃvat 1924 (= AD 1867-8) at Jodhpur.'

BIBLIOGRAPHY

Sarma 2008c, pp. 23-27.

D050⊙ ASTROLABE FOR LATITITUDE 26°, MADE FOR RAṆAKUṂJALĀLA, NOT SIGNED, NOT DATED

Ca. 1867, Jodhpur, Rajasthan

Diameter 207 mm

Heidelberg, PC



Figure D050.1 – Front of the astrolabe (photo by Oskar Kober)

This astrolabe has a crown similar to that of the previous astrolabe (D049) and the rete is also quite similar. It is also made for the latitude of 26° and is of about the same size. The altitude circles and azimuth arcs are drawn for the same intervals. Therefore

it is certain that it was made by the same astrolabe maker at Jodhpur and about the same time around 1867-68.

COMPONENTS

Plate with crown (d. 207, h. 247), shackle and ring, rete (d. 184) for 21 stars, alidade with a sighting tube, pin, bird-shaped wedge.

FRONT

On the front of the crown is inscribed *oṃ oṃ* in the upper line and *raṇakuṃjalāla* in the line below. Raṇakuṃjalāla must be the name of the person who commissioned the astrolabe.

The rim carries a degree scale which is divided in 1° and 6° and numbered from 1 to 60. The single degree divisions are uneven. Altitude circles are drawn for each 3°, every third line is emphasized by dots. These are numbered on the left as well on the right. Here many false lines were drawn first and then corrected. Azimuth arcs are drawn above and below the horizon for each 6° but not labelled. Lines for unequal hours are numbered from 1 to 12 from the western horizon. Below the local horizon is engraved in large digits 26 to declare that the plate is calibrated for 26°, the latitude of Jodhpur.

RETE

The rete is cut out crudely from a thick sheet. The edge is ribbed. The three rings of the Tropic of Capricorn, the equator and the ecliptic are held together by the equinoctial bar. The ring of the equator is counterchanged where it intersects with the ring of the ecliptic. The ecliptic is divided into 12 signs and labelled; each sign is divided into groups of 6°, which are numbered as 6, 12, 18, 24, 30. Twenty-one dagger shaped star pointers (10 outside the ecliptic and 11 inside the ecliptic) on which the star names are often incorrectly engraved.

Table D050-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣa*	*Samudrapakṣī*	β Ceti

	Star Name as engraved	Full/Correct Form	Identification
2	*Machāhara*	*Matsyodara*	β Andromedae
3	*Pretasira*	*Pretaśira*	β Persei
4	*Royanī*	*Rohiṇī*	α Tauri
5	*Bṛmaha*	*Brahmahṛdaya*	α Aurigae
6	*Ādrā*	*Ārdrā*	α Orionis
7	*Lubahaka*	*Lubdhaka*	α Canis Majoris
8	*Lubdhakabaṃdhu*		α Canis Minoris
9	*Mahāpuruṣa*		α Hydrae
10	*Maghā*		α Leonis
11	*Purabā Phālugaṇa*	*Pūrva-phāgunī*	δ Leonis
12	*Hasta*		δ Corvi
13	*Cāśā*	*Citrā*	α Virginis
14	*Marīca*	*Marīci*	η Ursae Majoris
15	*Svātī*	*Svāti*	α Bootis
16	*Sarapadhārī*	*Sarpadhārīśira*	α Oph
17	*Abhija*	*Abhijit*	α Lyrae
18	*Śravaṇa*		α Aquilae
19	*Aśvamukha*		ε Pegasi
20	*Satabhīṣā*	*Śatabhiṣā*	λ Aquarii
21	*Purabābha*	*Pūrva-bhādrapadā*	β Pegasi

BACK

The rim of the upper half carries the altitude scale, divided in 1° and 6° and numbered as 6—90; 90—6. The rim of the lower half is blank. In the upper left quadrant,

below the altitude scale, is engraved an astrological table with twelve columns and two rows with certain syllables engraved in each cell.

Table D050-2 Planets governing the twelve Hours of the Day

ra	*ca*	*ma*	*bu*	*pṛ*	*śu*	*śa*	*ra*	*ca*	*ma*	*bu*	*pṛ*
nraka	*imṛ*	*ro*	*lā*	*su*	*ca*	*ka*	*nra 6*	*imṛ*	*ro*	*lā*	*su*

The first row contains the names of planets in abbreviated form and the second row their influence. The table seems be to related to the so-called *chau-ghaḍiya* system where planetary regents are assigned to each 4 *ghaṭīs* of the day and of the night.[901] Thus in this system, the day is divided into 8 units of 4 *ghaṭīs* (= 96 minutes) each. In the present table, this system is applied to the day of 12 hours (and probably also to the night of 12 hours). There are many errors in the engraved table. The errors are corrected, the abbreviations expanded and translated in the following table.

Table D050-3 Planets and their influence on the twelve Hours of the Day

Ravi	Sun	*naraka*	hell
Candra	Moon	*amṛta*	immortality
Maṅgala	Mars	*roga*	disease
Budha	Mercury	*lābha*	gain, profit
Bṛhaspati	Jupiter	*śubha*	auspiciousness
Śukra	Venus	*cara*	fickle
Śani	Saturn	*kāla*	death
Ravi	Sun	*naraka*	hell
Candra	Moon	*amṛta*	immortality
Maṅgala	Marcs	*roga*	disease
Budha	Mercury	*lābha*	profit

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901 I did not find any reference to this system in Sanskrit texts, but one gets innumerable hits in Google. It is probably some aspect of popular astrology prevalent in northern India.

Bṛhaspati	Jupiter	*śubha*	auspiciousness

A similar table occurs in D017. There the effect the sun is stated to be *u[gra],* ‘fierce’.

The upper right quadrant has a sine-cosine graph, constituted by 30 horizontal and 30 vertical parallels. In the lower half there are carelessly drawn shadow squares, on the left for a base of 12 and on the right for 7. The scales are divided in appropriate number of divisions and numbered. In the centre of the squares are the labels, on the left: *12 dvādasa aṃgula* (*dvādaśāṅgula*) *chāyā*, ’shadow of 12 digits’; on the right: *7 sapata aṃgula* (*saptāṅgula*) *chāyā*, ‘shadow of 7 digits’.

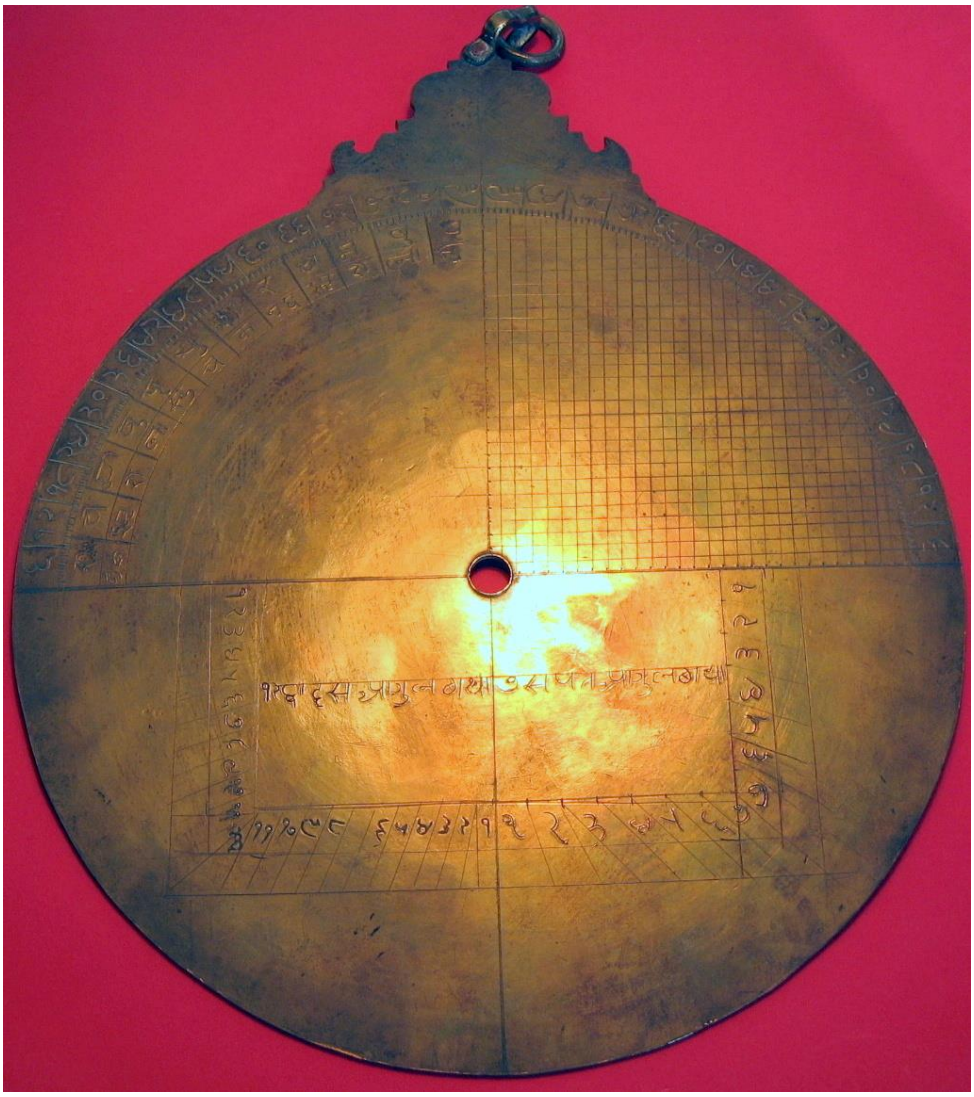


Figure D050.2 – Back of the astrolabe (photo Oskar Kober)

There is a straight bar alidade, one half of which is graduated. It is equipped with a sighting tube.

Inscription

On the front of the crown is the inscription *Om Om Raṇakuṃjalāla.* It must be the name of the person who commissioned the astrolabe.

Bibliography

Sarma 2008c, pp. 23-27.

D051⊙ ASTROLABE FOR LATITUDE 26°, NOT SIGNED, NOT DATED

19th century, Jodhpur, Rajasthan

Diameter 276 mm

Paris, PC



Figure D051.1 – Front of the astrolabe (courtesy Anthony J. Turner)

It is a neatly crafted astrolabe with a triangular crown. It is rare that the legends and numbers in a Sanskrit astrolabe exhibit such beautiful calligraphy. The numerals 4,

6, 9 have distinctive forms. In spite of his beautiful hand, the engraver committed some errors in numbering the divisions on the scales and in labeling the star pointers on the rete.

COMPONENTS

Plate with crown (d. 276, h. 340), rete (d. 247) for 21 stars, alidade, pin and wedge; shackle and ring are missing.

FRONT

The rim carries a degree scale, divided in 1° and 6°; the latter are numbered serially from 1 to 60. By mistake, the astrolabe maker engraved after 59, the number 90 instead of 60.

Altitude circles are drawn for each 2° and labelled accordingly on the left and on the right. The circles are neatly drawn, but not always quite uniformly. Azimuth arcs are both above and below the horizon for each 10˚, but the arcs that should occur immediately next to the meridian line on the right and left are omitted.

There are lines for the equal and unequal hours, both counted from the western horizon. Neither the azimuth lines, nor the hour lines are numbered.

There is no inscription mentioning the latitude for which the plate is calibrated, but the disposition of the altitude circles shows that it is made for the latitude of 26˚, probably for Jodhpur in Rajasthan.

RETE

The three rings containing the tropic of Capricorn, the equator and the ecliptic are held together by the complete equinoctial and complete solsticial bars, which have no counter changes. The ecliptic ring is wider than the other two. It is divided into the 12 signs and labelled with their names. Each sign is subdivided into 5 units of 6˚ each and the units are numbered as 6, 12, 18, 24, 30. Each of these subdivisions is further subdivided into 1˚. The division marks are engraved on the sloped edge of the ecliptic ring.



Figure D051.2 – Rete of the Astrolabe (courtesy Anthony J. Turner)

There are 20 dagger-shaped star pointers, 8 outside, i.e. south of the ecliptic, and 12 inside, i.e. north of the ecliptic. In addition, a star name *hasta* (δ Corvi) was engraved on the outer ring, but without the corresponding pointer. The astrolabe maker was not careful in engraving the star names. In some cases, the labels are clearly wrong. In some other cases, the names are right, but not correctly spelt. Often the *anusvāra*, i.e. the dot above the horizontal line denoting *ṃ*, is missing.

Table D051-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Matsyodarapāda*		γ Andromedae
3	*Rohiṇī*		α Tauri
4	*Brahmahadraya*	*Brahmahṛdaya*	α Aurigae
5	*Mithunaskandha*	*Mithuna-vāma-pāda*	β Orionis
6	*Mithunavāsaskaṃdha*	*Mithuna-vāma-skandha*	γ Orionis
7	*Lubdhaka*		α Canis Majoris
8	*Lubdhakabaṃdhu*		α Canis Minoris
9	*Maghā*		α Leonis
10	*Pūvāphālā*	*Pūrvaphālguṇī*	δ Leonis
11	*Hasta*		δ Corvi
12	*Marīca*	*Marīci*	η Ursae Majoris
13	*Citrā*		α Virginis
14	*Svāti*		α Bootos
15	*Vaśiṣṭa*	*Vaśiṣṭha*	ζ Ursae Majoris
16	*Sarpadhārīśira*		α Ophiuchi
17	*Abhijit*		α Lyrae
18	*Śrāvaṇa*	*Śravaṇa*	α Aquilae
19	*Śatabhiṣā* (sic!)	*Kukkuṭa-puccha*	α Cygni
20	*Pūrvā Bhādrapada*		β Pegasi
21	*Matsyodara* (sic!)	*Aśvanābhi*	δ Pegasi = α Andromedae

As in several other astrolabes, *Kukkuṭapuccha* is wrongly labelled as *Śatabhiṣā.* It appears that the astrolabe maker created the pointer for *Matsyodara* wrongly to the south of the horizontal bar instead of to the north.

BACK

The rim of the upper half carries the altitude scale, divided in 1° and 6° and labelled separately for each quadrant (6—90; 90—6). The rim in the lower half is blank.

The upper left quadrant has a sine graph, but strangely with 34 horizontal parallels and without any labels. In the upper right, there is a solar quadrant with declination circles for each 30° of solar longitude. The names of the related signs are engraved from the summer solstice to the winter solstice (*Makara, Kumbha, Mīna, Meṣa, Vṛṣa, Mithuna*) along the horizontal axis and from the winter solstice to the summer solstice (*Karka, Siṃha, Kanyā, Tulā, Vṛścika, Dhanu*) along the vertical axis.



Figure D051.3 – Back of the Astrolabe (photo courtesy Anthony J. Turner)

In the lower half are engraved shadow squares, on the left for the gnomon of 12 digits and on the right for the gnomon of 7 digits. The four scales are appropriately divided and numbered. They are accompanied by the following labels:

Vertical scale on the left: *dvādaśāgulaśakoḥ vilamachāyā* (! *dvādaśāṃgulaśaṃkor vilomachāyā*), ‘umbra versa of the 12-digit gnomon’,

Horizontal scale on the left: *dvādaśāgulaśakoḥ samachāyā* (! *dvādaśāṃgulaśaṃkoḥ samachāyā),* ‘umbra recta for the 12-digit gnomon’,
Horizontal scale on the right: *saptāgulaśakoḥ samachāyā* (! *saptāṃgulaśaṃkoḥ samachāyā),* ‘umbra versa for the 7-digit gnomon ’.
Vertical scale on the right: *saptāgulaśakor vilomachāyā* (! *saptāṃgulaśaṃkor vilomachāyā),* ‘umbra versa of the 7-digit gnomon’.

The alidade is rather short; it measures just 219 mm x 10 mm as against the diameter of 276 mm. Perhaps it is not original and is a replacement. There are two rectangular sighting plates with holes in them. The alidade is held by a pin and a wedge.

ASTROLABES FOR LATITUDE 30° MADE AT KURUKSHETRA OR THANESAR

As mentioned in the introduction to the section C, the production of Sanskrit astrolabes was largely confined to Gujarat and Rajasthan.[902] But there are four astrolabes whose plates are designed for latitude 30° (D052 to D055). There is no major town on this latitude in Gujarat or Rajasthan. Possibly these astrolabes were made either in Kurukshetra or in Thanesar, both situated roughly at 29;58° N, 76;50° E.

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[902] C. Introduction 2.2.

D052 ASTROLABE FOR LATITUDE 30°, NOT SIGNED, NOT DATED[903]

19th century, Kurukshetra / Thanesar

Diameter 174 mm

Chicago, Adler Planetarium & Astronomy Museum (# W-102)



Figure D052.1 – Front of the astrolabe (accession no. W-102)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

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[903] Entry based on Pingree 2009, no. 49, pp. 200-201.

This and the next three astrolabes are made for the latitude of 30°; Kurukshetra, Thanesar and Multan lie roughly on this latitude.

COMPONENTS

Plate with crown (d. 174, h. 211, t. 1), shackle, ring, rete (d. 156) for 22 stars, alidade with a sighting tube, washer, pin and wedge.

Numbers and labels are neatly engraved and filled with a black substance.

FRONT

The crown is high and solid; its profiles are made up of ogees at the base followed by lobes. The shackle has a trifoliate form with trifoliate bases. The ring is simple.

The circular scale on the rim is divided in 1° and in 6°. Groups of 6° are numbered serially from 1 to 60 clockwise from the south point. East-west and south-north lines are drawn; the later is extended on the surface of the crown as well. Altitude circles are drawn for every 3° and the azimuth arcs above and below the horizon for every 10°. In the lower half are the curves for unequal hours. None of these lines is numbered, nor is there any inscription mentioning the latitude for which the plate is made. But the plate is calibrated roughly for the latitude of 30°, probably for Kurukshetra, Thanesar or Multan which all have roughly the same latitude.

RETE

The rete consists of the three almost complete rings of the Tropic of Capricorn, the equator and the ecliptic, held together by a horizontal bar whose upper edge constitutes the equinoctial colure. The circular disc at the centre is joined to the ecliptic ring by a segment of the vertical solstitial bar. The equator ring is counterchanged at equinoxes where it intersects with the ecliptic ring.

The ecliptic ring is divided into the 12 zodiac signs and labelled with their respective names. Each sign is further subdivided into groups of 6° and labelled as 6, 12, 18, 24, 30. On the edge, these divisions are further subdivided into parts of 2° each. There are 22 star pointers. While most of them are dagger-shaped, a few of them are curved.

Table D052-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Matsyodara*		β Andromedae
3	*Ma.pā.*	*Matsyodara-pāda*	γ Andromedae
4	*Pre*	*Pretaśira*	β Persei
5	*Rohaṇī*	*Rohiṇī*	α Tauri
6	*Mi.vā.pā.*	*Mithuna-vāma-pāda*	β Orionis
7	*Vralāha*	*Brahmahṛdaya*	α Aurigae
8	*Ārdrā*		α Orionis
9	*Ludhvaka*	*Lubdhaka*	α Canis Majoris
10	*La.badhu.*	*Lubdhaka-bandhu*	α Canis Minoris
11	*Mahāpuruṣa*		α Hydrae
12	*Pū.phā.*	*Pūrva-phālgunī*	δ Leonis
13	*Hasta*		δ Corvi
14	*Citrā*		α Virginis
15	*Marīca*	*Marīci*	η Ursae Majoris
16	*Svāti*		α Bootis
17	*Sapadhārā*	*Sarpadhārīśira*	α Ophiuchi
18	*Abhiji*	*Abhijit*	α Lyrae
19	*Śravaṇa*		α Aquilae
20	*Aśvamuṣa*	*Aśvamukha*	ε Pegasi
21	*Śatabhiṣā*		λ Aquarii
22	*Pū.bhā.*	*Pūrva-bhādrapadā*	β Pegasi



Figure D052.2 – Back of the astrolabe (accession no. W-102)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

BACK

As in the front, the circular scale on the rim of the back is divided in 1° and in 6°. The groups of 6° are numbered from 6 to 90 in the upper half, starting from the east and west points and reaching up to the south point. On the left quadrant, 16 is engraved in the place of 18, apparently by mistake. As in the front, east-west and south-north lines are drawn; the later extending on the surface of the crown also. Otherwise, the four quadrants are blank.

BIBLIOGRAPHY

Pingree 2009, no. 49, pp. 200-201.

D053⊙ ASTROLABE FOR LATITUDE 30°, NOT SIGNED, NOT DATED

19th century, Kurukshetra / Thanesar

Diameter 174.5 mm

New Delhi, National Museum (#85406/A/B)



Figure D053.1 – Front of the astrolabe (courtesy National Museum, New Delhi)

This and the following two astrolabes (i.e., D053, D054 and D056) have crowns of different styles, but they are designed for the latitude of 30° and display the same

kind of workmanship. They are made of copper and the engraved parts are filled in with a white substance. The reverse side is bot completed in all them. They must have been fabricated by the same artisan about the same time. But it is difficult to say whether these were made at Kurukhetra, Thanesar or Multan which have roughly the same latitude.

COMPONENTS

Plate with crown (d. 174.5, h. 188), shackle and ring, rete for 25 stars. Alidade, pin and wedge are missing.

FRONT

A low arc-shaped simple crown with a shackle and ring. The degree scale on the rim is divided in 1° and in 6°. Groups of 6° are numbered serially from 1 to 15 in each quadrant separately, starting from the east and west points and reaching up to the south and north points. The plate is cluttered with altitude circles for every 2°, azimuth arcs above and below the horizon for every 2° and lines for seasonal hours, none of which is numbered. There are faint traces of the equator and the Tropic of Cancer. The disposition of the altitude circles suggests that this plate was made for use at the latitude of 30°.

RETE

The three rings of the Tropic of Capricorn, the equator and the Tropic of Cancer are held together by the equinoctial and solstitial bars, neither of which has a counter change. The equator ring is counterchanged at equinoxes where it intersects with the ecliptic ring.

The ecliptic ring is divided into the 12 zodiac signs and labelled with their names, each sign is divided into 5 parts and numbered accordingly. The beveled edge is divided into single degrees. There are more star names than pointers. In four cases (6, 14, 20, 24) star names are engraved on the circular rings or straight bars without providing corresponding pointers. The names are engraved very carelessly. Two alternative names (*dhanuṣkoṭi* and *sarpadhārīśira*) are engraved for α Ophiuchi (no. 19). On the star pointer 9 is given the abbreviated name *mi.vā,* its full expansion *vāmaskaṃdha* is engraved further away.

Table D053-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Madanopara*	*Matsyodara*	β Andromedae
3	*Pretaśirasa*	*Pretaśira*	β Persei
4	*Pretamita*	*Manuṣya-pārśva*	α Persei
5	*Rohiṇī*		α Tauri
6	*Ṣaṇmāya*	*Ṣaṇmukha*	α Aurigae
7	*Prajāpati*		δ Aurigae
8	*Mithunaskaṃdha*	*Mithuna-vāma-pada*	β Orionis
9	*Mi.vā.*	*Mithuna-vāma-skandha*	γ Orionis
10	*Lubdhaka*		α Canis Majoris
11	*Lubdhakabadhā*	*Lubdhaka-bandhu*	α Canis Minoris
12	*Maghā*		α Leonis
13	*Ārāphā*	*Pūrva-phālgunī*	δ Leonis
14	*Hasta*		δ Corvi
15	*Citrā*		α Virginis
16	*Marīci*		η Ursae Majoris
17	*Svāti*		α Bootis
18	*Viśaṣā*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
19	*Dhanuṣkoṭi*		α Ophiuchi
20	*Abhimata*	*Abhijit*	α Lyrae
21	*Śrāvaṇa*	*Śravaṇa*	α Aquilae
22	*---tajīvā*	*Kukkuṭa-cañcu*	β Cygni

	Star Name as engraved	Full/Correct Form	Identification
23	*Patamā*	*Pūrva-bhādrapadā*	β Pegasi
24	*Kārtikabhuja*	*Kartitakara*	β Cassiopeiae
25	*Aśvanātra*	*Aśvanābhi*	δ Pegasi

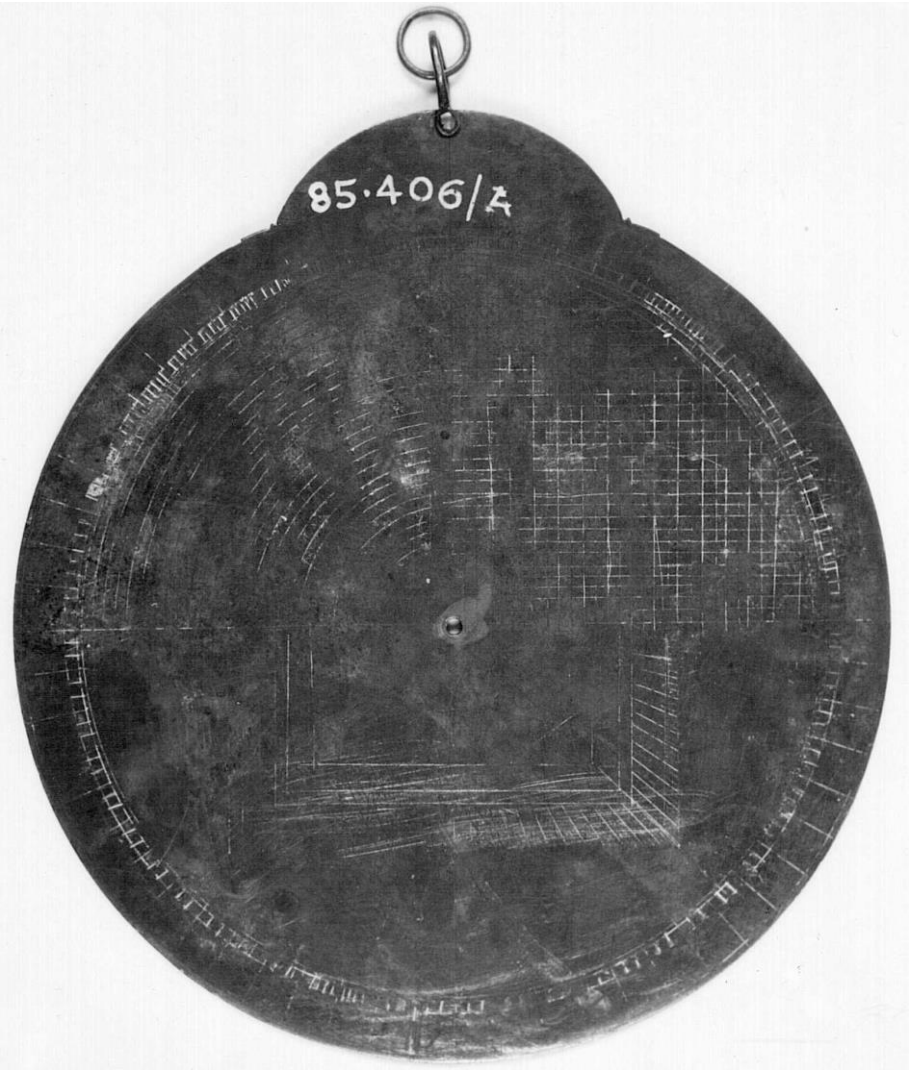


Figure D053.2 – Back of the astrolabe (courtesy National Museum, New Delhi)

BACK

The entire rim is covered by the degree scale which is divided in 1° and in 6° but not numbered. A solar quadrant with 24 quarter circles and no labels occupies the upper left. In the upper right quadrant is engraved a sine-cosine graph with 30 horizontal and 30 vertical parallels. In the lower half are shadow squares which are left unfinished. On

the right, the vertical and horizontal scales are divided in 12 parts each; on the left there are no such divisions. There are no labels or numbers on the entire surface.

D054⦿ ASTROLABE FOR LATITUDE 30°, NOT SIGNED, NOT DATED

19th century, Kurushetra / Thanesar

Diameter 236 mm

Vadodara, MS University of Baroda, Oriental Institute



Figure D054.1 – Front of the astrolabe (photo by S. R. Sarma)

COMPONENTS

Plate with the crown (d. 236, h. 285), rete (d. 207) for 17 stars; alidade, pin and wedge are missing.

FRONT

The crown is high; its profiles are formed by ogees at the base, followed by two lobes. On the front surface of the crown is engraved a half lotus enclosed within a semicircle. The back of the crown also carries a half lotus (but of slightly different design) inside a semicircle. The rim of the plate carries the degree scale, divided into 1° and 6°; the latter are numbered serially from 1 to 60. The lines of division are carelessly drawn; the divisions are not uniform; the lines should point towards the centre of the circle, but rarely do so.

Altitude circles are drawn for each 3° and numbered as 1, 2, 3 …28 on the left as well as on the right, and not as 3, 6, 9 ...90, which is the general practice. The last two numbers, viz. 29 and 30, are not engraved owing to the lack of space. Azimuth arcs are drawn above and below the horizon for each 9°, but some are omitted in the vicinity of the meridian. In the lower half, lines of unequal hours are drawn but not numbered. The lines on the left are very faint. There is no inscription stating the latitude for which the plate is calibrated; but the arrangement of the altitude circles shows that this plate was made approximately for the latitude of 30°.

RETE

The three almost complete rings representing the Tropic of Capricorn, the celestial equator and the ecliptic are held together by the equinoctial bar and a short segment of the solstitial bar which connects the Tropic of Capricorn and the equator. The equator ring is counter-changed at the two equinoxes where it intersects with the ecliptic ring. The ecliptic is divided into the 12 signs of the zodiac and labelled with their names. Each sign is divided into 5 parts of 6°; each part is further subdivided on the edge into 3 units of 2° each.

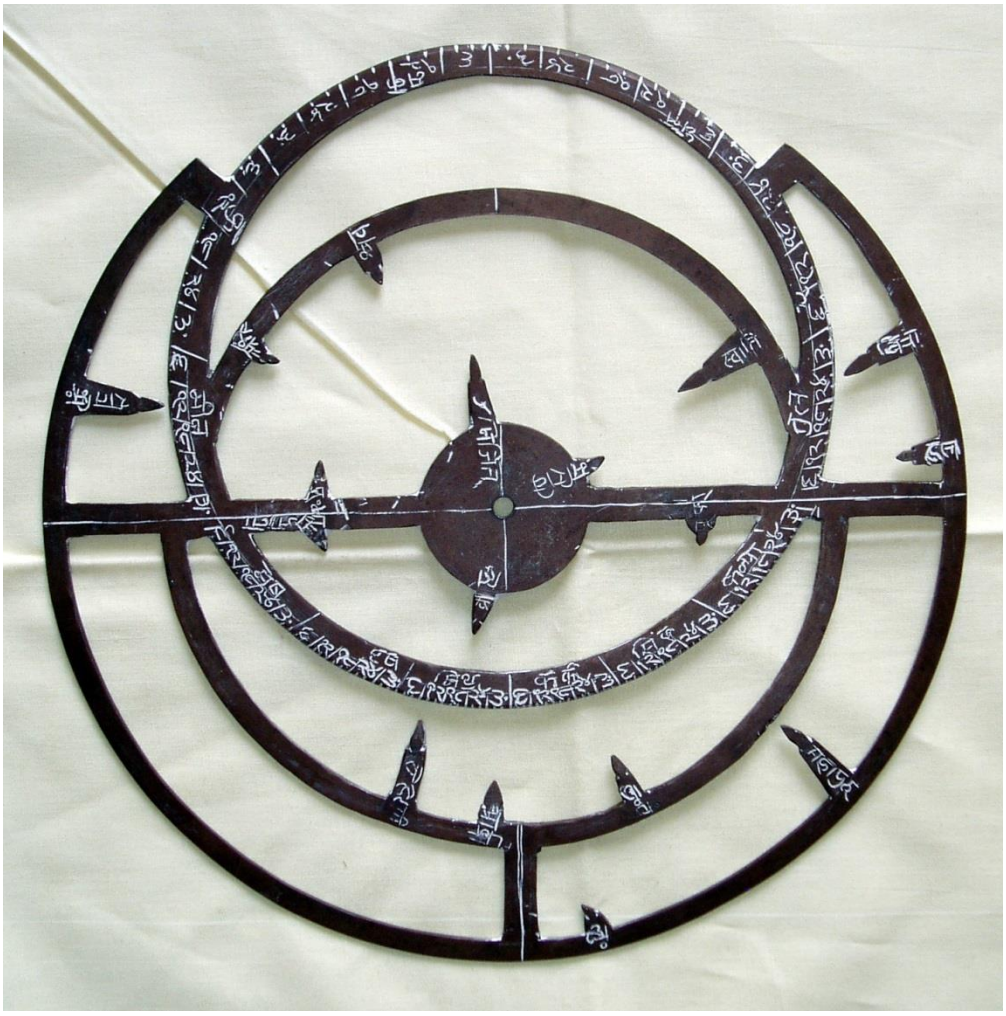


Figure D054.2 – Rete of the Astrolabe (photo by S. R. Sarma)

There are 17 dagger shaped star pointers, 5 outside the ecliptic and 12 inside. These are listed below in the order of their increasing right ascension.

Table D054-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Ajānā*	*Matsyodara* ?	β Andromedae
2	*Rohiṇī*		α Tauri
3	*Bra. hṛ.*	*Brahma-hṛdaya*	α Aurigae
4	*Ārdrā*		α Orionis
5	*Lu.*	*Lubdhaka*	α Canis Majoris
6	*Lu. ta.*	*Lubdhaka-bandhu*	α Canis Minoris

	Star Name as engraved	Full/Correct Form	Identification
7	*Mahāpuru*	*Mahāpuruṣa*	α Hydrae
8	*Pū. phā.*	*Pūrva-phālgunī*	δ Leonis
9	*Hasta*		δ Corvi
10	*Citrā*		α Virginis
11	*Marīci*		η Ursae Majoris
12	*Svāti*		α Bootis
13	*Abhijit*		α Lyrae
14	*Śrava*	*Śravaṇa*	α Aquilae
15	*Āśra*	*Aśvamukha*	ε Pegasi
16	*Śatabhi*	*Śatabhiṣā*	λ Aquarii
17	*Pū.bhā.*	*Pūrva-bhādrapadā*	β Pegasi

BACK

As in the front, the entire rim on the back is covered by a degree scale, divided in 1° and 6°. But only in the upper half the groups of 6° are labelled from 6 to 90, separately for each quadrant, starting from the east and west points and reaching up to the south point.

The upper left quadrant is blank. In the upper right quadrant are engraved 30 vertical and 30 horizontal lines at equal distances, forming the sine-cosine graph. There are no shadow squares in the lower half. Instead, two more circular scales are engraved inside, concentric with the rim, showing single degrees and groups of 6°. These are drawn inaccurately and have no function.

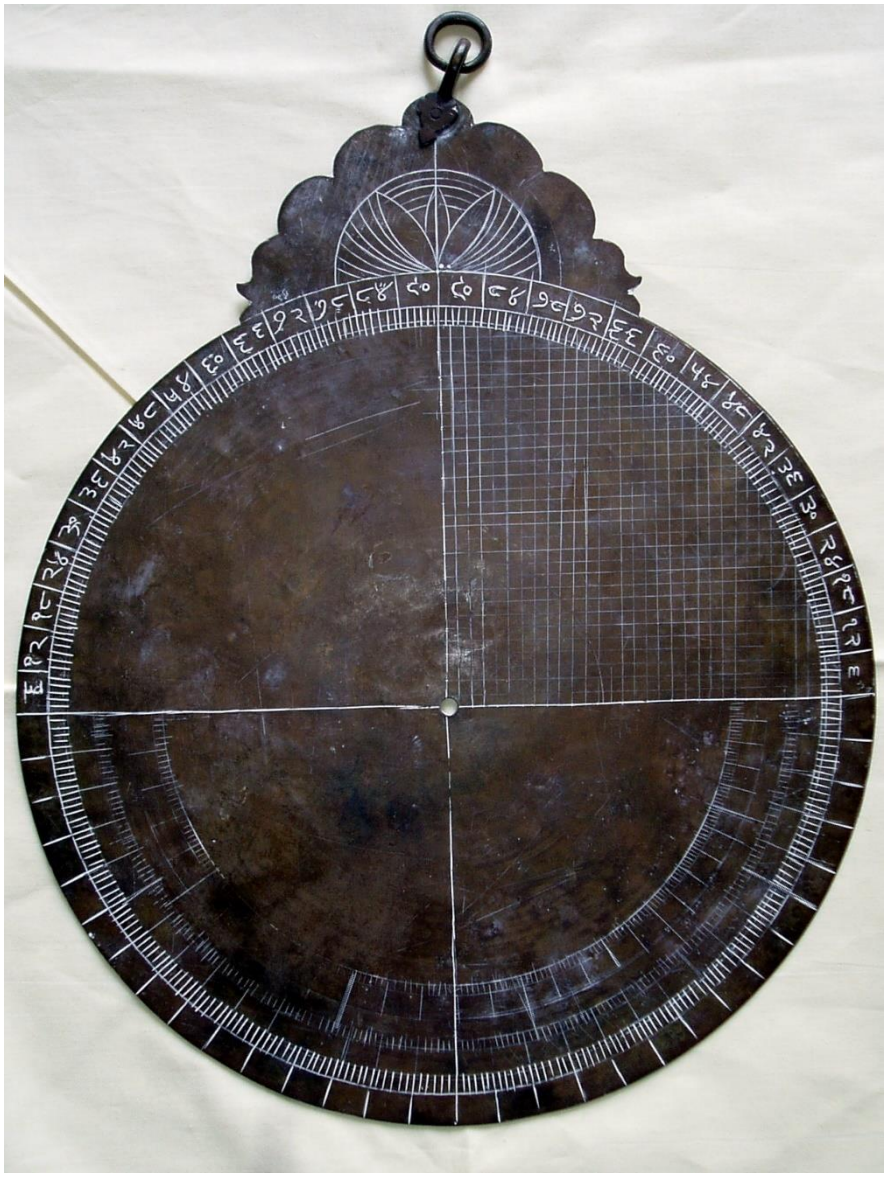


Figure D054.3 – Back of the astrolabe (photo by S. R. Sarma)

BIBLIOGRAPHY

Sarma 2009a, pp. 20-22, Figs. 7-10.

D055⊙ ASTROLABE FOR LATITUDE 30°, NOT SIGNED, NOT DATED

19th century, Kurukshetra / Thanesar

Diamter 218 mm

Varanasi, Sampurnanand Sanskrit University, Sarasvati Bhavan Library



Figure D055.1 – Front of the astrolabe (photo by S. R. Sarma)

COMPONENTS

Plate with crown (d. 218, h. 251, t. 1) with shackle and ring, rete (d. 197) for 25 stars, alidade with a sighting tube and pin. The original wedge is missing.

FRONT

The crown is high and lobed. To the crown is attached a shackle with a diamond cross section and trifoliate bases and a simple ring.

The rim, both in the front and back, carries a degree scale which is divided in 1° and 6°, but not numbered. On the front, altitude circles are drawn for each 2˚ and every third circle (i.e. of 6˚) is highlighted by a dotted line. However, these are not correctly placed with the result that there are more than 45 circles. Azimuth arcs are drawn for each 6˚ below the horizon. Some errors are made in drawing azimuths as well. The circles of Cancer and the prime meridian are not properly aligned. There are lines for seasonal hours. There is absolutely no legend or label on this plate. Even the latitude is not mentioned. But the disposition of the altitude circles shows that the plate is designed for the latitude of 30°.

RETE

The rete consists of the three rings of the Tropic of Capricorn, equator and ecliptic which are held together by the equinoctial bar without counter change. The ecliptic is divided into 12 signs, and these are labelled by the initial letters of their names. On the bevelled outer edge of the ecliptic circle, each sign is subdivided into 15 equal parts of 2˚ each.

There are 25 dagger-shaped star pointers, 10 outside the ecliptic and 15 within. One of these is not named. *Mithuna-Dakṣiṇa-pāda* (9) and *Ārdrā* (10) are alternative designations for the same star α Orionis. Here they are treated as two different stars.



Figure D055.2 – Rete of the astrolabe (photo by S. R. Sarma)

Table D055-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Nāsatya*		β Arietis
2	*Matsyodara*		β Andromedae
3	*Mṛgaśira*		λ Orionis
4	*Manuṣyapāda*	*Manuṣya-pārśva*	α Persei
5	*Rohiṇī*		α Tauri
6	*Brahmahṛdaya*		α Aurigae
7	*Mithuna-vāma-pāda*		β Orionis
8	*Mi.vaṃ.ha.*	*Mithuna-vāma-hasta*	γ Orionis
9	*Mithunadakṣiṇapāda*		α Orionis
10	*Ārdrā*		α Orionis

	Star Name as engraved	Full/Correct Form	Identification
11	*Luva*	*Lubdhaka*	α Canis Majoris
12	*Lubdhakabaṃdhu*		α Canis Minoris
13	*Mahāpuruṣa*		α Hydrae
14	*Pūrvāphā*	*Pūrva-phālgunī*	δ Leonis
15	*Citrā*		α Virginis
16	*Marīci*	*Marīci*	η Ursae Majoris
17	*Svātī*	*Svāti*	α Bootis
18	*Vi.mā.maṃ.*	*Viśākhā-mātṛ-maṃḍala*	α Coronae Borealis
19	*Su.dhā.śi.*	*Sarpadhārī-śira*	α Ophiuchi
20	*Abhijit*		α Lyrae
21	*Śravaṇa*		α Aquilae
22	*Aśvamukha*		ε Pegasi
23	*Pū.bhā.*	*Pūrva-bhādrapadā*	β Pegasi
24	*Utta.bhā.*	*Uttara-bhādrapada*	γ Pegasi



Figure D055.3 – Back of the Astrolabe

BACK

The back is divided into four quadrants. But only the upper left quadrant is filled with a sine-cosine graph with 30 vertical and 30 horizontal parallel equi-distant lines. The rest is blank.

ALIDADE

The alidade has no graduations. There are two holes in each sighting plate. A sighting tube passes through the upper holes which are larger. There is a pin, but no wedge.

ASTROLABES FOR OTHER LATITUDES

In the nineteenth century, the production of Sanskrit astrolabes with single plates spread to many other places in Rajasthan like Kota (latitude 25°), Bikaner (28°) and so on. Sūtradhara Sūryamalla produced, under the guidance of Kastūrīcandra, at least 5 identical astrolabes with a peacock perched on the central ring in the rete for the latitude of Bikaner at 28;16°. Sanskrit astrolabes continued to be made in Gujarat, although sporadically, e.g. D058 made for Karvan near Vadodara at the latitude of 22;35.30°.

Sakhārāma Jośī is said have produced astrolabes for places in Maharashtra, but these have not come to light so far.

Two outstanding astrolabes were designed by the astronomer Gaṅgāsahāya for the latitude of Bundi at 25;30° (D090) and for that of Tonk at 26° (D091). These will be described at the end of this section.

D056 ASTROLABE FOR LATITUDE 17;42° MADE / COMMISSIONED BY SAKHĀRĀMA JOŚĪ

1790

Diameter ?

PLU

Dikshit 1981, p. 233n, reports that in Śaka 1712 (= AD 1790-91), Sakhārāma Jośī made or commissioned a Sanskrit astrolabe for 17;42°, which is the latitude of Satara (modern coordinates: 17;41,29° N and 74;0,31° E). On this astrolabe, Jośī is said to have inscribed the transit altitudes of the junction stars of the 27 lunar mansions and of some other stars. For Maghā, for example, the transit altitude was given as 83;57° S. This and other instruments made by Sakhārāma Jośī were with his great-grandson Sakhārāma Śāstrī at Kaḍegaḍḍi near Belgaum, Sahapur Taluk, Maharashtra in 1896. No other information is available on this astrolabe.

Dikshit states further that Sakhārām Jośī, a resident of Kodoli, produced several instruments like the *Turya-yantra, Phalaka-yantra, Dhruvabhrama-yantra* and astrolabes during Śaka 1712-1718 (= AD 1790-97); he also wrote a commentary on Gaṇeśa Daivajña's *Pratoda-yantra.*

D057 ASTROLABE FOR LATITUDE 17;21° MADE / COMMISSIONED BY SAKHĀRĀMA JOŚĪ

1796

Diameter ?

PLU

Dikshit 1981, p. 233n, reports that in Śaka 1718 (= AD 1796-97), Sakhārāma Jośī made or commissioned a Sanskrit astrolabe for 17;21°, which is the latitude of his native place Koḍoli, near Kolhapur (modern coordinates: 16;41,30° N and 74;14° E). On this astrolabe, Jośī is said to have inscribed the transit altitudes of the junction stars of the 27 lunar mansions and some other stars. For Maghā, for example, the transit altitude was given as 84;15° S. This and other instruments made by Sakhārām Jośī were with his great-grandson Sakhārāma Śāstrī at Kaḍegaḍḍi near Belgaum, Sahapur Taluk, Maharashtra in 1896. No other information is available on this astrolabe.

On Sakārām Jośī, see the previous entry.

D058 ASTROLABE FOR LATITUDE 22;35,30°, NOT SIGNED[904]

1884, Gujarat

Diameter 314 mm

PLU



Figure D058.1 – Front of the astrolabe (courtesy Professor David Pingree)

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[904] Entry based on Moskowitz 1979, item 152, p. 35, and photographs and notes kindly provided by Professor David Pingree who read the astrolabe for Moscowitz.

According to the inscription on the inner surface of the mater, this large astrolabe was produced in 1884. This is perhaps one of the few astrolabes produced in Gujarat in the nineteenth century, for in this century the astrolabe production was mainly concentrated in Rajasthan. Its construction is also rather unusual. The front with the crown and the circular scale, cut of a thick sheet, and the back with the crown were riveted with several nails along the entire circumference, leaving space to accommodate just one latitude plate and the rete. Thus it combines the features of astrolabes with multiple plates and those with a single plate.[905] The workmanship is poor, the divisions in the scales are uneven, straight lines and circles carelessly drawn, the star pointers on the rete are crudely cut.

COMPONENTS

Mater with crown (d. 314, h. 429), shackle and ring, plate (d. 270) for the latitude of 22;35,30°, rete (d. 273) for 18 stars, alidade; original pin and wedge are replaced by a bolt and nut.

FRONT

High lobed crown with a trifoliate finial. The limb is divided very irregularly in 1° and in 6° and numbered from 1 to 60.

PLATE

The plate carries the circles of the equator and the Tropic of Cancer. On these are plotted, very crudely, altitude circles for every 3° which are numbered on both sides of the meridian. There are no azimuth arcs. Lines for seasonal hours are drawn and numbered from the western horizon. Below the eastern and the western ends of the horizon is written *horā* (hour), to designate the numbers engraved between the hour lines. In the centre, below the horizon, is engraved *akṣāṃśa 22/35/3,* 'latitude 22;35,3°'. The catalogue does not say what is on the other side of the plate; perhaps it is blank.

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[905] There is another single plate astrolabe, constructed in the same fashion; it is also of Gujarati provenance, with western Indian numerals, and the rete containing the 'bird in the cage' pattern (D071).

RETE

The three rings of the Tropic of Capricorn, the celestial equator (only the lower half) and the twice wide ecliptic ring are held together by the equinoctial bar which has no counter change. The ecliptic circle is divided into the 12 signs and labelled with their names and serial numbers. Each sign is divided into five parts which are numbered anticlockwise serially from 1 to 5, and not as 6, 12, 18, 24, 30 which is the general practice. Perhaps this is only the astrolabe to deviate from this standard practice. The 18 star pointers are crudely cut and not correctly positioned. They are joined by an inelegant tracery which displays the 'bird in the cage' pattern[906] in the upper half. But the numbers and legends are carefully engraved.

Table D058-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Revatī*		ζ Piscium
2	*Rohiṇī*		α Tauri
3	*Mithunavāmaskandha*		γ Orionis
4	*Mithunadakṣiṇapāda*		κ Orionis
5	*Ṣaṇmukha*		α Aurigae
6	*Ārdrā*		α Orionis
7	*Lubdhaka*		α Canis Majoris
8	*Lubdhakabandhu*		α Canis Minoris
9	*Maghā*		α Leonis
10	*Hasta*		δ Corvi
11	*Citrā*		α Virginis
12	*Svāti*		α Bootis

906 Sarma 2011b, p. 107-110.

	Star Name as engraved	Full/Correct Form	Identification
13	*Viśākhā*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
14	*Dhanakoṭi*	*Dhanuḥkoṭi*	α Ophiuchi
15	*Abhijit*		α Lyrae
16	*Śravaṇa*		α Aquilae
17	*Pūrvābhādrapada*	*Pūrva-bhādrapadā*	β Pegasi
18	*Akhanāna*	*Aśvanābhi*	δ Pegasi

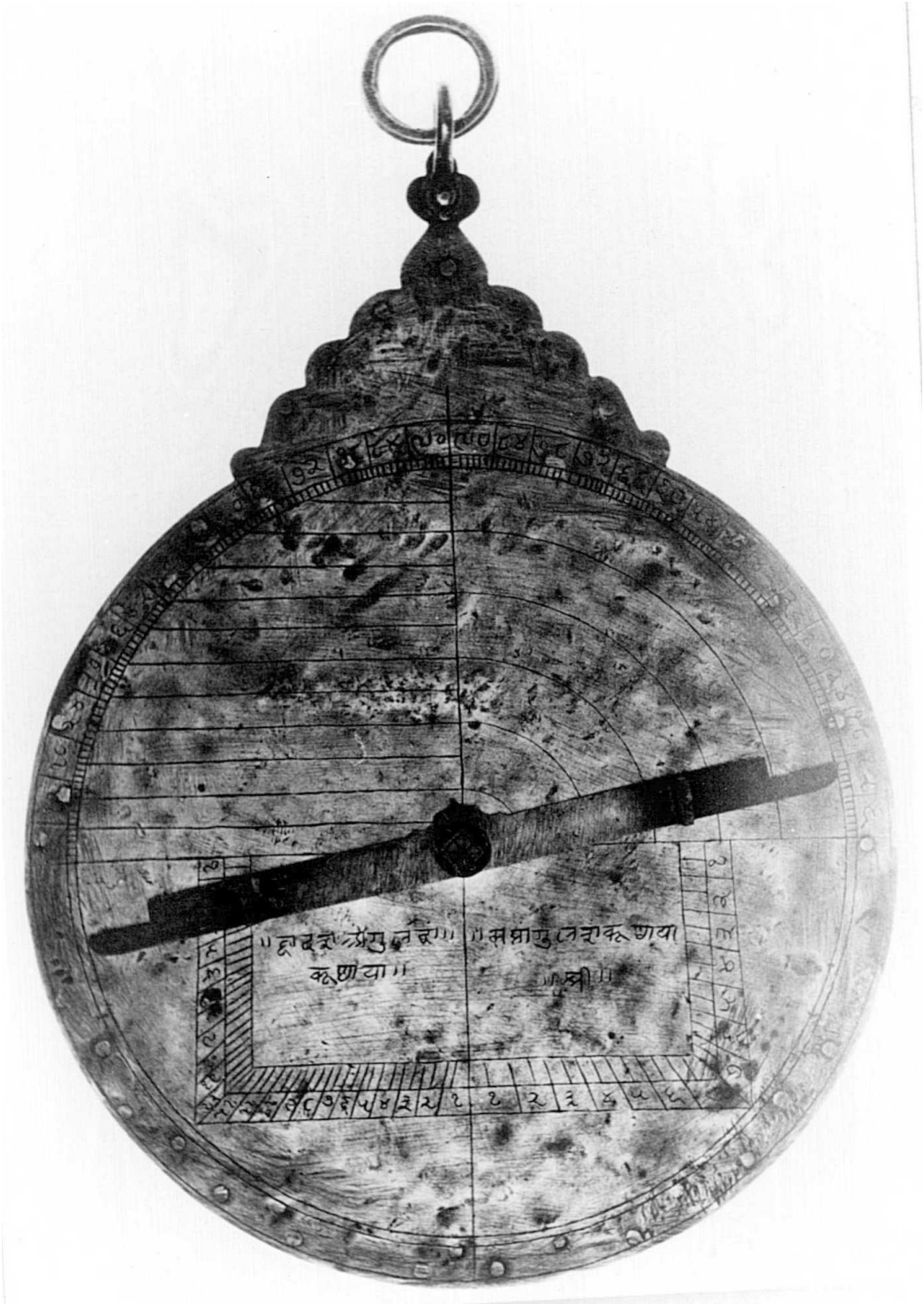


Figure D058.2 – Back of the astrolabe (courtesy Professor David Pingree)

BACK

The upper half of the rim carries the altitude scale divided in 1° and in 6°. The upper left quadrant contains a sine graph with 11 horizontal parallels which are poorly drawn. In the upper right quadrant, there are five concentric quarter circles without any label.

In the lower half, there are shadow squares, on the left for the gnomon of 12 divisions and on the right for the gnomon of 7 divisions. The divisions are numbered and halved. Inside the squares are engraved the following legends on the left and right respectively: *dvādaśa aṃgula śaṃkū chāyā* (shadow of the gnomon of 12 digits); *saptāṃgula śaṃkū chāyā* (shadow of the gnomon of 7 digits). ‖*śrīḥ*‖ '[Let it be] auspicious.

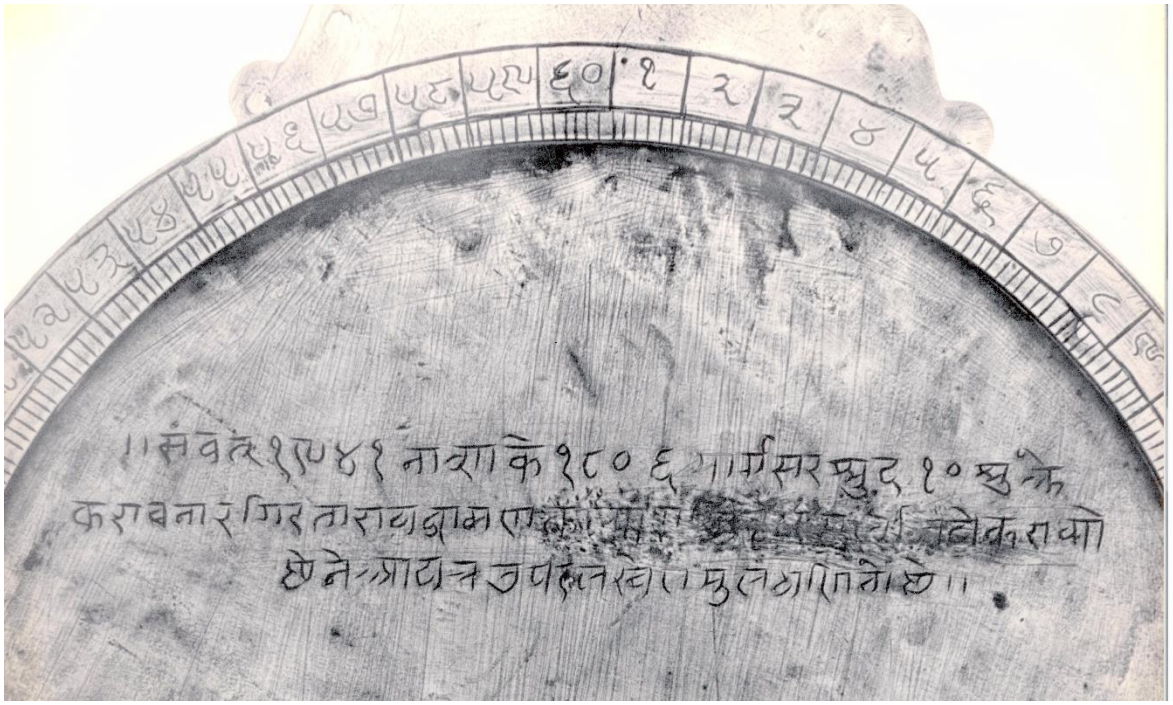


Figure D058.3 – Inscription on the inner side of the mater (courtesy Professor David Pingree)

INSCRIPTION

In the upper half of the inner surface of the mater is engraved the following inscription in three lines in a mixture of Sanskrit and Gujarati. The part filled with asterisks is scratched out.

‖ *saṃvat 1941 nā śāke 1806 mārgasara śuddha 10 śukre*
*karavānāra giratārāya brāmaṇa kṛṣṇa (?) ******* ka rā go*
chene āyatra upara lakha samu saṃgaṇite | che ‖

The first line translates to 'In Saṃvat [year] 1941 and Śaka 1806, in Mārgaśira bright [forthnight] on the tenth lunar day, Friday.' The second two lines are problematic. David Pingree, who saw the photos in 1976, commented as follows:

> 'I can offer no connected explanation of these lines. *Karavānāra* is perhaps a place name, in Gujarat or Rajasthan, and the Rāya Brāhmaṇa Kṛṣṇa … (or his son) caused the astrolabe to be engraved. (The erasure is deliberate, not

a mistake; it is precisely the name of the patron that is obliterated). The inscription on the plate below the horizon-line reads akṣāṃśa 22/35/30 --- "= 22;35,30°" This latitude runs very close to Baroda, and induces me to hypothesise that Karavanra is the ancient town of Karavana (modern Karvan) 15 miles south of Baroda.'

Pingree seems to have sent the following revised translation and the note about the patron which was printed in the catalogue thus:

'On Friday 10 śuklapakṣa of Mārgaśīrṣa in Saṃvat 1941, Saka 1806 (= November 28 1884) cut by the Brāhmaṇa, Kātyāyana (?), of the Girnārāyaṇa, (a resident of) Karāvanagara.'

'The maker of this instrument was a member of the Gujarātī family which was thought to have disappeared by the middle of the 18th century. This family played an important role in the history of transmission of Sanskrit astronomical texts and tables. It first appeared in Junagadh in the early 16th c, assuming the surname Bhatta in the early 17th c. The manuscripts of Girinārāyaṇajñāti formed part of a collection presented by the Gaikawar of Baroda to the East India Company in 1809. (The city of Baroda is only about 15 miles south of the marked latitude of the instrument here.)'

BIBLIOGRAPHY

Sotheby's, London, auction catalogue of 28 January 1977, lot 95A.

Moskowitz 1979, no. 1, p. 35.

D059⊙ ASTROLABE MADE FOR KOLKATA AT LATITUDE 24°/24°, NOT SIGNED, NOT DATED

19th century, Kuchaman, Rajasthan

Diameter 250 mm

Jaipur, PC

On the back of the crown is inscribed in Hindi *kalakātā kī,* 'of Kolakata'. Altitude circles are drawn on both sides of the plate for the latitude of 24° which is roughly the latitude of Kolkata; the actual values of Kolkata are 22°34' 11" N; 88°22' 11" E. But the astrolabe is made in Kuchaman in Rajasthan, which is indicated by the lotus like figure on the crown, the X-shaped three bridges between the rings, the incorrect term *loma chāyā* for umbra recta are characteristic of astrolabes made at Kuchaman. The single-plate astrolabes made at Kuchaman known so far are calibrated for 27° (18°) which is the latitude of Kuchaman. This one is calibrated for the latitude of 24°. This would suggest that the instrument makers of Kuchaman made an astrolabe for use in Kolkata, the capital of colonial India in the nineteenth century.

Components

Plate with crown (d. 250, h. 300), small shackle, ring, rete (d. 219) for stars, pin, alidade with a sighting tube. Wedge is missing.

Front

High crown with two projecting bits at the base on either side. An upturned lotus like figure is engraved on the crown. The rim carries the degree scale divided in 1° and 6°, and numbered in 6s serially from 1 to 60. Altitude circles are drawn for every 2° and each third line is highlighted by dots. Azimuth arcs are traced for every 6° above and below the horizon. There are lines for seasonal hours. The plate is calibrated for the latitude of 24° but there is no label to this effect.

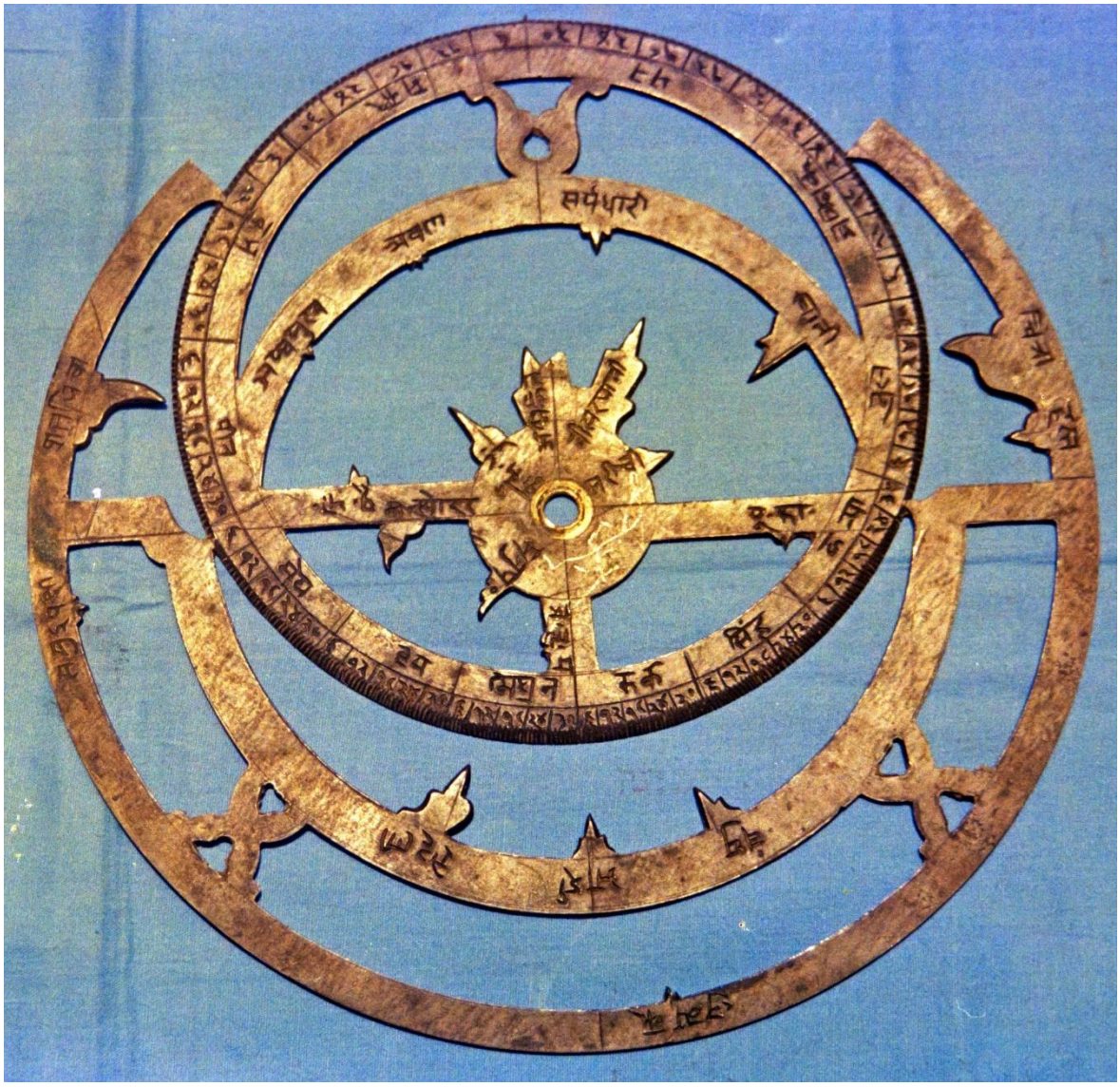


Figure D059.1 – Rete of the astrolabe (photo by S. R. Sarma)

RETE

The three rings of Capricorn, equator and ecliptic are held together by the eat-west equinoctial bar with one counter change. The equator ring is counterchanged at its two intersections with the ecliptic ring. It is connected to the Capricorn ring in the lower half by two X-shaped bridges. Below the south point, it is connected to the ecliptic ring by a U-shaped bridge. The ecliptic ring is divided into the 12 signs and labelled with their names, each sign is divided into 5 parts and labelled as 6, 12, .. 30. The bevelled edge is graduated into single degrees. There are 21 dagger-shaped star pointers, 8 outside the ecliptic and 13 inside.

Table D059-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Matsyodara*		β Andromedae
3	*Manupa*	*Manuṣya-pārśva*	α Persei
4	*Rohiṇī*		α Tauri
5	*Bra.hṛ.ya*	*Brahma-hṛdaya*	α Aurigae
6	*Ārdrā*		α Ophiuchi
7	*Lubdhaka*		α Canis Majoris
8	*Vaṃdhu*	*Lubdhaka-bandhu*	α Canis Minoris
9	*Pū. phā.*	*Pūrva-phālgunī*	δ Leonis
10	*Hasta*		δ Corvi
11	*Marīcī*	*Marīci*	η Ursae Majoris
12	*Citrā*		α Virginis
13	*Svātī*	*Svāti*	α Bootis
14	*Visara pātī*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
15	*Sarpadhārī*	*Sarpadhārī-śira*	α Ophiuchi
16	*Abhijit*		α Lyrae
17	*Śravaṇa*		α Aquilae
18	*Kurka. pu.*	*Kukkuṭa-puccha*	α Cygni
19	*Aśvamukha*		ε Pegasi
20	*Śatabhiṣā*		λ Aquarii
21	*Pū. bhā.*	*Pūrva-bhādrapadā*	β Pegasi

BACK

On the crown is written *kalakatā kī,* 'of Calcutta' . The rim carries a degree scale in two concentric rings. The inner ring divided in 1° and the outer ring in 6°. In the upper half of the outer ring, groups of 6° are numbered in 6s in the usual manner for measuring the degrees of altitude; from the east point to the south point as 6, 12, 18 … 90; likewise from from the west point to the south point.

In the lower half, however, groups of 6° are counted serially from the west point to the east point, running clockwise as 1, 2, 3 … 30.

In the upper half altitude circles are drawn for each 2° and every third dotted. The plate face is calibrated for the latitude of 24° but not so labelled. It appears that originally this side was to be the front but was abandoned after drawing the altitude circles.

Shadow squares are drawn in the lower half, on the left for the gnomon of 7 digits and on the right for a gnomon of 12 digits. The four scales are divided accordingly. On the left along the vertical scale is the legend *sa[pta] 7 [aṃgula] śaṃku viloma chāyā* (umbra versa of the gnomon of 7 digits) and above the horizontal scale the legend *sa[pta] 7[aṃgula] śaṃku loma chāyā* (umbra versa of the gnomon of 7 digits). On the right along the vertical scale is the legend *dvā[daśa] 12 [aṃgula] śaṃku viloma chāyā* (umbra versa of the gnomon of 12 digits) and above the horizontal scale the legend *dvā[daśa] 12[aṃgula] śaṃku loma chāyā* (umbra recta of the gnomon of 12 inches).

The alidade is equipped with a sighting tube.

D060 ASTROLABE FOR LATITUDE 25°, NOT SIGNED, NOT DATED[907]

19th century, Kota, Rajasthan

Diameter 177 mm

Chicago, Adler Planetarium & Astronomy Museum (#A-68);

CCA 2575



Figure D060.1 – Front of the astrolabe (accession no. A-68)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

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907 Entry based on Pingree 2009, no. 48, pp. 198-199.

COMPONENTS

Plate with crown (d. 177, h. 211, t. 1), shackle, ring, rete (d. 156) for 23 stars, washer, uninscribed alidade, pin. The sighting plates on the alidade are lost. The original wedge is also lost; the parts are now held together by a bent wire. A metal piece is riveted to the shackle which prevents the ring from turning.

FRONT

The profiles of the crown are made up of ogees at the base and lobes thereafter. The crown has a circular finial. On the front of the crown is engraved *antrarājaḥ*; the correct form should be *yantrarājaḥ.*

The scale on the rim is divided in 1° and 6°. Groups of 6° are numbered only in the upper half, from to 6 to 90, starting from the east and west points and reaching up to the south popint, as is done in the altitude scales on the back. The digit 8 is unusual; it resembles 4.

On the plate are drawn altitude circles for every 2° and each third is highlighted with dots. The azimuth arcs are drawn above and below the horizon for every 3° and each tenth curve is highlighted. Neither of these two sets is numbered, nor are they placed very accurately. There are no hour lines, but the circle of ecliptic is drawn unnecessarily. Below the horizon is an inscription *akṣa 25 palapā 5|35*. This should read *akṣāṃśa 25 palabhā 5|35,* 'latitude 25°, noon equinoctial shadow 5;35 digits'. Probably the astrolabe was made for use at Kota, a princely town in Rajasthan (25;0° N, 76;10° E).

RETE

The rete consists of the three almost complete rings of the Tropic of Capricorn, the equator and the ecliptic, which are held together by the horizontal bar whose upper edge constitutes the equinoctial colure. The circular disc at the centre is joined to the ecliptic ring by a segment of the solstitial bar.

The ecliptic ring is divided into the 12 zodiac signs and labelled with their respective names. Each sign is subdivided into groups of 6° and labelled as 6, 12, 18, 24, 30. There are 23 dagger-shaped star pointers. The engraver adds pedantically *visargas* to almost all star names and to all the names of the zodiac signs, even where it is unnecessary.

Table D060-1 Stars on the Rete

	Star Name as engraved	Correct/Full Form	Identification
1	*Samudrapakṣīḥ*	*Samudrapakṣī*	β Ceti
2	*Naharakoṭāroḥ*	*Nadyantaka*	θ Eridani
3	*Rohiṇīḥ*	*Rohiṇī*	α Tauri
4	*Mithunapādaḥ*	*Mithuna-vāma-pāda*	β Orionis
5	*Pati*	*Prajāpati*	δ Aurigae
6	*Ādrāḥ*	*Ārdrā*	α Orionis
7	*Vrahmāhada*	*Brahmahṛdaya*	α Aurigae
8	*Ludhbaka*	*Lubdhaka*	α Canis Majoris
9	*Lubdhakavadhaḥ*	*Lubdhakabandhu*	α Canis Minoris
10	*Māhāpuruṣa*	*Mahāpuruṣa*	α Hydrae
11	*Maghāḥ*	*Maghā*	α Leonis
12	*Hastaḥ*		δ Corvi
13	*Citrāḥ*	*Citrā*	α Virginis
14	*Svātiḥ*		α Bootis
15	*Viśākhāpītarāvaca*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
16	*Sarpadhāriśira*		α Ophiuchi
17	*Abhijit*		α Lyrae
18	*Śravaṇa*		α Aquilae
19	*Kukudapuccha*	*Kukkuṭapuccha*	α Cygni
20	*Aśvamukha*		ε Pegasi
21	*Śatabhiṣakaḥ*		λ Aquarii
22	*Pūrvā Bhādrapadā*		β Pegasi

	Star Name as engraved	Correct/Full Form	Identification
23	*Uttarā Bhādrapadā*		γ Pegasi



Figure D060.2 – Back the astrolbae (accession no. A-68)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Back

The rim of the back is graduated and numbered exactly as in the front. In addition, a scale of cotangents is marked on the rim of the lower right quadrant. This is the only single plate astrolabe that carries this scale.

The upper left quadrant carries a sine-cosine grid with 30 horizontal and 30 vertical parallels. In the upper right is a solar quadrant with quarter circles for each 5° of solar longitude. The corresponding zodiac signs are marked with their intial syllables along the two radii. Along the vertical radius from the the periphery to the centre are written *ma[kara], ku[bha], mi[sic! mina], me[ṣa], vṛ[ṣa], mi[thuna],* i.e., from winter solstice to summer solstice; along the horizontal radius from the centre to the peripheru are written *ka[rkaṭa], si[ṃha], ka[nyā], tu[lā], vṛ[ścika], dha[nu],* i.e. from summer solstice to winter solstice.

However, in general practice the sign names written here along the vertical radius are written along the horizontal radius and those written here along the horizontal radius are written along the vertiucal radius, e.g. in D051.

In the lower half there are shadow squares, on the left for the gnomon of 12 digits and on the right for the gnomon of 7 digits. The scales on the left are divided into 6 units each and numbered in 2s from 2 to 12. Each unit is halved in the next row and each half is divided into 3 parts in the succeeding row. The scales on the right are divided into 7 units each and numbered from 1 to 7; each unit is subdivided into 5 parts in the next parallel row.

The labels on these four scales are carelessly scribbled; the orthography is different from that on the rete;

Vertical scale on the left: *dvādaśāṅgulavelamachayasāraṇī* (*dvādaśāṅgula-viloma-chāyā-sāraṇī*), ‘the table of the reverse shadow of the 12-digit gnomon’,

Horizontal scale on the left: *dvadaśāṅgulavalachayasāraṇī* (*dvadaśāṅgula-sama-chāyā-sāraṇī*, ‘the table of the direct shadow of the 12-digit gnomon’,

Horizontal scale on the right: *saptaṅgulavelamachāyāsāraṇī* (*saptāṅgula-sama-chāyā-sāraṇī*), ‘the table of the direct shadow of the 7-digit gnomon’,

Vertical scale on the right: *saptaṅgulavelamachāyāsāraṇī* (*saptāṅgula-viloma-chāyā-sāraṇī*), ‘the table of the reverse shadow of the 7-digit gnomon’.

The alidade is uncalibrated and the sighting plates are lost.

D061 ASTROLABE FOR LATITUDE 28°, NOT SIGNED, NOT DATED, OWNED BY KHEŪJĪ ĀCĀRYA[908]

19th century, Bikaner, Rajasthan

Diameter 206

PLU, ex-Paris, Libraire Alain Brieux

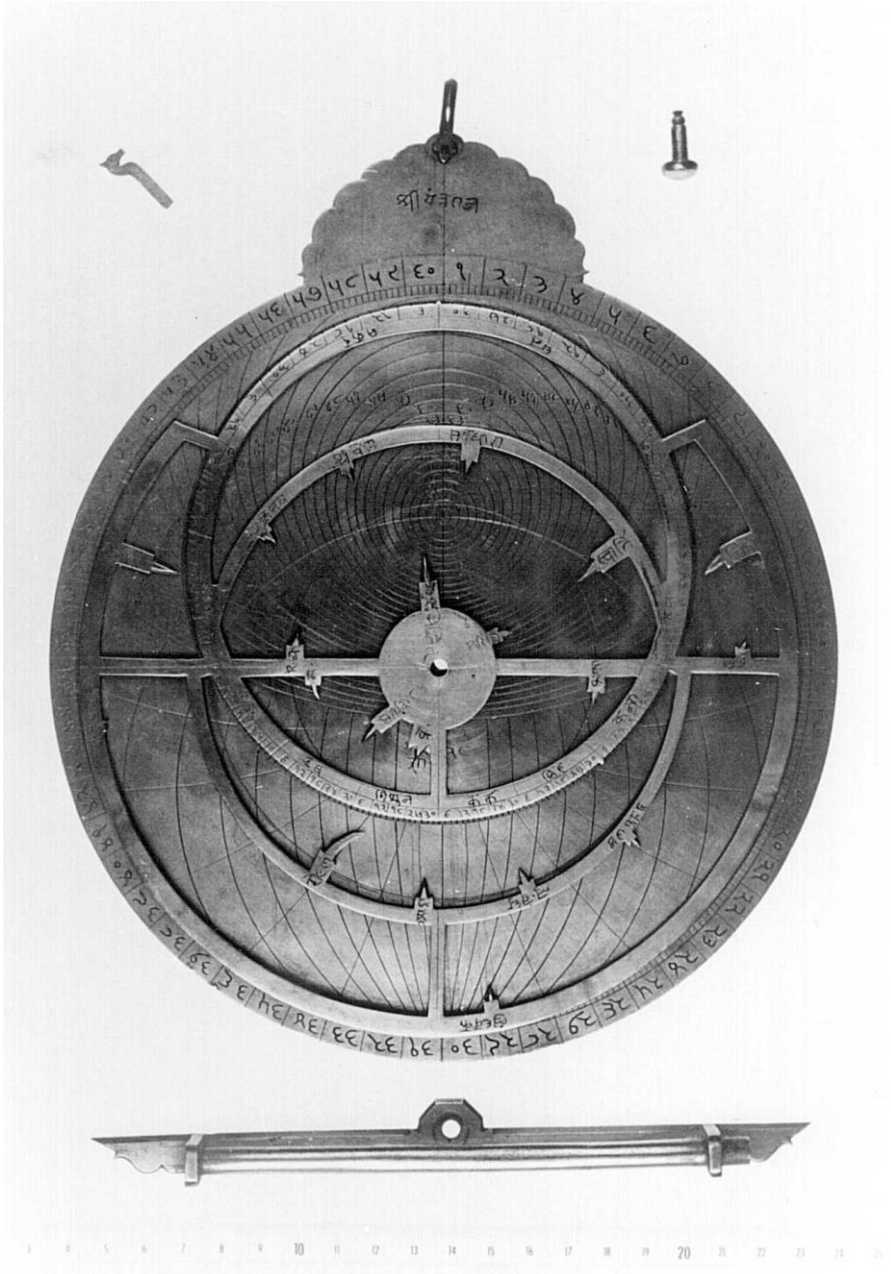


Figure D061.1 – Front of the strolabe (courtesy Museum of History of Science, Oxford)

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908 Description based on three photos and a brief typed description in French in the archives of the Museum of the History of Science, Oxford. The photos and the description are apparently by Alain Brieux, Paris.

COMPONENTS

Plate with crown (d. 206), shackle, rete for 21 stars, alidade with a sighting tube, pin and horse-headed wedge. The ring is missing.

FRONT

The crown has lobed profiles. The bases of the shackle are trifoliate. On the front of the crown is engraved *śrīyantrarāja,* 'the glorious king of instruments'.

The degree scale on the rim of the plate is divided in 1° and 6°; groups of 6° are numbered serially from 1 to 60. Altitude circles are drawn for every 3° and numbered on both sides. Azimuth arcs are drawn for every 10° below the horizon line, but not numbered. Lines are drawn for unequal hours. Below the horizon line is an inscription *akṣāṃśā 28,* 'degrees of latitude 28'.

RETE

The rete consists of three nearly complete rings of the Tropic of Capricorn, the equator and ecliptic, held together by the equinoctial bar which has no counter change. Segments of the solstitial bar join the disc at the centre with the ecliptic below and the equinoctial ring with the ring of the Tropic of Capricorn. The ecliptic ring is divided into the 12 signs of zodiac and labelled with their names. Each sign is divided into groups of 6° and numbered. The edge of the ecliptic ring is divided in 2°. There are 21 dagger-shaped star pointers.

Table D061-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	undecipherable	*Samudrapakṣī*	β Ceti
2	*Ma*	*Matsyodara*	β Andromedae
3	*Pratasira*	*Pretaśira*	β Persei
4	*Rohiṇī*		α Tauri
5	*Vra.*	*Brahmahrdaya*	α Aurigae
6	*Ārdrā*		α Orionis
7	*Ludhvaka*	*Lubdhaka*	α Canis Majoris

	Star Name as engraved	Full/Correct Form	Identification
8	*Lu.vaṃdha*	*Lubdhaka-bandhu*	α Canis Minoris
9	*Mahāpuruṣa*		α Hydrae
10	(not named)	*Maghā*	α Leonis
11	*Pū.phā.*	*Pūrva-phālgunī*	δ Leonis
12	*Hasta*		δ Corvis
13	*Citrā*		α Virginis
14	*Marīci*		η Ursae Majoris
15	*Svāti*		α Bootis
16	*Sarpadhārā*	*Sarpadhārī-śirā*	α Ophiuchi
17	*Abhijit*		α Lyrae
18	*Śravaṇa*		α Aquilae
19	*Aśvamakha*	*Aśvamukha*	ε Pegasi
20	illegible	*Śatabhiṣā*	λ Aquarii
21	*Pū.bhā.*	*Pūrva-bhādrapada*	β Pegasi

BACK

The scale on the rim is divided, as in the front, in 1° and 6°. Groups of 6° are numbered only in the upper two quadrants, as 6—90; 90—6. The upper left quadrant bears a sine-cosine graph with 30 horizontal and 30 vertical parallels. Other three quadrants are empty.

On the lower left quadrant is engraved *khe*. Realizing that the script is too large for the planned inscription, the engraver appears to have discontinued the engraving on this quadrant and engraved instead on the lower right quadrant the following, in smaller letters, in two lines: *kheūjī ācārya, bīkānera.* The script is different from the rest of the script on the astrolabe. So this inscription was added later and probably refers to the subsequent owner of the astrolabe. The princely city of Bikaner lies roughly on the

latitude of 28°. The astrolabe must have been made in Bikaner for some unnamed astronomer and must have changed hands later on.

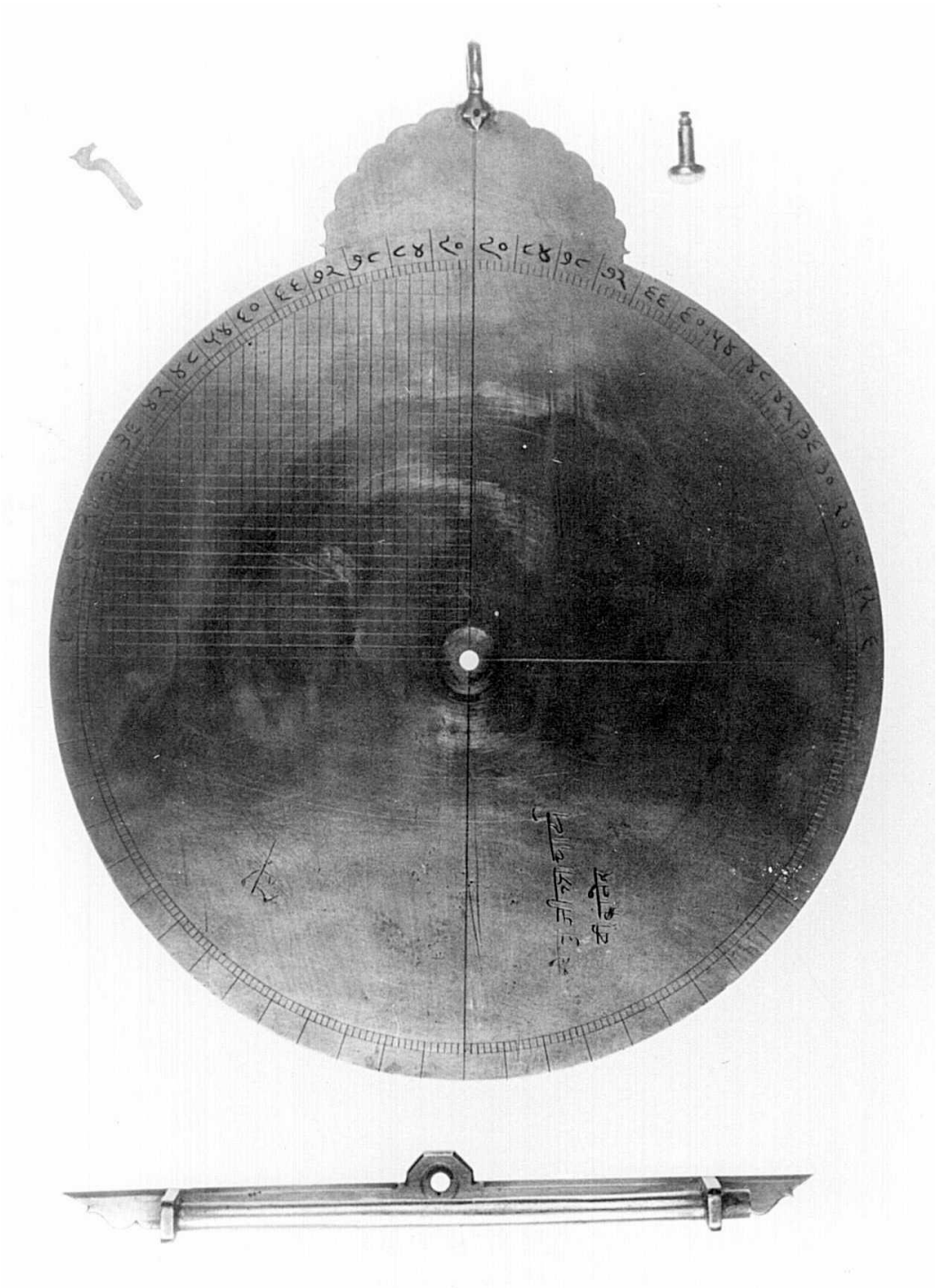


Figure D061.2 – Back of the astrolabe (courtesy Museum of the History of Science, Oxford)

D062⊙ ASTROLABE FOR LATITUDE 28;16°, DESIGNED BY KASTŪRĪCANDRA, MADE BY SŪTRADHĀRA SŪRYAMALLA, NOT DATED

19th century, Bikaner, Rajasthan

Diameter 273 mm

Cologne, PC



Figure D062.1 – Front of the astrolabe (photo by S. R. Sarma)

The inscription on the back states that this astrolabe was made by Sūryamalla according to Kastūrīcanda's instruction (*upadeupadeśa*) for the latitude of 28;16°. Probably Kastūrīcandra did not merely give oral instructions; he must have prepared the technical designs for the astrolabe and also drafted the text of the inscription on the back, where Sūryamalla receives the title *sūtradhāra*; the term, among others, denotes architect; here it is used in the sense of 'master craftsman' or 'artisan'.[909]

The plate is actually designed for latitude 27°, but can be used at 28;16° as well. It is likely that the astrolabe was made at the princely city of Bikaner (28;01° N, 73;19° E) in Rajasthan which is situated roughly on this latitude. The distinguishing feature of this astrolabe is the large flamboyant peacock perched on the central ring of the rete, its beak pointing to the star α Coronae Borealis. The raised neck and the feathers in the wings are depicted nicely with a series of parallel strokes.

Sūryamalla appears to have fabricated many specimens, four of whicha are known at present, viz. this and the next three astrolabes. These are almost identical: all have about the same size, the same design of the rete with the peacock motif, the same projections on the front of the plate and the same inscription on the back.

But each one has a different style of crown. There are other diffrences. Broadly speaking, the pair D062 and D063 differs from the pair D064 and D065 in three respects. First, in D062 and D063, the outer band of the degree scale on the rim is divided in 6° and numbered serially from 1 to 60. In the inner band, these divisions of 6° are subdivided, not into 6 units of 1° as is the common practice, but into 5 units of 1;12°. The same error is repeated in the altitude scale at the back and in the degree scale on the edge of the ecliptic ring in the rete. But in D064 and D065 the scales are correctly divided in 1° and 6°.

Second, while there are 24 named star pointers in D062 and D063, the retes in the other pair have 27 star pointers. Third, in D062 and D063 declination arcs are engraved on the upper right quadrant on the back; in D064 and D064 the upper right quadrants are empty.

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[909] Cf. Sūtradhāra Māyārāma who made C026 and C027 in 1810. An analogous title is *Ustād* (derived from Arabic) in D035, D036, D037 and D038.

While the workmanship is reasonably good in all the four specimens, the orthography is generally poor and there are serious errors in the star names. In all the four specimens *Kukkuṭapuccha* (α Cygni) is wrongly labelled as *Śatabhiṣā* (λ Aquarii) and *Kartitakara* (β Cassiopeiae) is wrongly placed in the northern hemisphere. *Dhanakoṭi* and *Sarpadhārī,* or more correctly *Dhanuḥkoṭi* and *Sarpadhārīśira,* are alternative names of the same star α Ophiuchi. In all the four specimens these two names are engraved on the solstitial bar as if there are the names of two different stars situated on either side of the meridian. While a pointer is provided for *Dhanuḥkoṭi* to the right to the solstitial bar, no pointer is provided for the other name.

Now the description of the present astrolabe D062.

COMPONENTS

Mater (d. 273, h. 319, t. 1.8) with ring and shackle, rete (d. 241) for 23 stars, alidade (244) with a sighting tube, pin and wedge.

FRONT

Simple ring and shackle; the crown is lobed. The rim is divided in 6° and numbered in 6s from 1 to 60. But, each unit of 6° is wrongly divided in 5 parts each measuring 1:12° and not 1°, and this error is repeated is on the edge of the ecliptic ring in the rete and in the altitude scales on the back.

Altitude circles are drawin for every 3°, these are numbered on both sides of the meridian. Azimuth arcs are drawn above and below the horizon for every 10°, but their intervals are not uniform. In the lower half are lines for seasonal hours and lines for equal hours which commence from the western horizon. The azimuth arcs and the two kinds of hour lines are not numbered.



Figure D062.2 – Rete of the astrolabe (photo by S. R. Sarma)

RETE

The rete consists of the Capricorn ring, fully representd equator ring and a much wider ecliptic ring; these three are held together by the equinoctial and solstitial bars which are fully represented without any counter change. The equator ring, however, has counterchanges at the two equinoxes where it intersects with the ecltiptic ring. The ecliptic is ring is divided in the 12 signs of the zodiac and labelled with their names. There are 24 dagger-shaped star pointers. The proper sequence of the stars is not always correctly maintained.

Table D062-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*	*Samudrapakṣī*	β Ceti
2	*Kārtikabhaja*[910]	*Kartitakara*	β Cassiopeiae
3	*Madasāra*	*Matsyodara*	β Andromedae
4	*Pretapūra*	*Pretaśira*	β Persei
5	*Pretapārśva*		α Persei
6	*Rohiṇī*		α Tauri
7	(not named)	*Brahma-hṛdaya*	α Aurigae
8	*Mithuna*	*Mithuna-vāma-pāda*	β Orionis
9	*Mithana-skandha*	*Mithuna-vāma-skandha*	γ Orionis
10	*Ladhṣaka*	*Lubdhaka*	α Canis Majoris
11	*Ladhṣakavadhu*	*Lubdhaka-bandhu*	α Canis Minoris
12	*Maghā*		α Leonis
13	*Hasta*		δ Corvi
14	*Marīci*		η Ursae Majoris
15	*Citrā*		α Virginis
16	*Svāti*		α Bootis
17	*Viśyā*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
18	*Dhanakoṭi*[911]	*Dhanuḥkoṭi*	α Ophiuchi
19	*Sarpadhārī*	*Sarpadhārīśira*	α Ophiuchi

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910 Wrongly placed in the northern hemisphere.

911 Nos 17 and 18, viz., *Dhanuḥkoṭi* and *Sarpadhārīśira,* refer to the same star α Ophiuchi.

	Star Name as engraved	Full/Correct Form	Identification
20	*Abhijata*	*Abhijit*	α Lyrae
21	*Śravaṇa*	α Aquilae	
22	*Śatabhiṣā*[912]	*Kukkuṭapuccha*	α Cygni
23	*Pūrvā Bhādapada*	*Pūrvā Bhādrapadā*	β Pegasi
24	*Asamukha*	*Aśvanābhi*	δ Pegasi

912 *Kukkuṭapuccha* (α Cygni) is wrongly labelled as *Śatabhiṣā* (λ Aquarii).

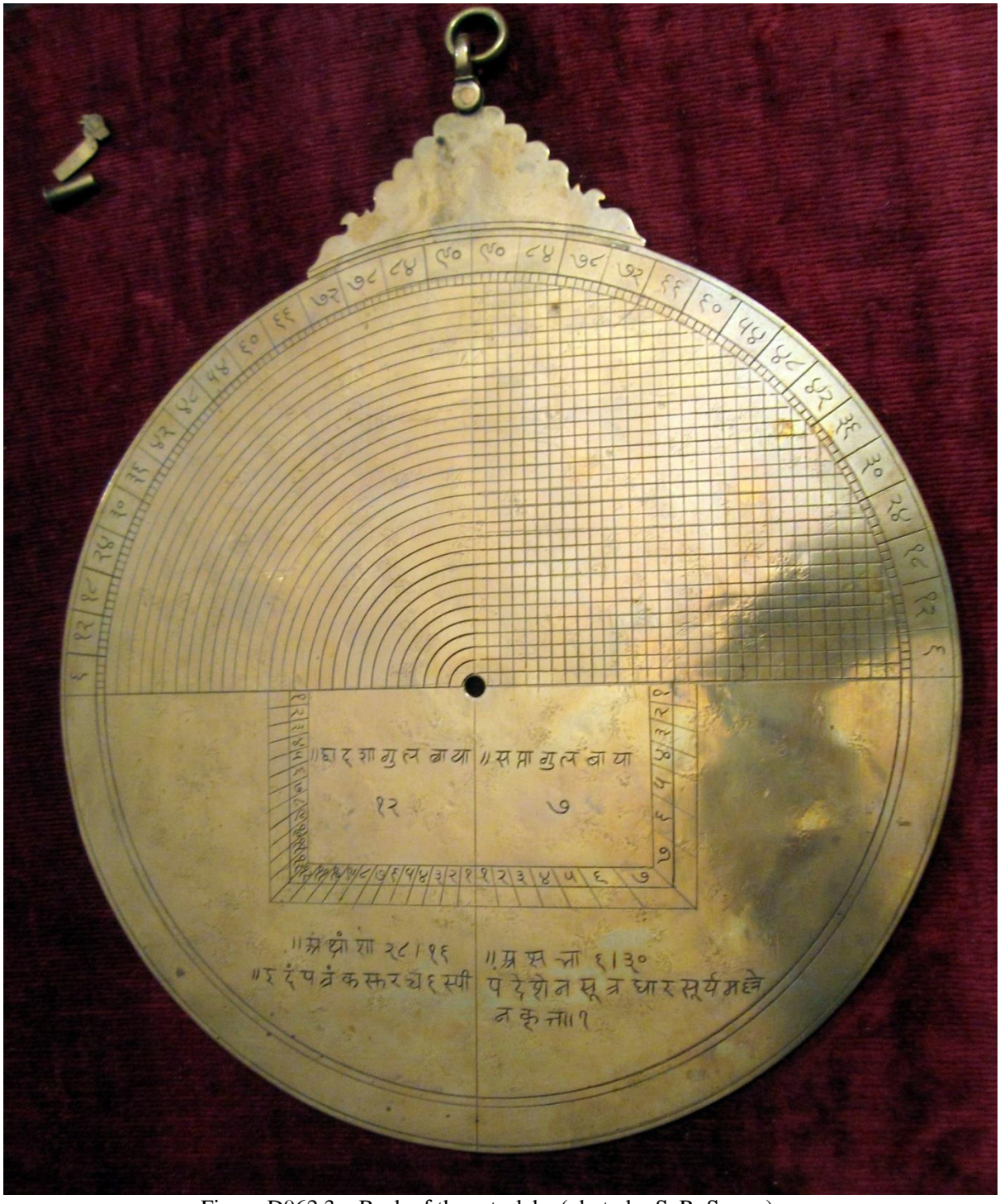


Figure D062.3 – Back of the astrolabe (photo by S. R. Sarma)

BACK

The rim of the upper half carries altitude scales which are divided in 6° and numbered as 6—90; 90—6. As in the front, here also the units of 6° are wrongly divided in 5 parts. The rim of the lower half is blank.

The upper right quadrant is filled with 30 horizontal and 30 vertical parallel lines. The 30 horizontal lines in this quadrant are extended into the left quadrant to form 30 declination circles. But there are no numbers or labels in these two quadrants.

In the lower half are shadow squares. The square on the left is for a base of 12; the vertical and horizontal scales are divided in 12 units and numbered from 1 to 12. In the middle of the square is engraved *dvādaśāṅgula-chāyā 12* (shadow of [the gnomon of] 12 digits). The square on the left is drawn for a base of 7. Here the vertical and horizontal scales are divided in 7 units and numbered from 1 to 7. In the middle of the square is the label stating *saptāṅgula-chāyā 7* (shadow of [the gnomon of] 7 digits).

Alidade

The alidade is equipped with a sighting tube. The end of the wedge is nicely shaped as a horse's head.

Inscription

Below the shadow squares is the inscription engraved on both sides of the vertical diameter, with many errors in orthography.

‖ *akṣāṃśa 28|16* ‖*akṣabhā 6|30*

‖ *idaṃ patraṃ kastaraca 6 syīpadeśena sūtradhāra sūryamalle-na kṛttā* ‖ *1*‖

The correct version should be

akṣāṃśāḥ 28|16, akṣabhā 6|30

idaṃ patraṃ kastūrīcandrasyopadeśena sūtradhāra-sūryamallena kṛtaṃ.

'Latitude 28;16 [degrees]. Midday equinoctial shadow 6;30 [digits].

'This plate was made by Sūtradhāra Sūryamalla according to Kastūrīcandra's instruction.'

D063⊙ ASTROLABE FOR LATITUDE 28;16°, DESIGNED BY KASTŪRĪCANDRA, MADE BY SŪTRADHĀRA SŪRYAMALLA, NOT DATED

19th century, Bikaner

Diameter 270 mm

PLU, Ex-Paris, Libraire Alain Brieux

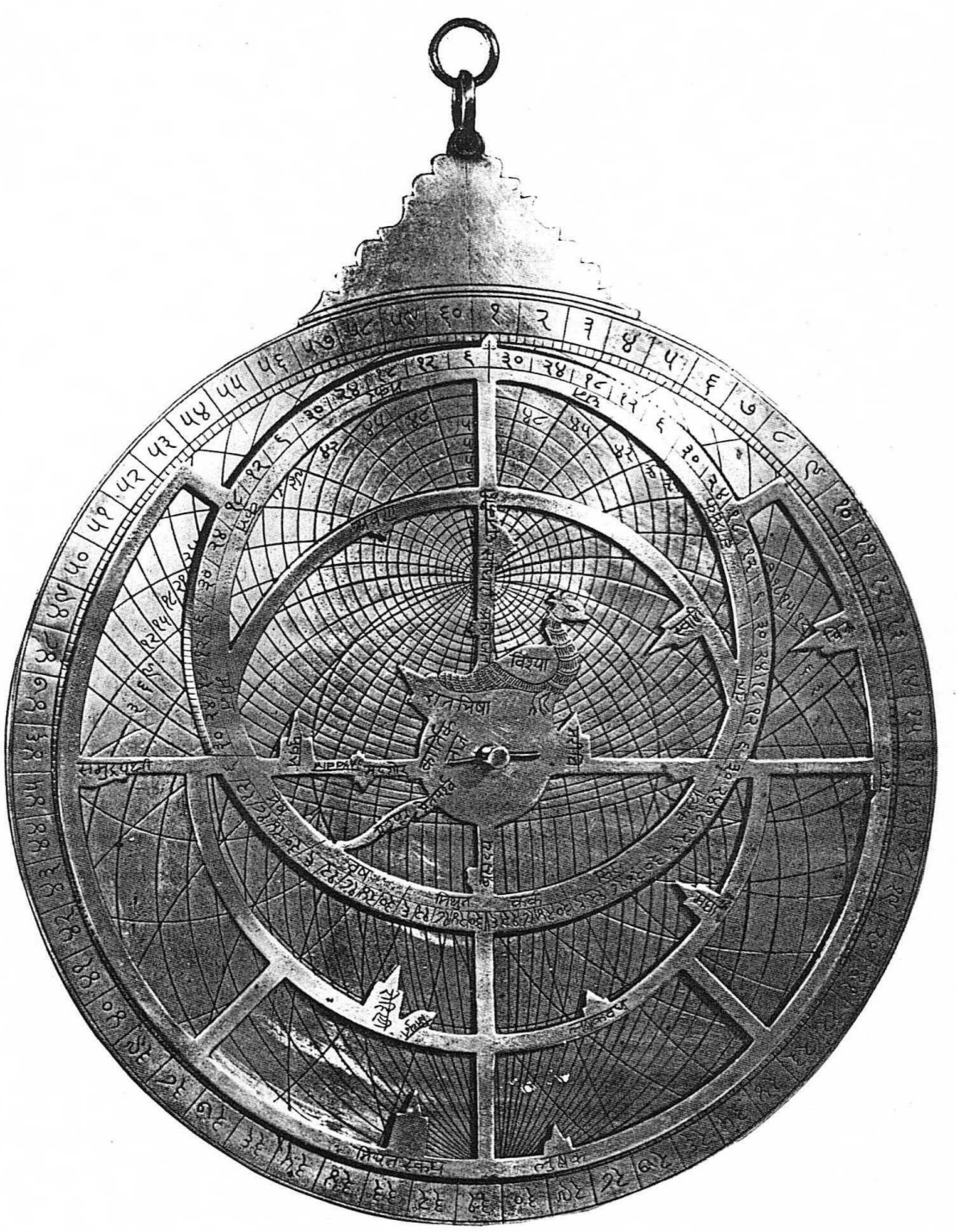


Figure D063.1 – Front of the astrolabe (courtesy Anthony J. Turner)

This astrolabe looks almost idental to the previous astrolabe D062, but for a few very minute differences. The triangular crown in both astrolabes looks almost alike, but careful examination shows a slight difference in the profiles near the base. The retes are almost the same, but two minor differences can be detetcted in the star pointers. In D062 the star name *Samudrapakṣī* (β Ceti) is engraved on the equinoctial bar, but pointer there is a small notch in the equinoctial bar, whereas in the present astrolabe a pointer can be seen below the equinoctial bar. Second, in D062 there is pointer for the star *Brahmahṛdaya* (α Aurigae) attached to the solstitial bar just above the ecliptic ring, but the star name is not engraved there. In the present astrolabe, the name is clearly visible. In the upper left quadrant on the back of this astrolabe, there are radial lines superimposed on the declination arcs; such is not the case in D062. The alidade in this astrolabe lost the sighting plates; in D062, it is fitted with a sihting tube.

COMPONENTS

Plate with crown (d. 270, h. 318), shackle, ring, rete (d. 241) for 24 stars, alidade in which the sighting plates are broken. Pin and wedge are modern.

FRONT

The high solid crown has an almost triangular form; the profiles are filled with small lobes. The degree scale on the rim is divided in 1° and 6° and numbered serially from 1 to 60. But these divisions are further subdivided wrongly into 5 units of 1;12°. The same error is repeated in the altitude scale at the back and in the degree scale on the edge of the ecliptic ring in the rete.

Altitude circles are drawn for each 3° and numbered on the east and west sides of the meridian. Azimuth arcs are drawn above the horizon for each 12° and below the horizon for each 6°. In the lower half, lines are drawn for the seasonal hours and equal hours as counted from the western horizon. The azimuth arcs and the hour lines are not numbered. Though the inscription at the back says that the astrolabe is made for the latitude of 28;16°, the altitude circles are actually arranged for the latitude of 27°.[913]

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913 The catalogue of the Libraire Alain Brieux states that the plate is calibrated for 23°. But that is not correct. I have personally examined the astrolabe and saw that it is made for 27°.

RETE

The rete is fashioned exactly as that in the previous astrolabe with the same errors.

Table D063-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Kārtikabhaja*[914]	*Kartitakara*	β Cassiopeiae
3	*Madasora*	*Matsyodara*	β Andromedae
4	*Pretapūra*	*Pretaśira*	β Persei
5	*Pretapārśva*		α Persei
6	*Rohiṇī*		α Tauri
7	*Mithunaskadha*	*Mithuna-vāma-pāda*	β Orionis
8	*Mithuna*	*Mithuna-vāma-hasta*	γ Orionis
9	*Brahmadaya*	*Brahma-hṛdaya*	α Aurigae
10	*Luvdhaka*	*Lubdhaka*	α Canis Majoris
11	*Luvdhakavadhu*	*Lubdhaka-bandhu*	α Canis Minoris
12	*Maghā*		α Leonis
13	*Hasta*		δ Corvi
14	*Citrā*		α Virginis
15	*Marīci*		η Ursae Majoris
16	*Svāti*		α Bootis
17	*Viśyā*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
18	*Dhanakoṭi*	*Dhanuḥkoṭi*	α Ophiuchi

[914] Wrongly placed in the northern hemisphere.

	Star Name as engraved	Full/Correct Form	Identification
19	*Sarpadhārī*[915]	*Sarpadhārīśira*	α Ophiuchi
20	*Abhijita*	*Abhijit*	α Lyrae
21	*Śravaṇa*		α Aquilae
22	*Śatabhiṣā*[916]	*Kukkuṭapuccha*	α Cygni
23	*Pūvabha*	*Pūrvabhādrapadā*	β Pegasi
24	*Aśvanābha*	*Aśvanābhi*	δ Pegasi

BACK

The altitude scales on the upper half are divided into units of 6° and numbered as 6—90; 90—6. The units of 6° are further subdivided into, as in the front, 5 parts of 1;12° each.

The upper right quadrant contains the sine-cosine graph with 30 horizontal and 30 vertical parallels. The 30 horizontal lines in this quadrant are extended into the left quadrant to form 30 declination circles. Upon these quarter circles are drawn 7 radial lines, creating 8 segments of 11 ¼ degrees each, the purpose of which is not clear.

In the lower half, there are shadow squares. On the left is the square for the gnomon of 12 digits; the vertical and horizontal scales are divided into 12 units each and numbered from 1 to 12; in the middle of the square is the label *dvādaśāṃgulachāyā 12* (shadow of twelve digits 12). On the right is the square for the gnomon of 7 digits; the vertical and horizontal scales are divided into 7 units each and numbered from 1 to 7; in the middle of the square is the label *saptāṃgulachāyā 7* (shadow of seven digits 7).

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915 Nos 18 and 19, viz., *Dhanakoṭi* and *Sarpadhārī,* more correctly *Dhanuḥkoṭi* and *Sarpadhārīśira,* refer to the same star α Ophiuchi.

916 *Kukkuṭapuccha* (α Cygni) is wrongly labelled as *Śatabhiṣā* (λ Aquarii).



Figure D063.2 – Back of the astrolabe (photo by S. R. Sarma)

ALIDADE

The alidade here has simple edges and a simple centre-piece. The two sighting plates are broken; consequently it is not known whether there was also a sighting tube originally.

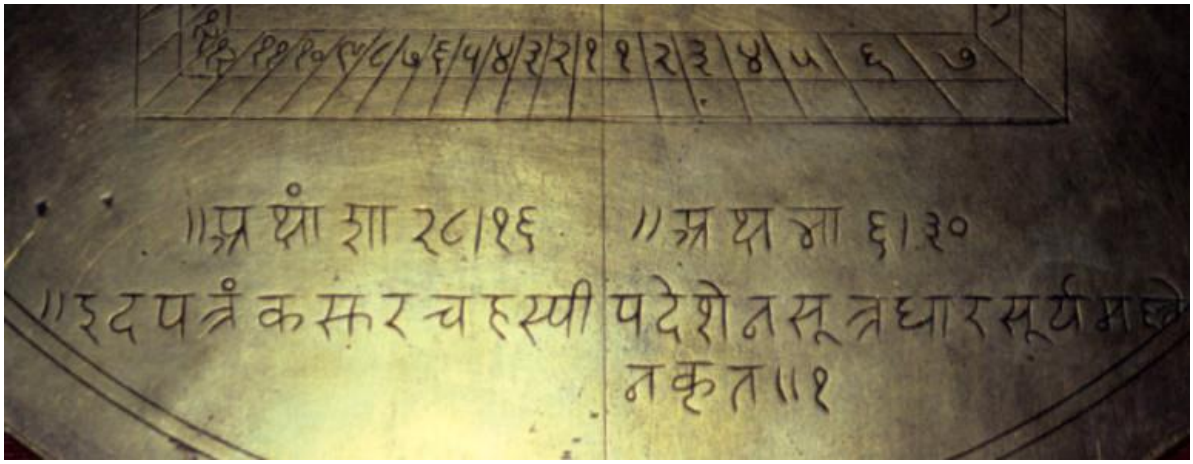


Figure D063.3 – Inscription on the back (photo by S. R. Sarma)

INSCRIPTION

Below the shadow squares is the same inscription as in the preceding astrolabe with minor variations in orthography.

BIBLIOGRAPHY

Libraire Alain Brieux, Paris, [catalogue] Histoire de Sciences et de la medicine, livres anciens et documentation, Septembre 1994.

D064 ASTROLABE FOR LATITUDE 28;16°, DESIGNED BY KASTŪRĪCANDRA, MADE BY SŪTRADHĀRA SŪRYAMALLA, NOT DATED

19th century, Bikaner, Rajasthan

Diameter 274 mm

Hastings-on-Hudson, NY, Tesseract



Figure D064.1 – Front of the astrolabe (photo courtesy Dr David Coffeen)

As stated above, this and the next astrolabe are closer to each other than to the other pair (D062 and D064), but the crowns of these two (D064 and D065) are totally different.

COMPONENTS

Plate with crown (d. 274) and shackle, rete for 27 stars, alidade with a sighting tube, pin and wedge, The ring is missing.

FRONT

The medium sized crown is elegantly reticulated. The scale on the rim is divided in 1° and 6°; groups of 6° are serially numbered from 1 to 60. Altitude circles are drawn for every 3° and numbered on both sides of the meridian. Azimuth arcs are drawn for every 10° above and below horizon, but not numbered. Lines for seasonal hours and lines equal hours drawn from the western horizon are not numbered. Altitude circles are arranged for the latitude of 27°.



Figure D064.2 – The plate of the astrolabe (photo courtesy Dr David Coffeen)

RETE

The rete is fashioned as in the previous two astrolabes, but with 27 stars pointers, the three extra stars being *Ṣaṇmukha* (no. 10), *Mithuna-vāma-hasta* (11) and *Uttarā Phālgunī* (15).



Figure D064.3 – Rete of the astrolabe (photo courtesy Dr David Coffeen)

Table D064-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	*Kartitabhujaḥ*[917]	*Kartitakara*	β Cassiopeiae
3	*Matsyodara*		β Andromedae
4	*Prataśiraḥ*	*Pretaśira*	β Persei
5	*Pretapārśva*		α Persei

[917] Wrongly placed in the northern hemisphere.

	Star Name as engraved	Full/Correct Form	Identification
6	*Rohiṇī*		α Tauri
7	*Mithunaskadha*	*Mithuna-vāma-pāda*	β Orionis
8	*Mithunavāmaskadhaḥ*	*Mithuna-vāma-skandha*	γ Orionis
9	*Brahmahṛdaya*		α Aurigae
10	*Ṣaṇyaraya*[918]	*Ṣaṇmukha*	δ Aurigae
11	*Mithunavāmahasta*	*Mithuna-dakṣiṇa-hasta*	α Orionis
12	*Lubdhaka*		α Canis Majoris
13	*Lubdhakabadhu*	*Lubdhakabandhu*	α Canis Minoris
14	*Maghā*		α Leonis
15	*Uttaraphā*	*Uttara-phālgunī*	β Leonis
16	*Hasta*		δ Corvi
17	*Marīci*		η Ursae Majoris
18	*Citrā*		α Virginis
19	*Svāti*		α Bootis
20	*Visaṣā*	*Viśākhā-matṛ-maṇḍala*	α Coronae Borealis
21	*Dhanakoṭi*	*Dhanuḥkoṭi*	α Ophiuchi
22	*Sarpadhārī*[919]	*Sarpadhārīśira*	α Ophiuchi
23	*Abhijit*		α Lyrae

[918] Wrong position.

[919] Nos. 21 and 22, viz., *Dhanakoṭi* and *Sarpadhārī,* more correctly *Dhanuḥkoṭi* and *Sarpadhārīśira,* refer to the same star α Ophiuchi.

	Star Name as engraved	Full/Correct Form	Identification
24	*Śravaṇa*		α Aquilae
25	*Śatabhiṣā*[920]	*Kukkuṭapuccha*	α Cygni
26	*Pūvabha*	*Pūrvabhādrapadā*	β Pegasi
27	*Aśvanābha*	*Aśvanābhi*	δ Pegasi

BACK

The upper half of the rim carries altitude scales which are divided in 1° and 6° and numbered as 6—90; 90—6. The upper left quadrant is blank. On the right is the trigonometric quadrant with 30 vertical and 30 horizontal parallels. In the lower half are the shadow squares, on the left for the gnomon of 12 digits and on the right for the gnomon of 7 digits. The scales are divided and numbered accordingly. Inside the square on the left is the label *dvādaśāṃgula chāyā 12* (shadow of [the gnomon of] 12 digits) and on the right *saptāṃgula chāyā 7* (shadow of [the gnomon of] 7 digits).

ALIDADE

The alidade is equipped with a sighting tube. The ends of the alidade, the centre piece and the upright supports of the sighting tube are elegantly shaped.

920 *Kukkuṭapuccha* (α Cygni) is wrongly labelled as *Śatabhiṣā* (λ Aquarii).



Figure D064.4 – Back of the astrolabe (photo courtesy Dr David Coffeen)

INSCRIPTION

Below the shadow squares is the following inscription in three lines:

|| akṣāṃśā 28|16

||akṣabhā 6|30

|| idaṃ patraṃ kasturīcaṃdasyīpadeśena sūtradhāra sūryamalle-

na kṛttaṃ || 1||

The correct version should be

akṣāṃśāḥ 28|16, akṣabhā 6|30

idaṃ patraṃ kastūrīcandrasyopadeśena sūtradhāra-sūryamallena kṛtaṃ.

‘Latitude 28;16 [degrees]. Midday equinoctial shadow 6;30 [digits].
‘This plate was made by Sūtradhāra Sūryamalla according to Kastūrīcandra’s instruction.’

PROVENANCE

Christie's South Kensington, 10 April 2014, lot 66 in their *Travel & Science* sale.

BIBLIOGRAPHY

Terreract Catalog One Hundred Two, Spring 2016, item 4.

D065 ASTROLABE FOR LATITUDE 28;16°, DESIGNED BY KASTŪRĪCANDRA, MADE BY SŪTRADHĀRA SŪRYAMALLA, NOT DATED[921]

19th century, Bikaner

Diameter?

PLU



Figure D065.1 – Front of the astrolabe (photo courtesy Anthony J. Turner)

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[921] Entry based on the photos from Alain Brieux, kindly given by Anthony J. Turner.

This astrolabe is identical to the preceding astrolabe, but for the solid crown with lobed profiles and peak-like projection on either at the base. The rete appears to be quite alike, with the same 27 named star pointers.

On the back, the upper left quadrant is blank as in the previous astrolabe and the upper right quadrant contains a sine-cosine graph. In the lower half the shadow squares are also the same. The inscription is almost the same with minor variations in orthography.

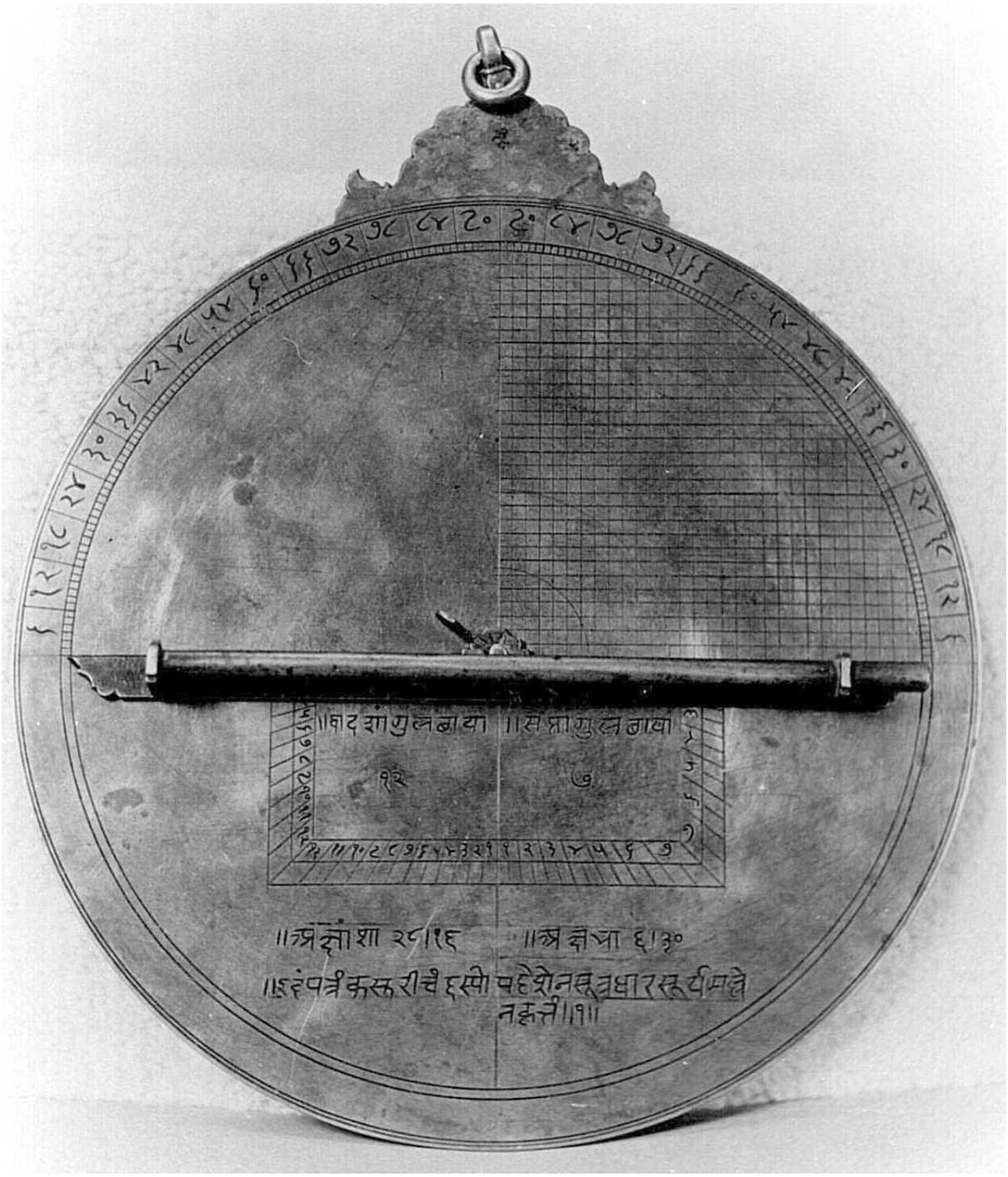


Figure D065.2 – Back of the astrolabe (photo courtesy Anthony J. Turner)

ALIDADE

As in D062, here also the alidade has ornate ends and an ornate centre-piece and is equipped with a sighting tube. The end of the sighting tube on the left is broken.

D066 ASTROLABE FOR LATITUDE 29°, NOT SIGNED, NOT DATED[922]

19th century

Diameter 197 mm

PLU; ex-Paris, Libraire Alain Brieux



Figure D066.1 – Front of the astrolabe (courtesy Museum of the History of Science, Oxford)

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922 In the archives of the Museum of the History of Science, Oxford, there are two photos of the front and back, and also photocopies of two other photos which show a closed wooden box and the open wooden box displaying the astrolabe and a cloth bag in it. The photocopies are too dark to be reproduced here. There is also a typed sheet with a short description of the astrolabe in French. Probably the astrolabe must have with Alain Brieux of Paris at some time.

COMPONENTS

Plate with a lobed crown, shackle, ring, tassel with many strands, rete for 26 stars, alidade with a sighting tube. The engraved lines and letters are filled with a white substance. On the back, some uneven part on the inner surface of the alidade scratched against the surface of the back and produced on it a wide circular scratch.

FRONT

The scale on the rim is divided in 1°, 2° and in 6°. Groups of 6° are numbered from 1 to 60. Altitude circles are drawn for every 3° and numbered, azimuth arcs for every 10° and numbered, unequal hour lines, numbered (?).

RETE

The rete consists of the three rings of the Tropic of Capricorn, equator and ecliptic. These and the central are held together by the equinoctial bar which has a counter change at the centre. A segment of the solstitial bar joins the central disc to the ecliptic ring below. The equator ring and the Capricorn ring are joined by a segment of the solstitial bar and by two other bars placed at equal distances symmetrically on either side of the solstitial bar.

The ring of the ecliptic is divided into the 12 signs of the zodiac and labelled. Each sign is divided into groups of 6° and numbered accordingly.

There are 26 dagger-shaped star pointers. All the names cannot be deciphered in the photos. Those that are visible are listed below. Those marked with * are wrongly placed.

Table D066-1 Stars on the Rete

	Star Names as engraved	Full/Correct Form	Identification
1	*Samudrapakṣī*		β Ceti
2	**Raṃjitaka*	*Rañjitakara*	α Cassiopeiae
3	*Ma.pakṣa*	*Manuṣyapārśva*	α Persei
4	*Vra.hrada*	*Brahmahṛdaya*	α Aurigae
5	*Lu. badhu.*	*Lu.baṃdhu*	α Canis Minoris

	Star Names as engraved	Full/Correct Form	Identification
6	*Marīci*		η Ursae Majoris
7	*Viśākhāmaṃ.*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
8	**Sarpadhārī*	*Sarpadhārīśira*	α Ophiuchi
9	**Sarpagrīva*	*Sarpagrīvā*	α Serpentis
10	*Abhijit*		α Lyrae
11	*Śravaṇa*		α Aquilae
12	*Ku. pūcha*	*Kukkuṭa-puccha*	α Cygni
13	*Śatabhiṣā*		λ Aquarii
14	*Aśvamuṣa*	*Aśvamukha*	ε Pegasi

BACK

The scale on the rim is divided in 1° and in 6° and numbered as 6—90; 90—6. The trigonometric quadrant in the upper left carries 30 vertical and 30 horizontal parallels; in the solar quadrant in the upper right are drawn just three quarter circles and no labels. In the lower half, there are shadow squares, on the left divided in 12 parts and numbered, on the right divided in 7 parts and numbered. There are no labels along the scales.

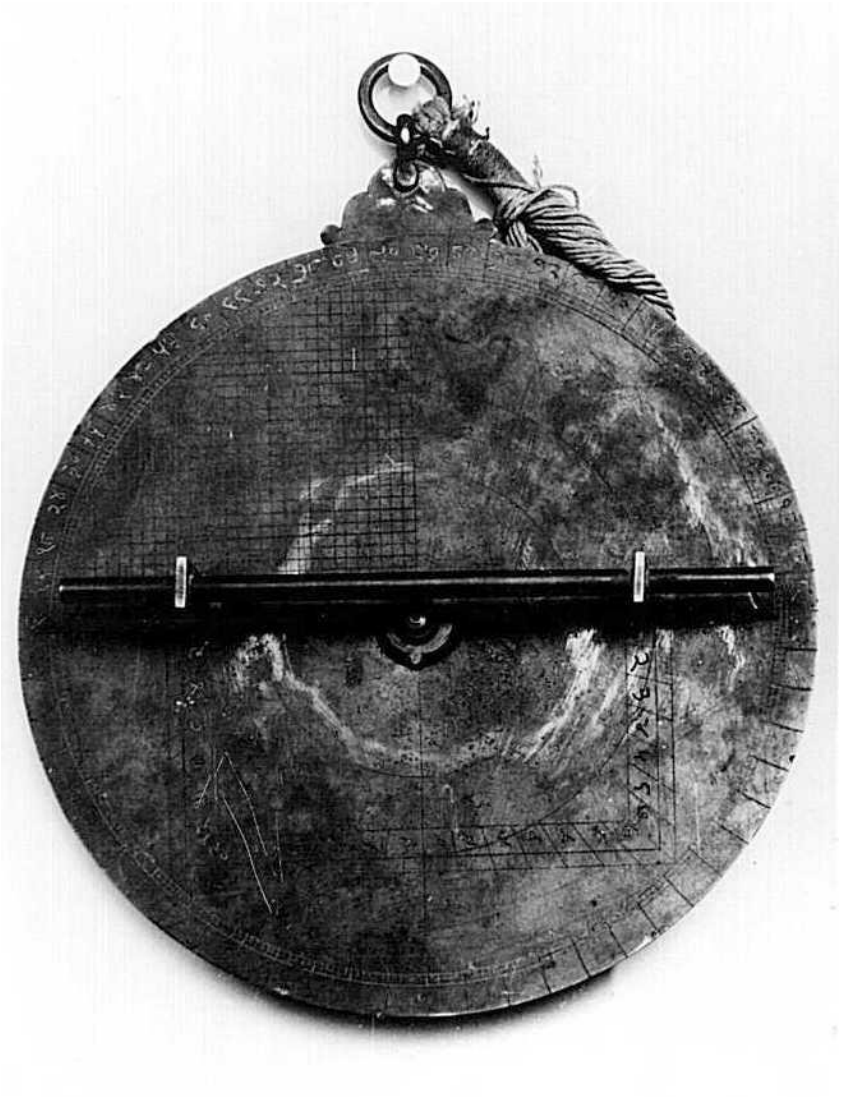


Figure D066.2 – Back of the astrolabe (courtesy Museum of the History of Science, Oxford)

D067⊙ COPY OF AN ASTROLABE MADE FOR JYOTIṢĀCĀRYA IN 1834

19th century, probably Jodhpur, Rajasthan

Diameter 259 mm

Brussels, PC



Figure D067.1 – Front of the astrolabe (photo by S. R. Sarma)

This and the next astrolabe (D068) carry inside the shadow squares on the back an identical inscription which commences with the word *jyotiṣācārya,* a respected academic title meaning ‘master of the astral science.’ Except for this single word, nothing turned out correctly in the inscription which appears to contain the name of the

astronomer who commissioned the astrolabe, the name of the ruling prince and the name of the artisan who made the astrolabe.

This is followed by the date which is engraved on the present astrolabe thus: *sā° 1891 mi° āsāḍha su° 7 sanavāśre.* The correct form, after expanding the abbreviations, reads: *saṃvat 1891 mita āśāḍha śukla 7 śanivāsare,* 'in the year measured by 1891 [of the Vikrama era], on Saturday, the 7th day of [the lunar month] Āṣāḍha.' This date corresponds to 13 July 1834 (Gregorian) which is a Sunday. A discrepancy of one day is usually admissible. After adjusting for this discrepancy, the modern equivalent would be Saturday, 12 July 1834. Below this the latitude of the astrolabe is stated to be 26°.

On astrolabe D068, the orthography is almost the same, but with a different year: *sa° 1765 mi° āsāḍha su° 7 sanavāśre.* This date translates to 25 June 1708 (Gregorian) which is a Monday. Here the weekday does not quite match.

However, the orthography of the inscriptions on both astrolabes is identical. Moreover, on both astrolabes this inscription is mixed up with the labels of the shadow squares almost in the same manner. Of the 23 star names inscribed on the two retes, hardly any one is correct. The workmanship in both these large astrolabes is equally crude. There cannot be much doubt that these two were produced by the same artisan. He could not have fabricated them on dates which are separated by 126 years. Hence one of the years (probably 1765 on D068) is dubious.

If an astronomer who enjoyed the coveted title *Jyotiṣācārya* had commissioned these two astrolabes and had prepared beforehand the necessary technical drawings for them, the astrolabes would not have turned out so poorly with such shoddy workmanship and orthography, even if the artisan was very incompetent.

What is more likely is that a certain astronomer with the title *Jyotiṣācārya* got an astrolabe made in 1834 for the latitude of 26° (i.e., Jodhpur in Rajasthan) and that sometime after 1834, two copies were made of the original astrolabe at the instance of a person whose enthusiasm for large astrolabes did not match with his knowledge of this instrument. But he was clever enough to add a different year on the second astrolabe. The artisan he chose was not competent to make accurate copies, nor was he literate enough to copy the names of the stars and the inscriptions correctly.

The artisan did not make exact copies as regards the size and shape. The sizes of these two specimens vary and also the shapes of the suspension brackets and of the retes. So also the disposition of the latitude circles: on the present astrolabe, they are arranged for the latitude of 33°, while on the next specimen their arrangement is roughly for the latitude of 26°. Apparently the man who commissioned the two pieces wanted large astrolabes. The main plate in D067 is somewhat smoothened and polished; this is not the case in D068. Here no attempt was made to smoothen the metal sheet out of which the main plate was cut. The sheet is just 1 mm thick and wobbly.

These two specimens are too large to hold aloft in one hand and to measure the altitudes of heavenly bodies. They are too incomplete to be of any use for didactic purposes. They could have served merely as display objects in some astrologer's place to impress the clients.

The other possibility is that these two are incompetently made modern copies of the original astrolabe made for the Jyotiṣācārya on 12 July 1834 at Jodhpur. It is not what happened to it. But its existence is testified by these two strange imitations.

Components

Plate (d. 259, h. 311, t. 2) with crown, rete (d. 228) for 23 stars, alidade with a sighting tube. These are held together by a modern bolt and nut. The ring and shackle are missing.

Front

The lobed crown has horn-like projections at the base on the left and right.

The rim carries a degree scale, divided in 1° and 6°, and numbered in 6s serially from 1 to 60. Altitude circles are drawn for every 3°, each sixth line highlighted by dots. On the meridian line, from the zenith upwards, there are deeply engraved dots which were used as the centres for drawing the altitude circles. Azimuth arcs are drawn above and below the horizon for each 15°, but not very accurately. In the lower half are drawn dotted lines for seasonal hours, also not regularly. None of these circles are numbered. Nor is there any label mentioning the latitude for which the plate is designed. But the arrangement of the altitude circles shows that the plate is made for the latitude of 33° and not for the latitude of 26° as stated in the inscription on the back.



Figure D067.2 – Latitude plate with the projections for 33° (photo by S. R. Sarma)

RETE

The rete was cut out of a sheet on which originally projections were engraved for a latitude plate. These engraved lines can be seen now on the reverse side of the rete. In the rete, the three almost complete rings representing the Tropic of Capricorn, the equator and the ecliptic are held together by the equinoctial bar and an almost complete solstitial bar which is interrupted once between the equatorial ring and the ecliptic ring below. Neither of these two bars has any counter change. The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names. Each sign is subdivided in 6° and numbered from 6 to 30.

There are 23 star pointers, shaped like tiger's claws or daggers, 10 outside the ecliptic and 13 inside the ecliptic. Their names are written so carelessly that it is very difficult to decipher them. Some are wrongly named and some others are incorrectly positioned. There is no handle.



Figure D067.3 – Rete of the astrolabe (photo by S. R. Sarma)



Figure D067.4 – Reverse side of the rete showing altitude circles (photo by S. R. Sarma)

Table D067-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Muīvadi*	*Samudrapakṣī*	β Ceti
2	*Madavo*	*Matsyodara*	β Andromedae
3	*Kṛtikā*	*Kṛttikā*	η Tauri
4	*Mavāsva*	*Manuṣya-pārśva*	α Persei
5	*Maśī*	*Manuṣya-śīrṣa*	β Persei
6	*Rohaṇa*	*Rohīṇī*	α Tauri
7	*Ṣaṇmukhabhra*	*Ṣaṇmukha*	α Aurigae

	Star Name as engraved	Full/Correct Form	Identification
8	*Miṣṭame cāka hitha*	*Mithuna-vāma-pāda*	β Orionis
9	*Mithunavāmahasta*		γ Orionis
10	*Mithunakra*	*Mithuna-dakṣiṇa-hasta*	α Orionis
11	*Satabhiṣā*[923]	(*Lubdhaka*)	α Canis Majoris
12	*Punarvasu*		β Geminorum
13	*Trāphālguṇī*	*Uttara-phālguṇī*	β Leonis
14	*Hasta vāma sa ka*	*Hasta*	δ Corvi
15	*Citrā*		α Virginis
16	*Svāti*		α Bootis
17	*Śīsarkasāmarthapāda*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
18	*Dhanakoṭā*	*Dhanuṣkoṭī*	α Ophiuchi
19	*Atrajita*	*Abhijit*	α Lyrae
20	*Śramaṇa*	*Śravaṇa*	α Aquilae
21	*Kutrasātabhā*	*Kukkuṭapuccha*	α Cygni
22	*Askanda*	*Aśvaskandha*	β Pegasi
23	*-nvatāga*	*Aśvanābhi*	δ Pegasi

[923] Wrong label; the correct name should be *Lubdhaka* (α Canis Majoris).



Figure D067.5 – Back of the astrolabe (photo by S. R. Sarma)

BACK

On the upper half of the rim are engraved the altitude scales, divided in 1° and 6°, and numbered in 6s as 6—90; 90—6. The lower half of the rim is blank.

The upper left quadrant is blank, except for a radial line joining the centre with the division of 84° in the altitude scale. The upper right quadrant contains a sine-cosine graph with 21 (!) horizontal and 21 (!) vertical parallels.

In the lower half, there are two shadow squares, on the left for a base of 7 and on the right for a base of 12. The four scales are divided and numbered accordingly.

The alidade has a counter change at the centre, which is rather unusual in astrolabes produced in India. A sighting tube is mounted upon two vertical supports on

the alidade. These vertical supports are joined to the alidade in a very crude manner. The ends of these supports are pushed through the surface of the alidade, spliced into two halves and bent on the other side of the alidade. But these are not completely flush with the inner surface of the alidade. When the alidade is rotated along the back of the astrolabe, the alidade is likely to produce scratches on the surface of the astrolabe.

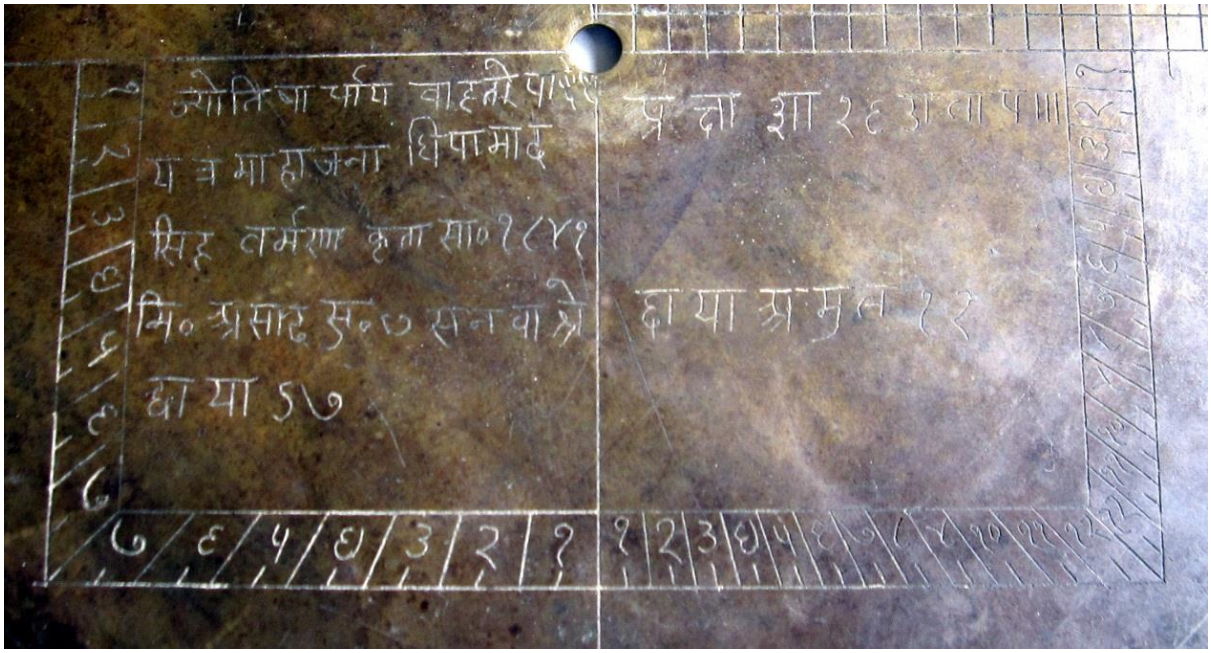


Figure D067.6 – Inscription at the back (photo by S. R. Sarma)

INSCRIPTION

The engraver, who is barely literate and cannot engrave with letters of the same size, mixed up the labels of the shadow squares with the main inscription which purports to provide the name of the person for whom the astrolabe was made, the name of the ruling prince and the name of the maker and the date of manufacture. The first four lines on the left constitute the main inscription:

jyotiṣārcāya vāhato pāṣda ṣṭa
yaṃtraṃ māhājanā dhipā māda
siṃha varmaṇā kṛtā sā° 1891
mi asādha su° 7 sanavāśre

'Master of Astral Science (*jyotiṣācārya*) Vāhatopāṣda (!).
Instrument (*yantraṃ*). Great king (*mahā-janādhipa*).
By Māda (?)Siṃha Varmā made. Year 1891
Bright half of Āṣāḍha 7[th day] Saturday (*śanivāsare*).'

The first line contains the name and title of the person who commissioned the astrolabe. While the title *jyotiṣārcāya* (! *jyotiṣācārya*) is written almost correctly, the actual name (*vāhato pāṣda ṣṭa*) makes no sense. The second line seems to refer to the ruling prince (*mahā-janādhipa* = great king). Then follows the name of the maker in instrumental case: *māda-siṃha-varmaṇā,* 'by Māda-siṃha-varman'. Here the first part (*māda*) seems to be corrupt. *kṛtā,* 'was made' is in feminine; it ought to be in neuter to match with *yaṃtraṃ*. The date corresponds to Saturday 12 July 1834.

The last line on the left is the label of the shadow square: *chāyā '7* (shadow [of the gnomon of] 7 [digits]. The last line on the right: *chāyā amula* [! *aṅgula*] 12 (shadow [of the gnomon of] 12 digits.

Finally the first line on the right which reads

akṣāśā 26 ḍālāpa |||

The first two words should be *akṣāṃśāḥ 26* (degrees of latitude 26). The third word *ḍālapa* makes no sense. As we saw from the arrangement of the altitude lines, 'degrees of latitude 26' is factually incorrect.

PROVENANCE

Acquired from Sotheby's in the auction of 30 September 1997 together with the loose rete D071.

BIBLOGRAPHY

Sotheby's, London, *Important Instruments of Science and Technology 1550-1950,* auction catalogue of 30 September 1997, lot 71, p. 51.

D068 COPY OF AN ASTROLABE MADE FOR JYOTIṢĀCĀRYA IN 1834

19th century, probably Jodhpur, Rajasthan

Diameter 321 mm

Dallas, PC



Figure D068.1 – Front of the astrolabe (photo by the owner)

About this specimen, see the introductory remarks on D067.

COMPONENTS

Plate (d. 321, h. 410, t. 1) with crown, rete for 23 stars, rudimentary alidade. These are held together by a modern bolt and nut. The ring and shackle are missing.

FRONT

The crown, consisting of two fronds of three leaves each, is made separately and joined to the main plate. The rim of the main plate carries a degree scale, divided in 1° and 6°, and numbered in 6s from 6 to 90, separately in each quadrant. Altitude circles are drawn for every 2°, each fifth line is highlighted by dots. On the meridian line there are deeply incised dots from the zenith upwards which were used as the centres for drawing the altitude circles. There are faint traces of azimuth arcs below the horizon for every 6°. In the lower half are drawn dotted lines for seasonal hours, but not regularly. None of these circles is numbered. The arrangement of the altitude circles indicates that the plate is calibrated for the latitude of 26°.



Figure D068.2 – Latitude plate with the projections for 26° (photo by the owner)

RETE

In the rete, the three almost complete rings representing the Tropic of Capricorn, the equator and the ecliptic are held together by the equinoctial bar which has no counter change. The ecliptic ring is divided into the 12 signs of the zodiac and labelled with their names. Each sign is subdivided in 6° and numbered from 6 to 30. There are 23 star

pointers, shaped like tiger's claws or daggers, 10 outside the ecliptic and 13 inside the ecliptic. In many cases their names are too faint to decipher. Clearly visible are the names *Rohaṇa* (correct form *Rohiṇī,* α Tauri), *Ārdrā* (α Orionis), *Citrā* (α Verginis), *Svāti* (α Bootis) and *Śravaṇa* (α Aquilae). The star pointer of *Uttara-bhādrapadā* (γ Pegasi) is wrongly labelled as *Utrā Phālgunī* (correct form *Uttarā Phlgunī*, β Leonis). There is no handle to turn the rete around the centre.



Figure D068.3 – Rete of the astrolabe (photo by the owner)

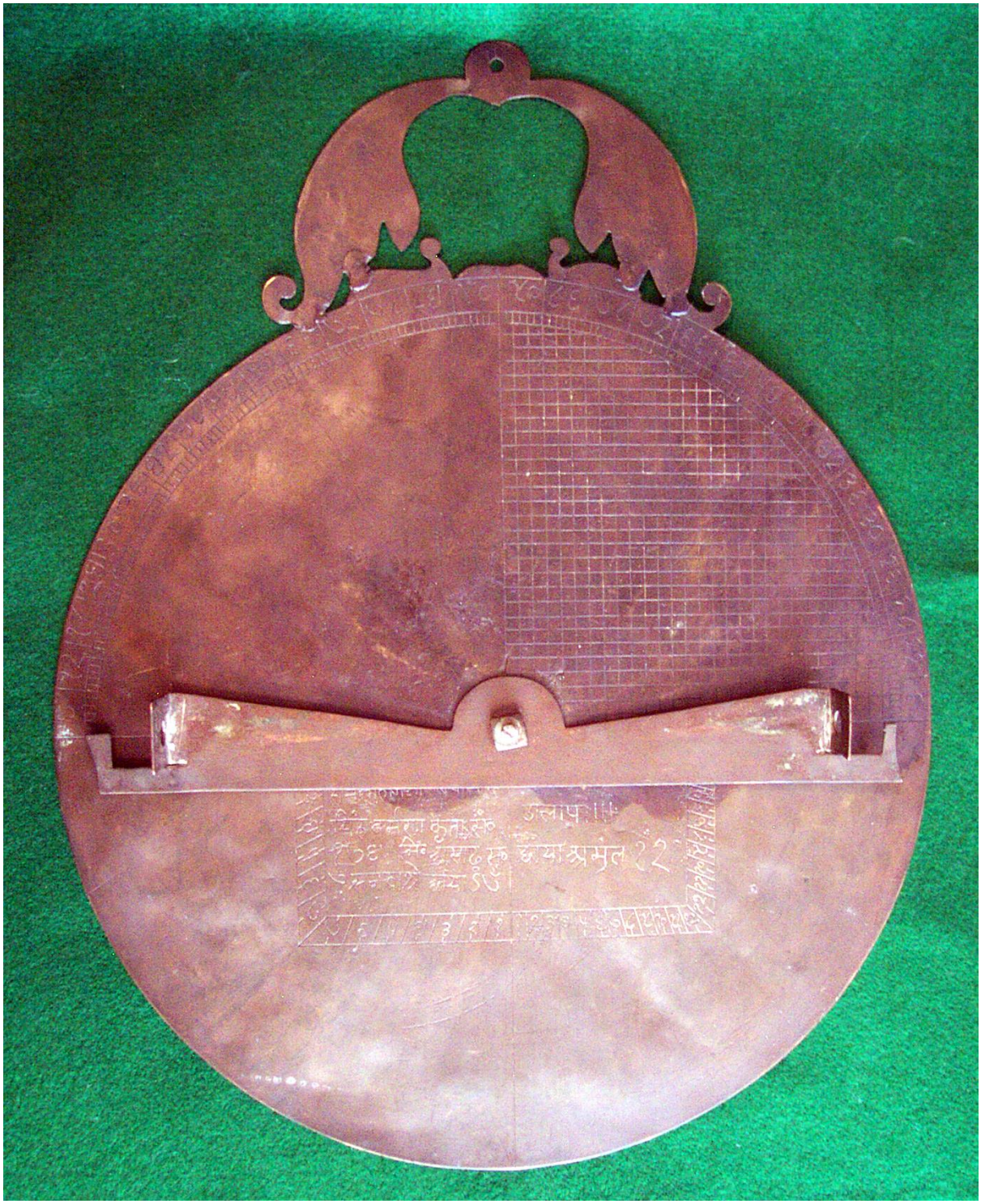


Figure D068.4 – Back of the astrolabe (photo by the owner)

BACK

On the upper half of the rim are engraved the altitude scales, divided in 1° and 6°, and numbered in 6s as 6—90; 90—6. The lower half of the rim is blank.

The upper left quadrant is blank. The upper right quadrant contains a sine-cosine graph with 30 horizontal and 30 vertical parallels.

In the lower half, there are two shadow squares, on the left for a base of 7 and on the right for a base of 12.

The alidade has an unusual shape. A small part at each end is cut and bent at right angles to serve as the sighting plate. Each sighting plate has a hole in it. The holes are correctly positioned.

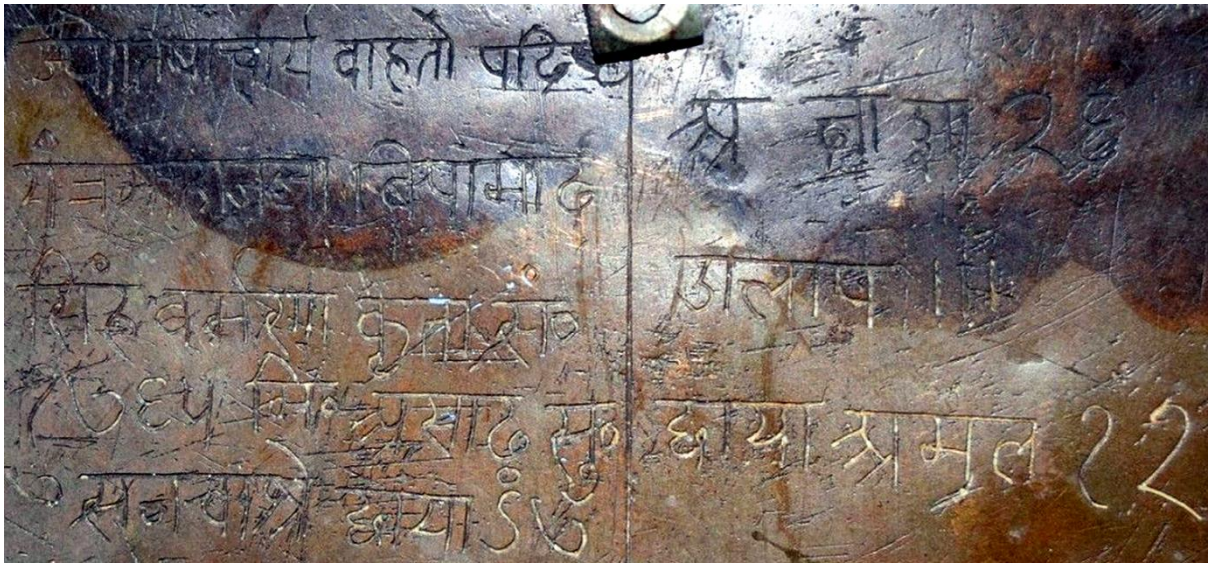


Figure D068.5 – Inscription at the back (photo by the owner)

INSCRIPTION

The inscription is almost the same as in the previous astrolabe D067, with minor variations. The five lines on the left read as follows:

jyotiṣācārya vāhato padriṣṭa
yaṃtra māhājanā bipā māda
siṃha varmaṇā kṛtā sam°
1865 mi° asādha su°
7 sanavāśre

'Master of Astral Science (*jyotiṣācārya*) Vāhatopadriṣṭa.
Instrument (*yantraṃ*). Great king (*mahā-janādhipa*).
By Māda (?)Siṃha Varmā made. Year 1765
Bright half of Āṣāḍha 7 [th day] Saturday (*śanivāsare*).'

The first line contains the name and title of the person who commissioned the astrolabe. While the title *jyotiṣācārya* is written correctly, his actual name (*vāhato pāṣda ṣṭa*) makes no sense. The second line seems to refer to the ruling prince (*mahā-janādhipa* = great king). Then follows the name of the maker in instrumental case: *māda-siṃha-*

varmaṇā, ‘by Māda-siṃha-varman’. Here the first part (*māda*) seems to be corrupt. *kṛtā,* ‘was made’ is in feminine; it ought to be in neuter to match with *yaṃtraṃ*. The date corresponds to 25 June 1708.

The last line on the left ends with *chāyā ‘7* (shadow [of the gnomon of] 7 [digits]. The last line on the right: *chāyā amula* [! *aṅgula*] 12 (shadow [of the gnomon of] 12 digits.

Finally the first line on the right reads

akṣāśā 26 ḍālāpa |||

The first two words should be *akṣāṃśāḥ 26* (degrees of latitude 26). The third word makes no sense.

ASTROLABES WITH SOLID RETES

Sir Pratap Singh Museum in Srinagar owns two rather large Sanskrit astrolabes in which there are no perforated retes containing star pointers but solid discs made to the size of the ecliptic circles and pivoted to the central pin eccentrically. The star pointers in the perforated rete allow the use of the astrolabe at night. In the absence of the star pointers, these astrolabes cannot be used at night. It is difficult to see what advantage was sought to be achieved by these unusual solid retes.

These two specimens are not signed or dated. On the back of both the astrolabes, the upper right quadrant contains a sine-cosine graph, which is identical in style to the sine-cosine grids on the astrolabes and *Dhruvabhrama-yantras* made by Bulhomal of Lahore. However, the Devanagari script in these astrolabes is different from the script in Bulhomal's other productions. These astrolabes must have been designed by Bulhomal, but engraved by different assistants in his workshop.

Several astrological tables are engraved on the back of first specimen (D069), but they do not occur in the second specimen (D070).

D069 ASTROLABE WITH SOLID RETE FOR LATITUDE 30°, ATTRIBUTABLE TO THE WORKSHOP OF BULHOMAL OF LAHORE

Mid-19th century, Lahore

Diameter 260 mm

Srinagar, Sir Pratap Singh Museum (ex- Central Asian Museum, University of Kashmir, Srinagar #8-201).



Figure D069.1 – Front of the astrolabe (photo by Nazir Ahmad Doshab)

In the present specimen, under the solid rete is engraved latitude 30° together with the corresponding midday equinoctial shadow (*akṣabhā*) and the duration of the longest day there (*paramadina*). It suggests that this specimen or both were not made for Lahore like all the other instruments of Bulhomal, but for some other place 2° south of Lahore,

probably Kapurthala, the seat of Bulhomal's patron the Maharaja of Kapurthala, or for Patiala.

Components

Plate with crown, shackle and ring, solid rete, alidade, pin; wedge is missing.

Front

The shackle is plain and the ring is large. The crown is rather low; its profiles contain ogees at the base and top with a lobe in the middle. The degree scale in the rim is divided in 1° and 6° and numbered in 6s from 1 to 60. Inside the rim, south-north and east-west diameters are marked, as also the circles of the celestial equator and of the Tropic of Cancer. Altitude circles are engraved for every 6° and numbered on both sides. Azimuth arcs are drawn for every 15° above the horizon and numbered. In the lower half there are lines for seasonal and equal hours.

Rete

The rete is a solid disc whose outer circumference coincides with the ecliptic circle. The scale on its rim is divided into the twelve zodiac signs and labelled with the respective names of the signs. Each sign is divided into groups of 6° and numbered 6, 12, 18, 24, 30 anticlockwise. The first point of Capricorn (*makarāsya*) is extended as a sharp point. South-north and east-west lines are drawn which pass through the centre of the astrolabe.

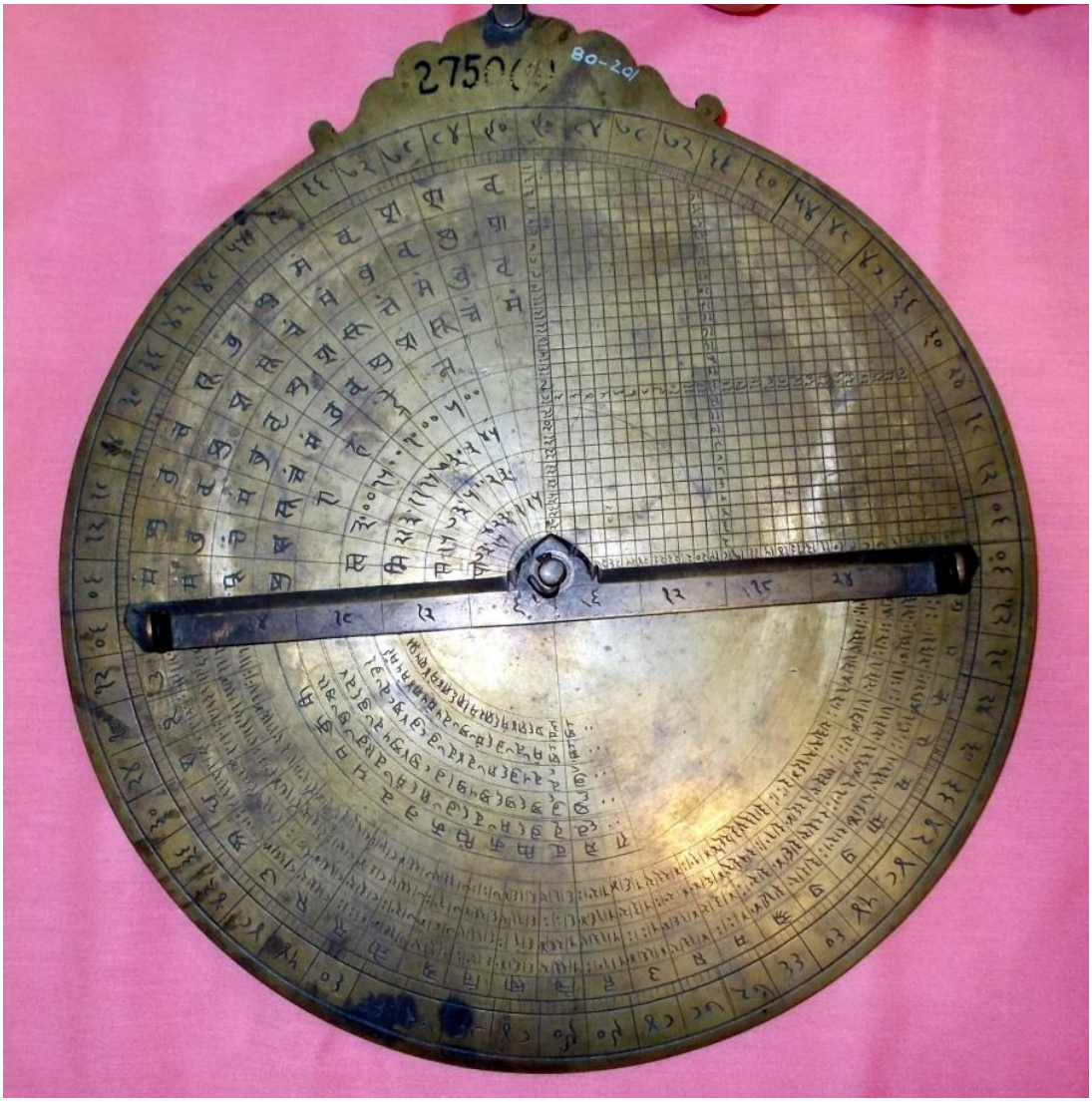


Figure D069.2 – Back of the astrolabe (photo by Nazir Ahmad Doshab)

BACK

On the back the scale on the rim is divided in 1° and 6° and numbered in 6s from 6 to 90, separately in each quadrant, starting from the east point thus: 6—90; 90—6; 6—90; 90—6. The upper right quadrant carries the sine-cosine graph with 30 equidistant horizontal parallels and 30 equidistant vertical parallels. On this the quarter circle of obliquity is drawn. The parallels are numbered along both the vertical and horizontal radii from 1 to 30, starting at the arc and reaching up to the centre. In the 13th vertical and horizontal parallels (as counted from the radii), the parallels are numbered once again, this time starting from the respective radius. The design and numbering of this sine-cosine graph are exactly as in the Bulhomal's signed instruments.

The other three quadrants are filled with diverse astrological tables. Barring one, the rest are different from the tables on the two astrolabes C028 and C029 which are also attributable to Bulhomal. Dr Martin Gansten has kindly interpreted these tables me.

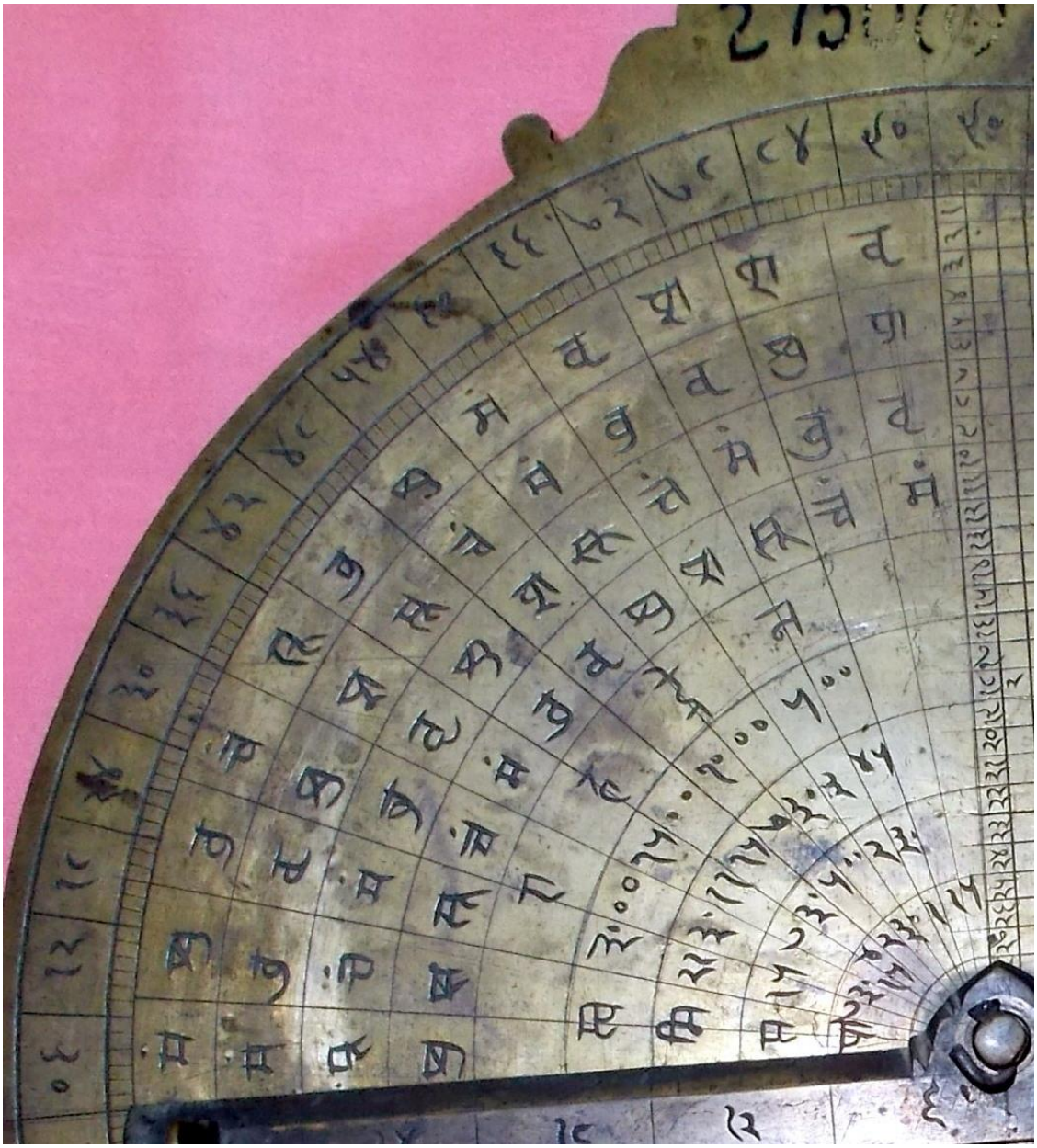


Figure D069.3 – Astrological tables on the upper left quadrant (detail of Figure D069.4)

Table 1

In the upper left quadrant is engraved a table of 48 cells, arranged in 12 columns and 4 rows. The initial syllable of the name of a planet is written in each cell. The topmost row (in bold letters) is separate from the rest of the table and displays the names of the regents of the 12 zodiac signs, as in the Table C028-3. Therefore, in the table as reproduced below, the topmost row is separated from the rest by a blank row.

Mars	**Venus**	**Mercury**	**Moon**	**Sun**	**Mercury**	**Venus**	**Mars**	**Jupiter**	**Saturn**	**Saturn**	**Jupiter**
Mars	Mercury	Jupiter	Venus	Saturn	Sun	Moon	Mars	Mercury	Jupiter	Venus	Saturn
Sun	Moon	Mars	Mercury	Jupiter	Venus	Saturn	Sun	Moon	Mars	Mercury	Jupiter
Venus	Saturn	Sun	Moon	Mars	Mercury	Jupiter	Venus	Saturn	Sun	Moon	Mars

The rest of the table of 36 cells can be read in two different ways. The first is to read each row from from left to right, one after the other: this gives the order of the days of the week, beginning with Mars/Tuesday.

The second way is to read each column downwards, starting with the column on the left. This provides the names of planets in the descending order of apparent velocity or of the extent of their orbits (i.e., Saturn, Jupiter, Mars, Sun, Venus, Mercury and Moon), again beginning with Mars. The purpose of this arrangement is show graphically the names of the planetary regents of each of the 24 hours in a day-and-night (*kālahorā*) of all the seven weekdays. The first hour of the day (beginning at sunrise) is governed by the regent of the entire day, after whom the day is named. One can begin at any planet in the upper row and find the regents of the 24 hours of that particular weekday, by proceeding successively through the columns. For example, Mars is the regent of Tuesday and also of the first hour of Tuesday. The subsequent hours are ruled by the planets next in velocity, as shown in the table (Venus, Mercury, Moon and so on).[924]

Table 2

In the same upper left quadrant is engraved the following table below the larger table.

	Rā[śi]	***H[orā]***	***Dre[ṣkāṇa]***	***Na[vāṃśa]***
Sva[kṣetra]	30;00	15;00	10;00	5;00

924 Cf. Bīrūnī 1934, pp. 237-238: 'With regard to the distribution of the days of the week among the planets, it is natural that the first hour of the first day Sunday should be given to the planet which is the cause of day and night, viz. the sun. The second hour is allotted to the next lower planet Venus, the third to Mercury, the fourth to the moon, the fifth to Saturn and so on till the second day Monday whose first hour falls to the moon, second to Saturn, and so on in the same way until another Sunday arrives, when the first hour is again the turn *01'* the sun. The lords of the hours having been determined in this way it was natural that the days of the week should be assigned to the planet associated with the first hour thereof'; Ackermann 2005, p. 75, Table 7.4.

Mi[trakṣetra]	22;30	11;15	7;30	3;45
Sa[makṣetra]	14	7;30	5;00	2;30
Pā[pa-kṣetra?]	7;30	1;45	2;30	1;15

This table is related to a system of assigning 'strength' to the planets based on their location in the zodiac (*sthāna-bala*). The abbreviations in the first column on the left stand for *sva-kṣetra* or *-gṛha* (own sign or domicile), *mitra-kṣetra* (friendly sign) and *sama-kṣetra* (neutral sign). The fourth ought to be *śatru-* or *ripu-kṣetra* (inimical sign). But on the astrolabe is engraved *pā* which can be expanded to *papa-kṣetra,* which would mean 'malefic sign' which is different from inimical sign. The numerical values in the table are not degrees of arcs, but points of strength on a scale from 15 (planet in an inimical sign) to 60 (planet in its own sign).

Table 3

The third table is engraved below the degree scale in the two lower quadrants in five semi-circular rows and 27 columns. At the top of each column is written the initial syllable of the name of a lunar mansion (*nakṣatra*). The four numbers in each column are the longitudes (in a sidereal zodiac) of the beginning of each quarter (*pāda*) of a lunar mansion, expressed in degrees, minutes and seconds. The 27 x 4 = 108 *pādas* of the lunar mansions are identical with the 12 x 9 = 108 *navāṃśas* (nonenaries) of the zodiac signs. That is to say, the eight quarters of the two lunar mansions *Aśvinī* and *Bharaṇī,* together with the first quarter of *Kṛttikā* (4 + 4 + 1), constitute the zodiac sign *Meṣa* (Aries) with its nine divisions.

The table is reproduced below; for sake of convenience, the 27 columns are arranged here as rows. On the astrolabe, zero is represented by a dot and two zeroes by two dots on below the other; here zeroes are used.

Table D069-1 Longitudes of the four quarters of the Lunar Mansions.

Lunar Mansion	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Aśvinī	[0] | 00 | 00	[0] | 3 | 20	[0] | 6 | 40	[0] | 10 | 0
Bharaṇī	00 | 13 | 20	00 | 16 | 40	00 | 20 | 0	00 | 23 | 20
Kṛttikā	00 | 26 | 4	1 | 00 | 00	1 | 3 | 20	1 | 6 | 40
Rohiṇī	1 | 10 | 00	1 | 13 | 20	1 | 16 | 40	1 | 20 | 00

Lunar Mansion	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Mṛgaśirā	1 | 23 | 20	1 | 26 | 40	2 | 00 | 00	2 | 3 | 20
Ārdrā	2 | 6 | 40	2 | 10 | 00	2 | 13 | 20	2 | 16 | 40
Punarvasu	2 | 20 | 00	2 | 23 | 20	2 | 26 | 40	3 | 00 | 00
Puṣya	3 | 3 | 20	3 | 6 | 40	3 | 10 | 00	3 | 13 | 20
Aśleṣā	3 | 16 | 40	3 | 20 | 00	3 | 23 | 20	3 | 26 | 20
Maghā	4 | 00 | 00	4 | 3 | 20	4 | 6 | 40	4 | 10 | 00
Pūrva-phālguṇī	4 | 13 | 10	4 | 16 | 20	4 | 20 | 00	4 | 23 | 20
Uttara-phālguṇī	4 | 26 | 40	5 | 00 | 00	5 | 3 | 20	5 | 6 | 40
Hasta	5 | 10 | 00	5 | 13 | 20	5 | 16 | 40	5 | 20 | 00
Citrā	5 | 23 | 20	5 | 26 | 40	6 | 00 | 00	6 | 3 | 20
Svāti	6 | 6 | 40	6 | 10 | 00	6 | 13 | 20	6 | 16 | 40
Viśākhā	6 | 20 | 00	6 | 23 | 20	6 | 26 | 40	7 | 00 | 00
Anurādhā	7 | 3 | 20	7 | 6 | 40	7 | 10 | 00	7 | 13 | 20
Jyeṣṭhā	7 | 16 | 40	7 | 20 | 00	7 | 23 | 20	7 | 26 | 40
Mūla	8 | 00 | 00	8 | 3 | 20	8 | 6 | 40	8 | 10 | 00
Pūrvāṣāḍha	8 | 13 | 20	8 | 16 | 40	8 | 20 | 00	8 | 23 | 20
Uttarāṣāḍha	8 | 26 | 40	9 | 00 | 00	9 | 3 | 20	9 | 6 | 20
Śravaṇa	9 | 10 | 00	9 | 13 | 20	9 | 16 | 40	9 | 20 | 00
Dhaniṣṭhā	9 | 23 | 20	9 | 26 | 40	10 | 00 | 00	10 | 3 | 20
Śatabhiṣā	10 | 6 | 40	10 | 10 | 00	10 | 13 | 20	10 | 16 | 40
Pūrva-bhādrapadā	10 | 20 | 00	10 | 23 | 20	10 | 26 | 40	11 | 00 | 00
Uttara-bhādrapadā	11 | 3 | 20	11 | 6 | 40	11 | 10 | 00	11 | 13 | 20
Revatī	11 | 16 | 40	11 | 20 | 00	11 | 23 | 20	11 | 26 | 40

Table 4

In the lower left quadrant, below the large table 3, is engraved table of the limits or terms of signs; for sake of convenience, the 12 columns are arranged here as rows.

Table D069-2 Limits of Signs

Aries	6 Jupiter	6 Venus	8 Mercury	5 Mars	5 Saturn
Taurus	8 Venus[925]	6 Mercury	8 Jupiter	5 Saturn	3 Mars
Gemini	6 Mercury	6 Venus	5 Jupiter	7 Mars	6 Saturn[926]
Cancer	7 Mars	6 Venus	6 Mercury	7 Jupiter	4 Saturn
Leo	Jupiter 6	Venus 5	Saturn 7	Mercury 6	Mars 6
Virgo	Mercury 7	Venus 10[927]	Jupiter 4	Mars 7	Saturn 2
Libra	Saturn 6	Mercury 8	Jupiter 7	Venus 7	Mars 2[928]
Scorpio	Mars 7	Venus 4	Mercury 8	Jupiter 5	Saturn 6
Sagittarius	Jupiter 12	Venus 5	Mercury 4	Mars 5	Saturn 4
Capricorn	Mercury 7	Jupiter 7	Venus 8	Saturn 4	Mars 4
Aquarius	Venus 7	Mercury 6	Jupiter 7	Mars 5	Saturn 5
Pisces	Venus 12	Jupiter 4	Mercury 3	Mars 9	Saturn 2

ALIDADE

A graduated straight bar alidade is pivoted to the centre at the back. The sights are attached very close to the ends. There is a broad-headed pin passing through the holes in the rete, in the main plate and in the alidade. The wedge to hold the pin tight is lost; a bent nail is doing this function.

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925 There is just *vṛ* for Jupiter without any numerical sign; it is clearly an error, because Jupiter is mentioned elsewhere in the same.

926 Here the initial syllable of the planet's name looks more like *pra* and not *śa* as it ought to be.

927 Here the number engraved is just 1.

928 Here the number engraved is 3.

PROVENANCE

This astrolabe was on loan to the Central Asian Museum of the University of Kashmir, Srinagar, from 1980 to 2015 February. It is now transferred to the original owner Sir Pratap Singh Museum, Srinagar.

BIBLIOGRAPHY

Sarma 2015b, pp. 283-284, no. [24]

D070 ASTROLABE WITH SOLID RETE FOR LATITUDE 30°, ATTRIBUTABLE TO THE WORKSHOP OF BULHOMAL OF LAHORE

Mid-19th century, Lahore

Diameter 245 mm

Srinagar, Sir Pratap Singh Museum (ex- Central Asian Museum, University of Kashmir, Srinagar #8-202).



Figure D070.1 – Front of the astrolabe (photo by Nazir Ahmad Doshab)

This astrolabe is almost similar to the previous one, but with certain differences. The suspension bracket is engraved with an ornate design on both sides and there are no astrological tables on the back.

COMPONENTS

Plate with crown (d. 245) and shackle, solid rete, alidade, washer and pin. The original ring and wedge are missing.

FRONT

The shackle is small with a trifoliate form and circular bases. The crown is of medium height, the profiles are formed by ogees with curved lower tip at the base, followed by a lobe and another ogee, with a circular finial. There are decorative engravings on the surface of the crown; their pattern on the front is different from the pattern on the back.

The degree scale on the rim of the plate is divided in 1° and 6° and numbered clockwise in 6s from 1 to 60. Within the rim, the south-north and east-west diameters are marked and also the circles of the celestial equator and of the Tropic of Cancer. Altitude circles are engraved for every 6° and numbered on both sides of the meridian. Azimuth arcs are drawn for every 15° above the horizon and numbered. In the lower half there are lines for seasonal hours and equal hours. The former are numbered just below the circle of equator from 1 to 12 starting from the western horizon. The lines of equal hours are also numbered in the manner, but above the circle of Capricorn.

When the rete is removed, at the middle of the plate can be seen the following inscription in Devanagari:

akṣāṃśaḥ 30 *akṣabhā 7*
paramadina *24/58*
‘Latitude 30 [degrees]. Midday equinoctial shadow 7 [digits]
Duration of the longest day 34 [*ghaṭīs*], 58 [*palas*] (i.e., 13;59 hours).’

RETE

As in the previous astrolabe, the rete here is a solid disc whose outer circumference is formed by the ecliptic circle. The scale on its rim is divided into the twelve zodiac signs and labelled carelessly with the respective names of the signs. Each sign is divided into groups of 6° and numbered anticlockwise from 6 to 30. The first point of Capricorn

(*makarāsya*) is extended as a sharp point. South-north and east-west lines are drawn which pass through the centre of the astrolabe.

Back

On the back, the rim is graduated in 1° and 6° and numbered in 6s from 6 to 90, separately in each quadrant. The numbers in each quadrant commense at the east or west points and reach up to the south or north point. In the upper left quadrant are traced 8 declinations arcs, but there are no numbers or labels on them. The upper right quadrant contains a sine-cosine graph with 30 equidistant horizontal parallels and 30 equidistant vertical parallels, drawn and numbered in the characteristic style of Bulhomal. The two lower quadrants are blank.

Alidade

The alidade is almost the same as in the previous astrolabe, the centre piece being more ornate. The length of the alidade is divided into 5 parts in each half, but not numbered.

A broad-headed pin passes through the holes in the rete, in the main plate and in the alidade. The original wedge is missing. Now the ensemble is held together by a rusty nail.



Figure D070.2 – Back of the astrolabe (photo by Nazir Ahmad Doshab)

PROVENANCE

This astrolabe was on loan to the Central Asian Museum of the University of Kashmir, Srinagar, from 1980 to 2015 February. It is now transferred to the original owner Sir Pratap Singh Museum, Srinagar.

BIBLIOGRAPHY

Sarma 2015b, pp. 283-284, no. [24]

ASTROLABES FOR UNKNOWN LATITUDES

In some extant specimens, it is difficult to determine the latitude for which they were made, either because the specimen is not completely extant, or because of faulty construction, or for other reasons.

D071⊙ ASTROLABE FOR UNKNOWN LATITUDE, NOT SIGNED, NOT DATED

18th century? Gujarat

Diameter 169 mm

New York, Columbia University, Butler Library, D. E. Smith Collection (#27-252)



Figure D071.1 – Front of the astrolabe (courtesy Butler Library, Columbia University)

The construction of this astrolabe is rather unusual. The front with the crown and the circular scale, cut of a thick sheet, and the back with the crown were riveted with a series of nails along the circumference, creating a recess to accommodate the rete. Thus

it combines the features of astrolabes with multiple plates and those with a single plate. However, the latitude plate made for this astrolabe is missing. Without it the astrolabe is non-functional. There is one other specimen constructed in this fashion, but there the latitude plate with projections for the latitude of 22;35,39° is surviving (D058). In both astrolabes, the rete exhibits the 'bird in the cage' pattern and the numerals are of the western Indian type, indicating that both the astrolabes may have been produced in Gujarat.

In the present astrolabe the engraved lines and letters are filled with some white substance.

COMPONENTS

Two plates forming the mater and crown (d. 169, h. 209), shackle, rete for 13 stars, alidade (177) with a sighting tube (180), and an index (70) in the front.

FRONT

The crown has an unusual shape with deep scallops near the base on either side. The degree scale on the rim is divided in 1° and in 6°; the divisions of 6° are numbered serially from 1 to 60. The numerals are large and of the western Indian type.

RETE

The rete is well made. It contains the complete rings of the Tropic of Capricorn and the ecliptic. Only the lower half of the equator is represented. These are held together by the east-west equinoctial bar which is interrupted near the western part of the ecliptic to accommodate a star pointer. The rest of the space is filled with foliate tracery with creepers and leaves, creating the 'bird in the cage' pattern in the upper half.[929] In particular, this rete has a very close resemblance to the rete in an astrolabe made in 1618 which is now in the Raja Dinkar Kelkar Museum in Pune (C002) and in another in the American Museum of Natural History, Washington D.C., which was produced by Vīrabha or Vīrabhadra in 1805 (C024). The ecliptic ring is divided into the 12 zodiac signs, which are labelled with the initial syllables of their names. As against the general practice of dividing each sign into 5 parts of 6° each, here each sign is

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929 On this pattern, see Sarma 2011b, pp. 107-110.

divided into 6 parts of 5° and these parts are numbered anticlockwise as 5, 10, 15, 20, 25, 30. Again each of these parts is subdivided into single degrees on the edge of the ecliptic ring. There are several star pointers, but only 13 are named. There is a well defined Capricorn index, but no knob to rotate the rete.

Table D071-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudra*	*Samudrapakṣī*	β Ceti
2	*Ma.śī.*	*Manuṣyapārśva*	α Persei
3	*Ārdrā*[930]	*Ārdrā*	α Canis Majoris
4	*Maghā*		α Leonis
5	*Nuta*	*Uttaraphālgunī*	β Leonis
6	*Citrā*		α Virginis
7	*Viśā*	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
8	*Dhanu*	*Dhanuṣkoṭi*	α Ophiuchi
9	*Abhi*	*Abhijit*	α Lyrae
10	*Śrava*	*Śravaṇa*	α Aquilae
11	*Śata*[931]	*Kukkuṭa-puccha*	α Cygni
12	*Bhāva*	*Aśvamukha*	ε Pegasi
13	*Pūbhā*	*Pūrva-bhādrapadā*	β Pegasi

930 This astrolabe follows Mahendra Sūri in naming α Canis Mojoris as *Ārdrā* or *Ārdrā-lubdhaka.* Otherwise, *Ārdrā* is the designation of α Orionis.

931 Here the star *Kukkuṭapuccha* (α Cygni) is wrongly named as *Śatabhiṣā* (λ Aquarii); see also C002, C004, C024, D062, D063 and D064.

BACK

On the back, the two upper quadrants carry the altitude scales divided in 1° and 6° and numbered in 6s as 6—90; 90—6. Otherwise the four quadrants are blank.

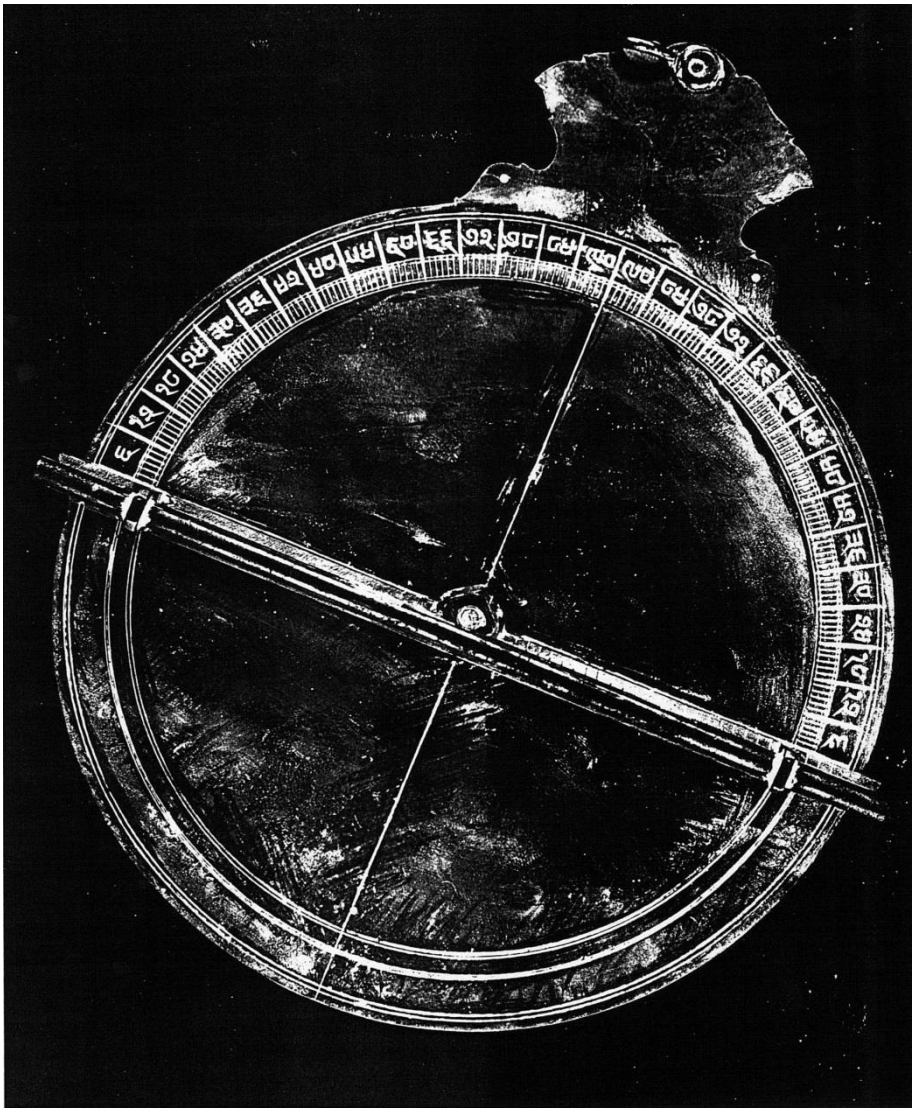


Figure D071.2 – Back of the astrolabe (courtesy Butler Library, Columbia University)

ALIDADE

The alidade is longer than the diameter of the astrolabe and the sighting tube attached to the alidade is still longer. The index in the front is not graduated.

D072⦿ ASTROLABE FOR UNKNOWN LATITUDE, NOT SIGNED, NOT DATED

19th century, Rajasthan

Extant only the rete (d. 194, t. 1.5) for 17 stars

PC: Brussels



Figure D072.1 – Rete of an astrolabe (photo by S. R. Sarma)

It is not known whether this rete belonged to an astrolabe with multiple plates or to an astrolabe with a single plate. The almost complete rings of the Tropic of Capricorn, equator and the ecliptic are joined by the equinoctial bar (without any counter change) and parts of the solstitial bar. The ecliptic is divided into 12 signs of the zodiac and labelled with their names (except for the last sign). Each sign is divided into groups of 6° and labelled in the usual manner. These are further subdivided into groups of 2° on the sloping edge of the ecliptic ring.

There are 17 star pointers, 8 outside the ecliptic and 7 inside. These are shaped in almost all cases like equilateral triangles and carry, in most cases, the Sanskrit names of

the lunar mansions (*nakṣatras*). But it is very strange that in as many as ten instances wrong names are inscribed on the star pointers.

Table D072-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*A*	*Aśvinī*	β Arietis
2	*Rohaṇī*	*Rohiṇī*	α Tauri
3	*Jeṣṭā*[932]	*Jyeṣṭhā*	α Scorpii
4	*Ārdrā*		α Orionis
5	*Dhruva*[933]		α Ursae Minoris
6	*Uttarā Bhadrapadā*[934]		γ Pegasi
7	*Mṛgasara*[935]	*Mṛgaśirā*	λ Orionis
8	*Bharaṇī*[936]		41 Arietis
9	*Hasta*		δ Corvi
10	*Citrā*		α Virginis
11	*Mārica*	*Marici*	η Ursae Majoris
12	*Svāti*		α Bootis
13	*Dhaniṣṭā*[937]	*Dhaniṣṭhā*	β Delphini
14	*Puṣya*[938]		δ Cancri

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932 Wrong label; the correct name is *Brahmahṛdaya* (α Aurigae).

933 Wrong label; the correct name is *Lubdhaka* (α Canis Majoris).

934 Wrong label; the correct name is *Lubdhakabandhu* (α Canis Minoris).

935 Wrong label; the correct name is *Mahāpuruṣa* (α Hydrae).

936 Wrong label; the correct name is *Pūrvaphālgunī* (α Leonis)

937 Wrong label; the correct name is *Abhijit* (α Lyrae).

938 Wrong label; the correct name is *Śravaṇa* (α Aquilae).

	Star Name as engraved	Full/Correct Form	Identification
15	*Aśleṣā*[939]		ζ Cancri
16	*Pratāganita*[940]		
17	*Maghā*[941]		α Leonis

PROVENANCE

Acquired at Sotheby's auction of 30 September 1997, together with the astrolabe D067 in one lot.

BIBLOGRAPHY

Sotheby's, London, *Important Instruments of Science and Technology 1550-1950,* auction catalogue of 30 September 1997, lot 71, p. 51.

939 Wrong label; the correct name is *Aśvamukha* (ε Pegasi).

940 There is no such star name; it should be *Śatabhiṣā* (λ Aquarii).

941 Wrong label; the correct name is *Pūrva-bhādrapadā* (β Pegasi).

D073 ASTROLABE FOR UNKNOWN LATITUDE, NOT SIGNED, NOT DATED[942]

19th century?

Diameter 293 mm

PLU; ex-Skinner, Bolton, MA

FRONT

The crown is simple. The limb is divided in 1° and in 6°. Groups of 6° are numbered serially from 1 to 60. Altitude circles and azimuth arcs are very crudely drawn. Is it is not known for which latitude the plate is calibrated.

RETE

The ecliptic ring circle is divided in signs and labelled; each sign is subdivided into five parts and numbered accordingly. There are 24 named star pointers. The stars are as follows:

Table D073-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudrapakṣi*	*Samudrapakṣī*	β Ceti
2	*Matanedara*	*Matsyodara*	β Andromedae
3	*Manupakṣi*	*Manuṣyapārśva*	α Persei
4	(not named)	*Aśvinī*	γ Arietis
5	*Rohiṇī*		α Tauri
6	*Vrahṛdaya*	*Brahmahṛdaya*	α Aurigae
7	*Si.vā.pa*	*Mithuna-vāma-pāda*	β Orionis
8	*Ārdrā*		α Orionis

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942 Entry is based on the notes kindly provided by Dr Clemency Williams who read the astrolabe for Skinner.

	Star Name as engraved	Full/Correct Form	Identification
9	*Tipā or tiśa*	*Prajāpati*	δ Aurigae
10	*Luvataka*	*Lubdhaka*	α Canis Majoris
11	*Lu.vandha*	*Lubdhaka-bandhu*	α Canis Minoris
12	*Mahāpuruṣa*		α Hydrae
13	*Purvaphaghi*	*Pūrva-phālgunī*	δ Leonis
14	*Hasna*	*Hasta*	δ Corvi
15	*Citrā*		α Virginis
16	*Svāti*		α Bootis
17	*Marīci*		η Ursae Majoris
18	*Sarpagribā*	*Sarpagrīvā*	α Serpentis
19	*Abhijit*		α Lyrae
20	*Śravaṇa*		α Aquilae
21	*Kukkuṭapu*	*Kukkuṭpuccha*	α Cygni
22	*Aśvamukha*		ε Pegasi
23	*Satabhīṣā*	*Śatabhiṣā*	λ Aquarii
24	*Purvābhadrapada*	*Pūrvabhādrapadā*	β Pegasi

Back

The back is incomplete. It just carries the altitude scale on the rim of the upper half; the scale is numbered in 6s from the east point onwards as 6—90; 90—6.

Provenance

Came up for auction at Skinner, Bolton, on 13 April 2002

Bibliography

Skinner 2002, lot 243, p. 38, without any photo.

D074 ASTROLABE FOR UNKNOWN LATITUDE, NOT SIGNED, NOT DATED

19th century ?

Diameter 127 mm

Hastings-on-Hudson, NY, Tesseract (Catalog 55, no. 5)



Figure D074.1 – Front of the astrolabe (photo courtesy Dr David Coffeen)

With its very crude workmanship and equally crude and undecipherable legends, it is a poor apology for an astrolabe. The letters and numbers are not engraved with a

pointed burin in a continuous flow but in unconnected strokes of a chisel. It appears to be an incompetent copy of an astrolabe.

Components

Plate with crown (d. 127), shackle and rete; the ring and the alidade are missing.



Figure D074.2 – The crown of the astrolabe (photo courtesy Dr David Coffeen)

Front

With its deep scallops on either side, the crown resembles the crowns in the three astrolabes from Jodhpur, made around 1867 and 1877. As in those three astrolabes, here also is an inscription on the crown, but very crudely executed; it probably reads *śrī-sarvajñāya namaḥ* ‖, ‘Salutation to the Glorious Omniscient One’.

The rim of the plate is divided crudely in 1° and 6°; groups of 6° are numbered serially from 1 to 15, separately in each quadrant. The numbers in the upper left quadrant are visible; in other quadrants they are very faint. Inside the rim are drawn altitude circles, azimuth arcs both above and below the horizon, and also several radial lines; these are traced so faintly that it is not possible to determine their frequency and the latitude for which the plate is designed.



Figure D074.3 – Central disc of the rete with the star pointers (photo courtesy Dr David Coffeen)

RETE

The rete consists of the three rings of Capricorn, equator and ecliptic, held together by the equinoctial bar without any counter change. There are 19 dagger-shaped star pointers; the names are not always decipherable; but it is certain that the following stars are represented.

Table D074-1 Stars on the Rete

	Star Name	Identification
1	*Samudrapakṣī*	β Ceti
2	*Nadyantaka*	θ Eridani
3	*Pretaśira*	β Persei
4	*Rohiṇī*	α Tauri
5	*Mithuna-vāma-pāda*	β Orionis
6	*Mithuna-dakṣiṇa-hasta*	γ Orionis
7	*Lubdhaka*	α Canis Majoris
8	*Lubdhaka-bandhu*	α Canis Minoris
9	*Mahāpuruṣa*	α Hydrae
10	*Pūrvā Phālgunī*	δ Leonis

	Star Name	Identification
11	*Hasta*	δ Corvi
12	*Citrā*	α Virginis
13	*Viśākhā-mātṛ-maṇḍala*	α Coronae Borealis
14	*Sarpadhārī-śira*	α Ophiuchi
15	*Abhijit*	α Lyrae
16	*Śravaṇa*	α Aquilae
17	*Śatabhiṣā*	λ Aquarii
18	*Kukkuṭapuccha*	α Cygni
19	*Uttarā Bhādrapadā*	γ Pegasi



Figure D074.4 – Back of the astrolabe (photo courtesy Dr David Coffeen)

BACK

On the back, as in the front, the entire rim is crudely devided in 1° and 6°; groups of 6° are numbered serially from 1 to 15, separately in each quadrant. Within the rim in the lower half, there is yet another circular scale which divides the half circle into 27 parts and each part into 4 divisions. Its purpose is unknown. In the upper left is a trigonometric quadrant with several vertical and horizontal lines and in the upper right a solar quadrant with several declination arcs, without any numbers or labels. In the lower half are drawn shadow squares; apparently on the right for a base of 12 and on the left for a base of 7.



Figure D074.5 – Detail of the back showing parts of the trigonometric and solar quadrants (photo courtesy Dr David Coffeen)

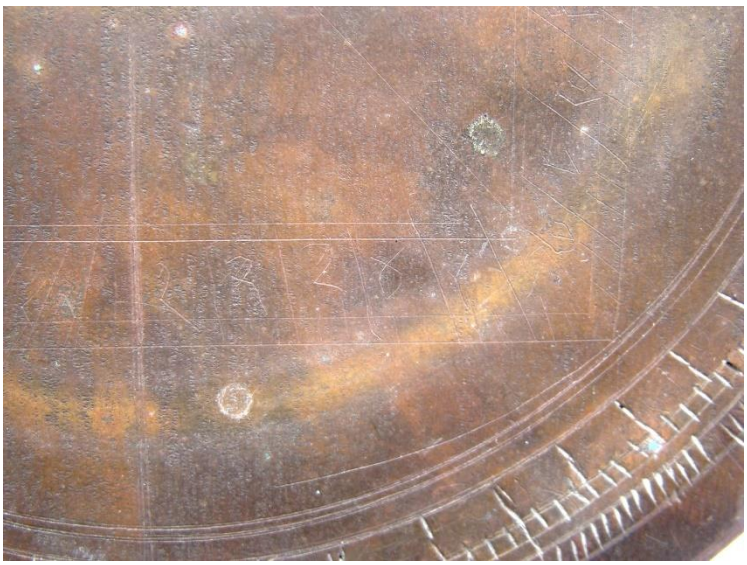


Figure D074.6 – Detail of the back showing a part of the shadow square on the right (photo courtesy Dr David Coffeen)

D075 ASTROLABE WITH TWO RETES[943]

18th century, Lahore

Diameter 86 mm

PLU; ex-London, Christie's



Figure D075.1 – Front of the astrolabe (photo from Christie's catalogue 1991)

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943 In the archives of the Museum of the History of Science, Oxford, there are photos of the front and back, besides photocopies of photos of all components (two retes, plate, alidade, pin and wedge), and a sheet of paper on which is written, in F. Maddison's hand: 'Indian astrolabe, probably ge[nuine?] 19th or 20th century. Inscribed in Nagari script. Sent to Mr Maddison for exam by Sotheby in August 1978. Sotheby reference: 27008. Neg. ref. no.: 78-23.35.5.' If Sotheby's sent the photos to Maddison in August 1978, they must have offered the astrolabe in auction soon thereafter. The astrolabe was offered again in auction by Christie's on 21.3.1991, catalogue, lot 85, pp. 48-49.

This is an unusual astrolabe with a single plate, both sides of which carry multiple projections, and two retes, one of which is the usual variety and the other consisting just of the ecliptic ring. It is difficult to place this astrolabe chronologically or geographically. One side of the plate is calibrated partially for the latitude 27° and the other side partially to 36°. While latitude 36° serves the middle of the fourth of the seven climates of antiquity, latitude 27° can refer either to Agra or Jaipur. If Agra was intended, then the astrolabe may have been made during the Mughal rule, before Shah Jahan shifted the capital from Agra to Delhi, i.e., in the first half of the seventeenth century. Since the main centre of astrolabe production during the Mughal rule was Lahore, the astrolabe may have been made there in the workshop of the Lahore family. If, on the other hand, Jaipur was intended by the latitude 27°, then the astrolabe may have been made a century later in the first quarter of the eighteenth century at Jaipur at the behest of Sawai Jai Singh.

On the plate itself there is absolutely no writing on either side. On the rete, the names of the zodiac signs are marked with the initial syllables of the Sanskrit names in Devanagari script; likewise the positions of 10 stars are marked by the initial syllable of the Sanskrit star names. Therefore the astrolabe may be treated as a Sanskrit astrolabe produced at Jaipur during the reign of Sawai Jai Singh or soon after. Jai Singh encouraged the production of Sanskrit astrolabes with standard retes with star pointers as well as with minimal retes. So this astrolabe combines both the trends.

On the other hand, it may be an Indo-Persian astrolabe produced in the workshop of the Lahore family to which Sanskrit letters were added later. The complexity of projections on the two sides of the plate speaks strongly in favour of this hypothesis.

Components

Plate with crown (d. 86), shackle, ring, two retes, alidade with a sighting tube, pin and horse-headed wedge.

Suspensory Apparatus

The lobed but plain crown has diamond-shaped finial to which a small but heavy shackle is attached. The ring is large; its two ends are not joined properly.

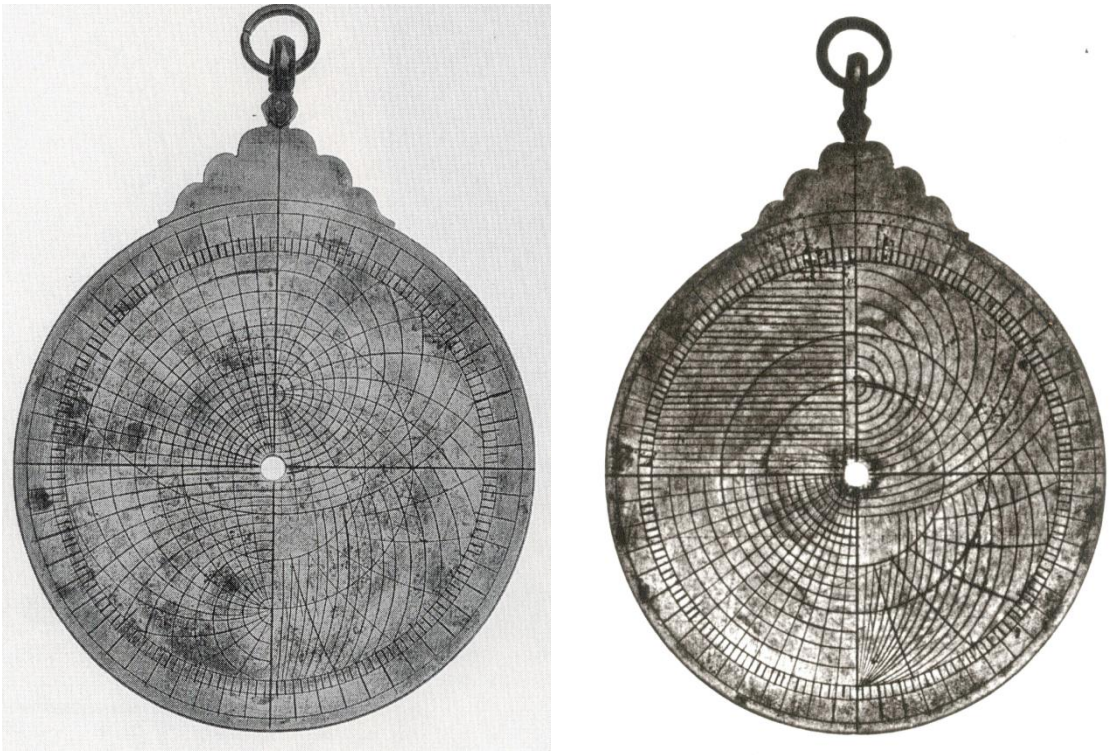


Figure D075.2 – The projections on the two sides of the plate: (left) obverse side; (right) reverse side. (From the photocopies in the archives of the Museum of the History of Science, Oxford)

PLATE

On both sides the scale on the rim is divided in 2° and 6°, but not numbered. The plate is divided into four quadrants by the vertical and horizontal diameters. Each quadrant has a different projection. The two circles of equator and Cancer are drawn.

On the **obverse** side, the right half has projections for the latitude of 36°. Altitude circles are drawn for every 6°, azimuth arcs below the horizon for every 6° and above the horizon for every 12° and lines for seasonal hours.

In the lower left quadrant, there are projections for the latitude 0°, i.e. for the terrestrial equator, with altitude circles for every 6° and azimuth arcs for every 12°.

In the upper left is the solar quadrant with 17 declination circles, upon which 14 radial lines are superimposed connecting the centre with each 6° division mark in the degree scale.

On the **reverse side** of the plate, the right half is calibrated for the latitude of 27° with altitude circles for every 6°, azimuth arcs only below the horizon for every 6° and lines for seasonal hours.

In the upper left is the trigonometric quadrant with 30 horizontal parallels. In lower left is the solar quadrant as on the obverse side with declination circles and radial lines.

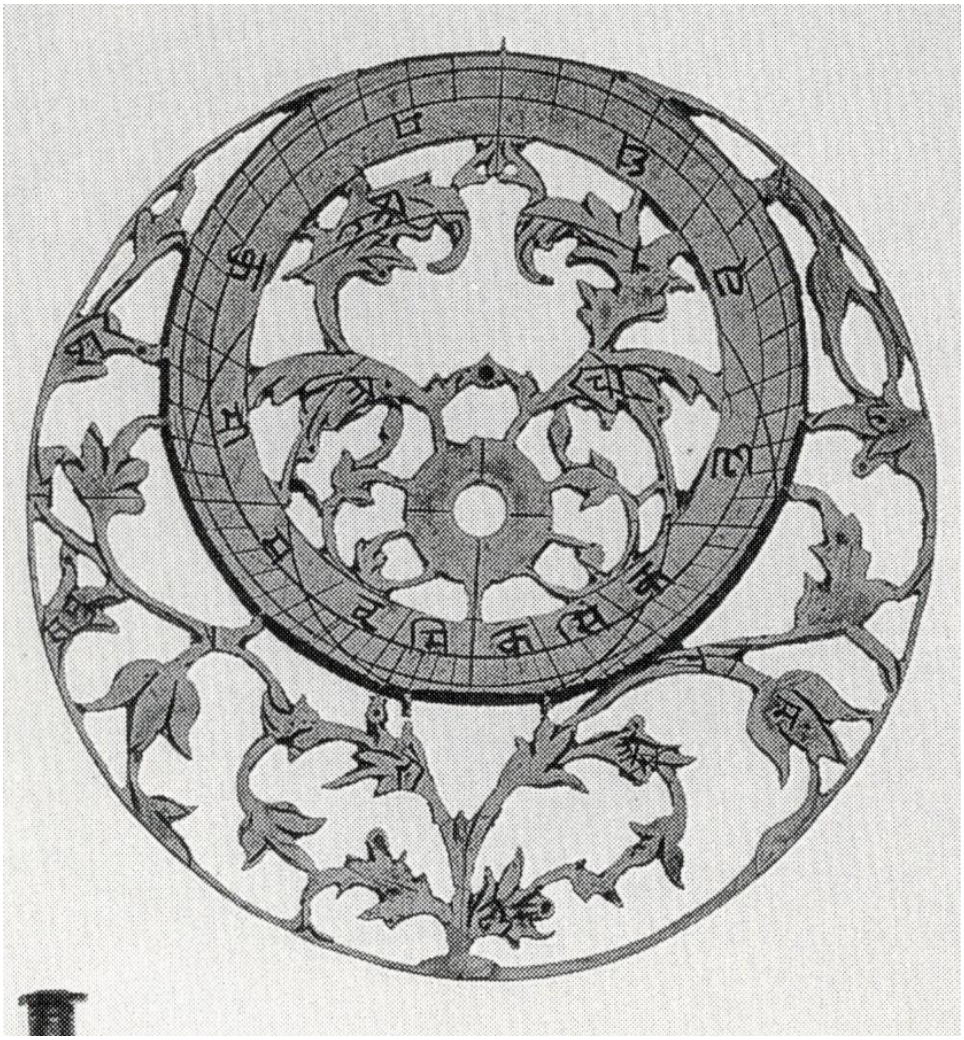


Figure D075.3 – Rete 1 (from Christie's catalogue 1991)

RETE 1

The rete consists of a very narrow, almost wire-like, ring of the Tropic of Capricorn and a very wide ecliptic ring, the two joined by floral tracery. Likewise the central disc and the ecliptic ring are also joined by floral tracery. Contary to the statement in Christie's catalogue, the ecliptic circle is correctly divided into the 12 zodiac signs and labelled with the intial syllables of the names of the signs. Each sign is divided into five parts of 6° each, but these are not numbered.

There are 10 named star pointers, but many of these pointers are not well defined.

Table D075-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samu*	*Samudrapakṣī*	β Ceti

	Star Name as engraved	Full/Correct Form	Identification
2	*Ro*	*Rohiṇī*	α Tauri
3	*Lu*	*Lubdhaka*	α Canis Majoris
4	*Ā*	*Āśleṣā*	ζ Cancri
5	*Ma*	*Mahāpuruṣa*	α Hydrae
6	*Ha*	*Hasta*	δ Corvi
7	*Svā*	*Svāti*	α Bootis
8	*Śra*	*Śravaṇa*	α Aquilae
9	*A*	*Aśvamukha*	ε Pegasi
10	*Śa*	*Śatabhiṣā*	λ Aquarii

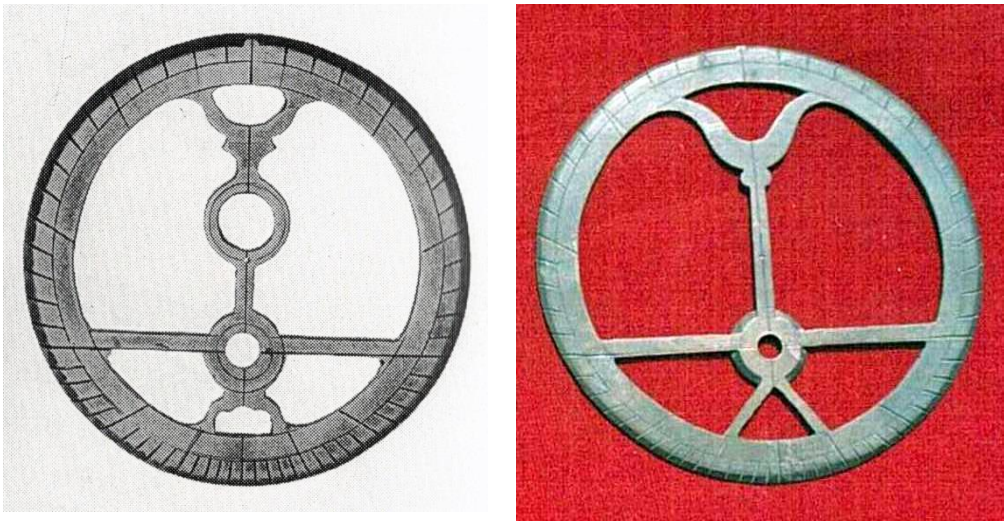


Figure D075.4 – Left: Rete 2 of the present astrolabe, Right: Rete of D078.

RETE 2

The second rete consists just of the ecliptic ring and the equinoctial and solstitial bars. The ecliptic ring is divided into the 12 signs of the zodiac, but not labelled. Each sign is divided into 5 parts of 6° each, but not numbered. On the solstial bar is a a decorative arrangement of rings. This rete closely resembles a minimal rete of an astrolabe at the Jaipur Observatory (D078).

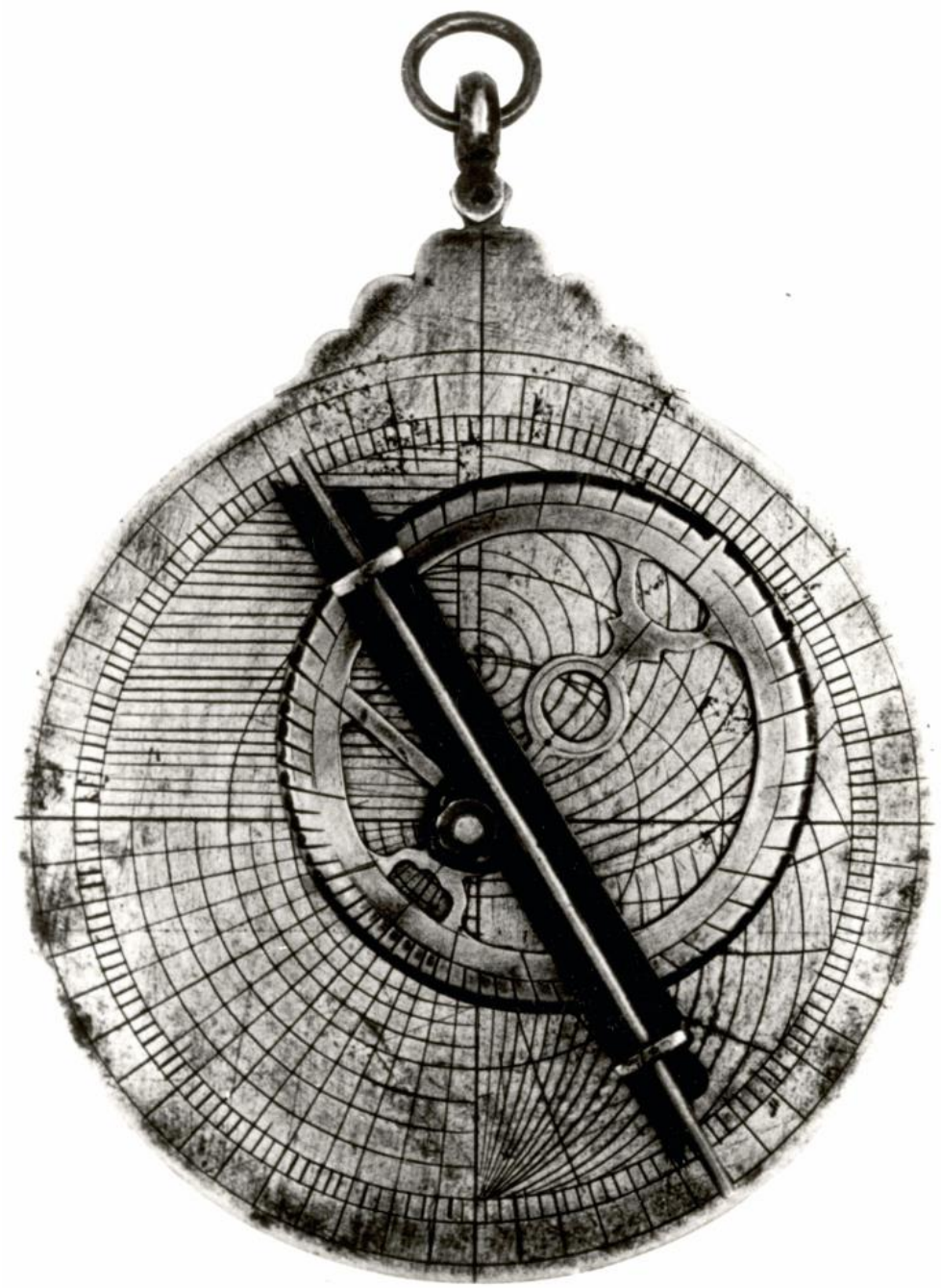


Figure D075.4 – Back of the astrolabe (courtesy Museum of the History of Science, Oxford)

ALIDADE

The straight bar alidade with pointed tips is equipped with a very narrow sighting tube which is much longer than the alidade.

D076⊙ ASTROLABE FOR LATITUDES 36° AND 27°, NOT SIGNED, NOT DATED, INCOMPLETE

19th century, Rajasthan

Diameter 394 mm

Cologne, PC



Figure D076.1 – Front of the astrolabe (photo by the owner)

On the main plate of this large astrolabe, the engraver at first drew the degree scale and altitude circles for the latitude of 27 on what is now the back. But for some unknown reason, work was stopped on this side and continued on what is now the front. Originally this side was intended to be the back of the astrolabe; therefore, the upper half of the rim was engraved with altitude scales. This side was later engraved with altitude circles for the latitude of 36°, azimuth arcs and lines for seasonal hours.

Components

Mater (d. 394, h. 474, t. 1.4) with crown, ring and shackle, rete (d. 360) for 25 stars, alidade with a sighting tube, pin and wedge.

Front

The ring and shackle are plain. The crown is triangular, the profiles are almost straight with faint lobes. The upper half of the rim carries altitude scales divided in 1° and 6° and labelled as 6—90; 90—6. The lower half is blank. Inside the rim are drawn the concentric circles of equator and Cancer, but not correctly. The circle of equator is too close to the circle of Cancer. The circle of Cancer passes through the zenith; this happens roughly at the latitude 23° and not at other latitudes. Altitude circles are drawn for every 2° and numbered on both sides of the meridian. Azimuth arcs are drawn above and below the horizon at irregular intervals, but leaving some space on both sides of the meridian. These are not numbered.

In the lower half are drawn lines for seasonal hours; these are not numbered either. The latitude for which the plate is calibrated is not mentioned on the plate, but from the disposition of the attitude circles, it can be seen that the plate is made for latitude 36° which represents the middle of the fourth climate of antiquity; it is far north of the Gujarat-Rajasthan region where Sanskrit astrolabes are produced and used, indeed far north of India proper.

Rete

In the rete, the peripheral ring of Capricorn is partly represented, while the equator and ecliptic rings are fully shown. These three rings are held together by the equinoctial bar without any counter change. At the centre, there is a small disc. The ecliptic ring is divided into the 12 signs of the ecliptic and labelled with their names. Each sign is

divided into 1° and 6°, but the groups of 6° are not numbered. There are 26 dagger-shaped star pointers, with the names of the stars engraved on them.



Figure D076.2 – Rete of the astrolabe (photo by S. R. Sarma)

Table D076-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Matsyodarapāda*		β Andromedae
2	*Nahairi ko Tārā*	*Nahar ko Tārā*[944]	γ Eridani
3	*Manuṣyapārśva*		α Persei
4	*Pretaśira*		β Persei
5	*Rohiṇī*		α Tauri
6	*Brahmahṛ[daya]*		α Aurigae
7	*Mi.vā.pāda*	*Mithuna-vāma-pāda*	β Orionis
8	*Mi.da.pāda*	*Mithuna-dakṣiṇa-pāda*	κ Orionis
9	*Āra*	*Ārdrā*	α Orionis
10	*Luvaka*	*Lubdhaka*	α Canis Majoris
11	*Luddvakavadha*	*Lubdhaka-bandhu*	α Canis Minoris
12	*Mahāpuruṣa*		α Hydrae
13	*Maghā*		α Leonis
14	*Pūphālgunī*	*Pūrva-phālgunī*	δ Leonis?
15	*Citrā*		α Virginis
16	*Marīca*	*Marīci*	η Ursae Majoris
17	*Svātī*	*Svāti*	α Bootis
18	*Viśākhāmātṛma[ṇ]ḍala*		α Coronae Borealis
19	*Sa.dhā.śira*	*Sarpadhārī-śira*	α Ophiuchi

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944 The star is usually called *Nadyantaka,* ‘that which is the end of the river’. Here is a Rajasthani rendering meaning ‘star of the canal’. The Arabic name is *Ākhir al-Nahr,* ‘the end of the river’.

	Star Name as engraved	Full/Correct Form	Identification
20	*Abhijita*	*Abhijit*	α Lyrae
21	*Śravaṇa*		α Aquilae
22	*Aśvamukha*		ε Pegasi
23	*Pravābhāratapada*	*Pūrva-bhādrapadā*	β Pegasi
24	*Samudrapakṣī*		ι Ceti
25	*Bhā.pa.*	*Uttara-bhādrapadā*	γ Pegasi

BACK

The rim is divided in 1° and 6°. The groups of 6° are numbered serially from 1 to 60. Inside the rim are drawn the circles of equator and Cancer, incorrectly as in the front. Altitude circles are drawn rather unevenly for every 3°, but not numbered. Their disposition shows that the plate is calibrated for the latitude of 27°. There are no azimuth arcs, except the prime meridian. There are no hour lines either.



Figure D076.3 – Back of the astrolabe (photo by the owner)

ALIDADE

The alidade is fitted with a slender sighting tube; it is well crafted.

UNFINISHED ASTROLABES AND ASTROLABE PARTS AT JAI SINGH'S OBSERVATORY AT JAIPUR

In the stores of the Jaipur observatory, there are several astrolabes and astrolabe parts in different stages of completion. They give the impression as if their production came to a stop all of a sudden in the palace workshop. This could only have been due to the sudden death of Sawai Jai Singh in 1843.

In the first specimen of this group (D077), the rete has a beautiful floral tracery, but the ecliptic ring is not correctly positioned. Probably for this reason it was abandoned. In the second specimen (D078), the rete is minimal and the two sides of the plate are engraved with projections for latitudes 27° and 30° respectively. Then the work stopped; no numbers or labels were added on either side, nor any star positions.

Then follows a set of five unfished astrolabe plates of slightly different diameters, all with the crown in the shape of a bell with a handle. These were obviously meant for single plate astrolabes, but never fully completed. On some the projections of altitude circles etc. are drawn but not labelled or numbered. In four of these, no hole is drilled at the centre for the pin to pass through, nor at the apex of the crown for suspension. But the small decorative circles on either side at the base of the crown are pierced.



Figure D1 – Five unfinshed astrolabes (photo by S. R. Sarma)

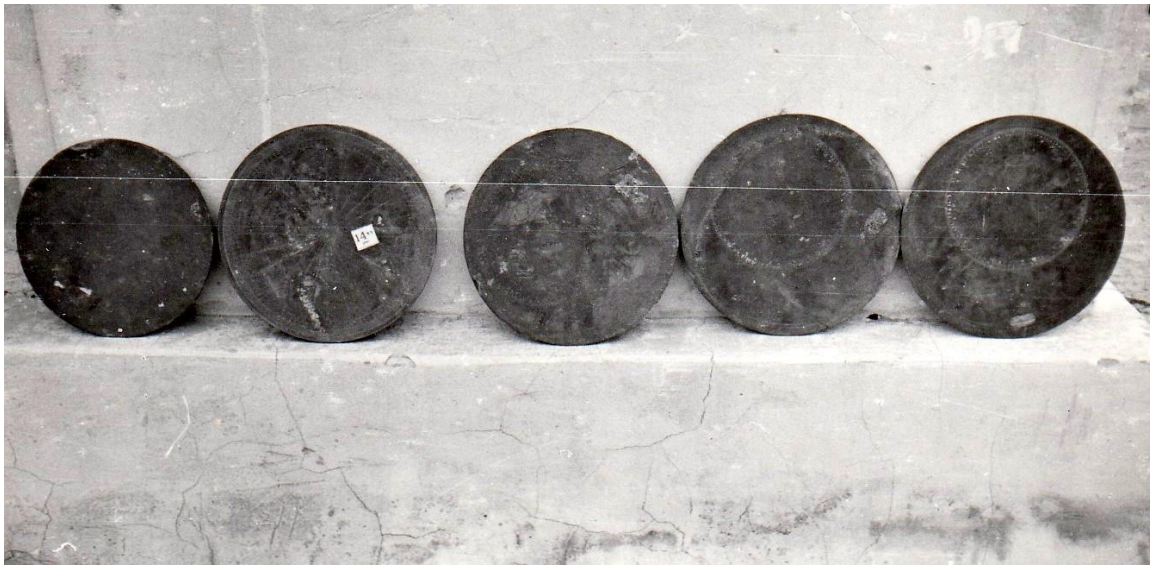


Figure D2 – Five unfinshed circular plates (photo by S. R. Sarma)

There is another set of 5 thick circular discs. One of these was meant to be made into the limb of a mupliple plate astrolabe, three were intended to be made into astrolabe retes, and the last one was probably to be dresigned as an astrolabe plate.

D077⦿ UNFINISHED ASTROLABE WITH A FLORAL RETE

18th century, Jaipur, Rajasthan

Diameter 280 mm

Jaipur, Jai Singh’s Observatory



Figure D077.1 – Front of the astrolabe (photo by S. R. Sarma)

COMPONENTS

Plate with crown (d. 280, h. 336), rete, alidade, pin, wedge.

FRONT

The low crown with 8 lobes on each side resembles outline of the Hawa Mahal Palace at Jaipur, with a trifoliate finial. The shackle has a trifoliate form, but with plain bases. The ring is plain. The rim is graduated in 1° and 6°, but not numbered. Inside the degree scale are drawn a series of altitude circles with northern orientan in the upper part of the plate and another series with southern orientation in the lower half so that several circles intersect in the east and west. But there are no numbers or legends on the entire surface.

RETE

The peripheral Capricorn ring and the ecliptic ring are held together by the complete equatorial and solastial bars; the equatorial bar no counter changes while the solstial bar has three strange counter changes. The equator is not represented at all. The whole intrior is filled with a very elegant tracery of leaves and flowers. However, the zodiac circle is not correctly represented. It should touch the Tropic of Cancer in the north and Tropic of Capricorn in the South. But it is much farther from the Tropic of Capricorn, because its centre and radius are not correctly chosen. Probably for this reason, the rete was not completed. There are no labels either on the zodiac ring or on the star pointers.

BACK

The entire rim is covered by a degree scale which is divided in 1° and 6° but not numbered. The four quadrants are blank.

The alidade has ornate ends and an ornate and central piece. One of the sighting plates is broken and lost; the other sighting plate has two pinholes. The pin is well formed; the wedge is a simple rectangular piece.

The plaque attached to the suspension ring states *yaṃtrarāja do ṭo patra ek ko,* ‘astrolabe with two plates in one (?)’. This may or may not have belonged to this astrolabe originally.

D078⦿ UNFINISHED ASTROLABE FOR LATITUDES 27° AND 30° WITH A MINIMAL RETE, NOT SIGNED, NOT DATED

18th century, Jaipur

Diameter 109 mm

Jaipur, Sawai Jai Singh's Observatory

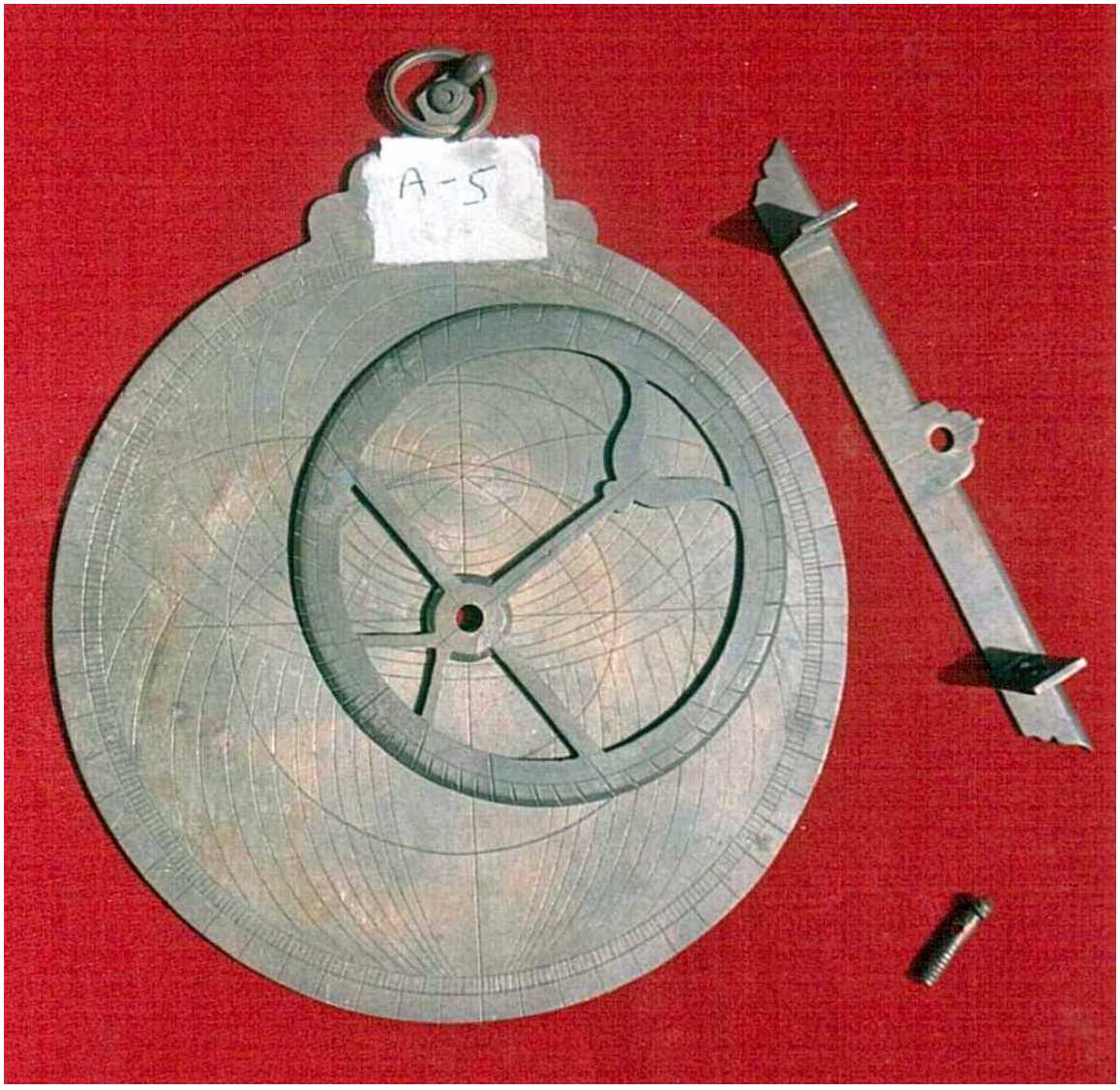


Figure D078.1 – Front of the astrolabe, with rete, alidade and pin (photo by S. R. Sarma)

The astrolabe is absolutely without any numeral or legend. Indeed it can also be treated as an Indo-Persian astrolabe. But because it is only the Sanskrit instruments which are usually left unfinished and because there are many examples of this nature in the collection at Jai Singh's Observatory, it is reasonable to treat this as a Sanskrit astrolabe rather than an Indo-Persian astrolabe. Interestingly, on both faces of this plate, projections are drawn for latitudes 27° and 30° respectively. The rete is minimal,

consisting of just the ecliptic ring, but its design is different from the minimal retes in D001, D002 and D003. But unlike in these astrolabes, no star positions are marked on the plate here.

COMPONENTS

Plate with crown (d. 109), shackle and ring, rete, alidade, pin; the wedge is missing.

FRONT

The profiles of the crown have three lobes on each side. The finial is diamond shaped; the shackle is small and the two ends of the ring are not welded together. The rim carries a degree scale which is divided in 1° and 6°, but not numbered. East-west and south-north diameters, circles of the tropics and equator are drawn. Altitude circles are drawn for the latitude of 30° at intervals of 6°. Azimuth arcs are drawn for every 30° above 6°the horizon and for every 6° below the horizon. But below the horizon several azimuth arcs are omitted on either side of the meridian, leaving empty space there. There are no hour lines.

BACK

The back of the astrolabe is also fashioned like the front, but for the latitude of 27°. The rim carries a degree scale divided in 1° and 6°, but not numbered. East-west and south-north diameters, circles of the Tropics and equator are drawn. Altitude circles are drawn at intervals of 6°. Azimuth arcs are drawn for every 6 below the horizon and for every 30° above the horizon, but on both sides of the meridian, several azimuths are not drawn and the place is left empty.

RETE

The rete consists of the ecliptic ring only. It is divided into the 12 signs, and each sign is subdivided into 5 parts.



Figure D078.2 – Back of the astrolabe (photo by S. R. Sarma)

ALIDADE

Alidade (length 99) has ornate ends and an ornate centre piece, but plain sighting plates with 2 apertures. There is a pin, but the wedge is lacking.

Interestingly, a sketch of of this astrolabe is used by many to explain the functions of the astrolabe. Thus Garrett & Guleri 1902, pp. 58-60 and plate IX, do not mention this astrolabe per se, but reproduce its sketch to explain the use of the astrolabe for determining the time.

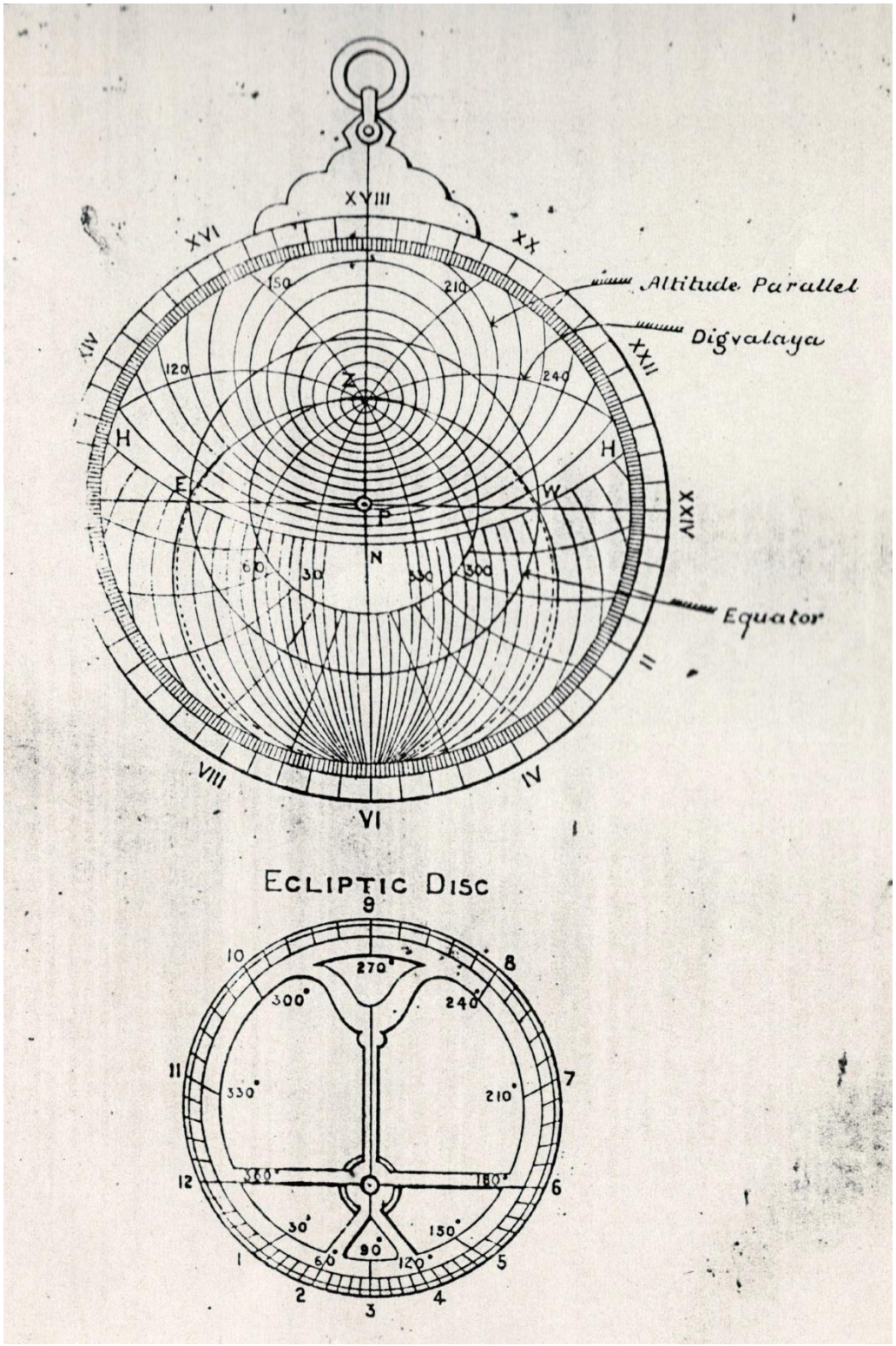


Figure D078.3 – Sketch of the astrolabe (from Garrett & Gulati 1902)

Likewise, Noti 1911, pp. 74-75 explains the Great Astrolabe (D001) by means of a diagram of this astrolabe. The same diagram is reproduced in Kern 1976, p. 34.

D079⊙ UNFINISHED ASTROLABE PLATE FOR LATITUDE 27°, NOT SIGNED, NOT DATED

18th century, Jaipur

Diameter 212 mm

Jaipur, Jai Singh's Observatory

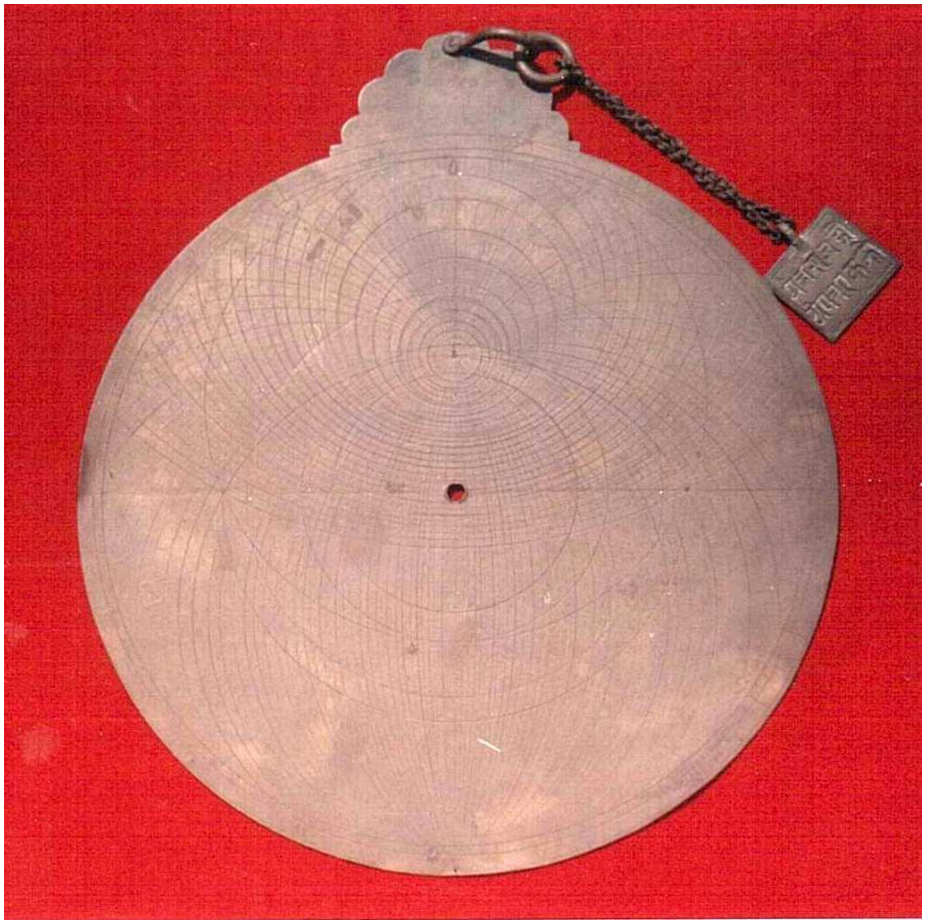


Figure D079.1 – Front of the astrolabe (photo by S. R. Sarma)

It consists of just the mater with a lobed crown, shackle and ring. On both sides of the plate are engraved projections for the latitude of 27°, with east-west and south-north diameters, circles of the tropics, equator and also the ecliptic. The Tropic of Capricorn the equator and the prime vertical are sought to be emphasized by double circles. But there is no degree scale on the rim. Altitude circles are for every 3° and azimuth arcs above and below the horizon for every 3°. There are no hour lines. There are absolutely no numbers or no legends.

A small plaque is attached to the ring with the inscription *yaṃtrarāja choto patra ek ko,* 'astrolabe small one plate'.

D080⦿ UNFINISHED ASTROLABE PLATE FOR LATITUDE 27°

18th century, Jaipur

Diameter 261 mm, height 344 mm

Jaipur, Jai Singh's Observatory



Figure D080.1 – Front of the astrolabe plate (photo by S. R. Sarma)

FRONT

It is an astrolabe plate with the crown in the shape of a bell with a handle. The rim of the plate is divided in 1° and 6° and numbered anticlockwise from the east point as as 1, 2, … 60, which is unusual. Altitude circles for each 2°, every third highlighted. Azimuth arcs below the horizon for each 6°. Lines for seasonal hours and dotted lines for equal hours counted from the western and eastern horizons. Altitude circles, azimuth arcs and the hour lines are not numbered.



Figure D080.2 – Back of the astrolabe plate (photo by S. R. Sarma)

BACK

The rim on the back is divided in 1° and 6° and numbered in 6s, separately for each quarter, starting from the east and west points and going to the south and north points.

Upper left quadrant has 30 horizontal and 30 vertical parallels. Upper right quadrant is blank. Outlines of double shadow square in the lower half. No hole is bored in the centre, nor in the crown.

D081⊙ UNFINISHED ASTROLABE PLATE FOR LATITUDE 27°

18th century, Jaipur

Diameter 272 mm, height 352 mm

Jaipur, Jai Singh's Observatory



Figure D081.1 – Front of the astrolabe Plate (photo by S. R. Sarma)

FRONT

The rim of the plate divided in 1° and 6° and numbered from the east point onwards anticlockwise as 6, 12 … 60. Tropics, equator and prime vertical are drawn. Altitude circles for each 2°, every third circle dotted. Azimuth arcs below the horizon for each 6°. Lines for seasonal hours and dotted lines for equal hours counted from the eastern and western horizons. Except the degree scale on the rim, other lines are not numbered.

Here a small hole is made in the centre for the pin to pass through.

BACK

The rim on the back is divided in 1° and 6° and numbered in 6s, separately for each quarter, starting from the east and west points and going to the south and north points.

Upper left quadrant has 30 horizontal and 30 vertical parallels. The rest is blank.

D082⊙ UNFINISHED ASTROLABE PLATE FOR LATITUDE 27°

18th century, Jaipur

Diameter 270 mm, height 350 mm

Jaipur, Jai Singh's Observatory



Figure D082.1 – Front of the astrolabe plate (photo by S. R. Sarma)

Front and back are engraved exactly in the same manner as in the previous astrolabe D081.



Figure D082.2 – Back of the astrolabe late (photo by S. R. Sarma)

D083⦿ UNFINISHED ASTROLABE PLATE FOR LATITUDE 27°

18th century, Jaipur

Diameter 269 mm, height 354 mm

Jaipur, Jai Singh's Observatory



Figure D083.1 – Front of the astrolabe (photo by S. R. Sarma)

The plate carries in the front three concentric circles for the two tropics and the equator, vertical and horizontal diameters, altitude circles for every 2°, only 35 circles are drawn are drawn leaving an empty space in the middle. There are no other projections. The back is blank.

D084⦿ UNFINISHED ASTROLABE PLATE FOR LATITUDE 27°

18th century, Jaipur

Diameter 268 mm, height 354 mm

Jaipur, Jai Singh's Observatory



Figure D084.1 – Front of the astrolabe (photo by S. R. Sarma)

FRONT

This plate carries on the front three concentric circles on the rim for the degree scale, three concentric circles to represent the two tropics and equator and vertical and

horizontal diameters. Dots are made on the degree scale to indicate the marks of divisions; similar dots are made also on the equator and the Tropic of Cancer, which is unnecessary. Altitude circles are traced for each 2°; but only 35 circles are drawn leaving an empty space in the middle.

BACK

On the back are drawn just three concentric circles on the rim for the degree scale and vertical and horizontal diameters. The rest is empty.

D085⊙ LIMB OF AN UNFINISHED ASTROLABE

18th century, Jaipur

Diameter 260 mm, thickness 8 mm

Jaipur, Jai Singh's Observatory

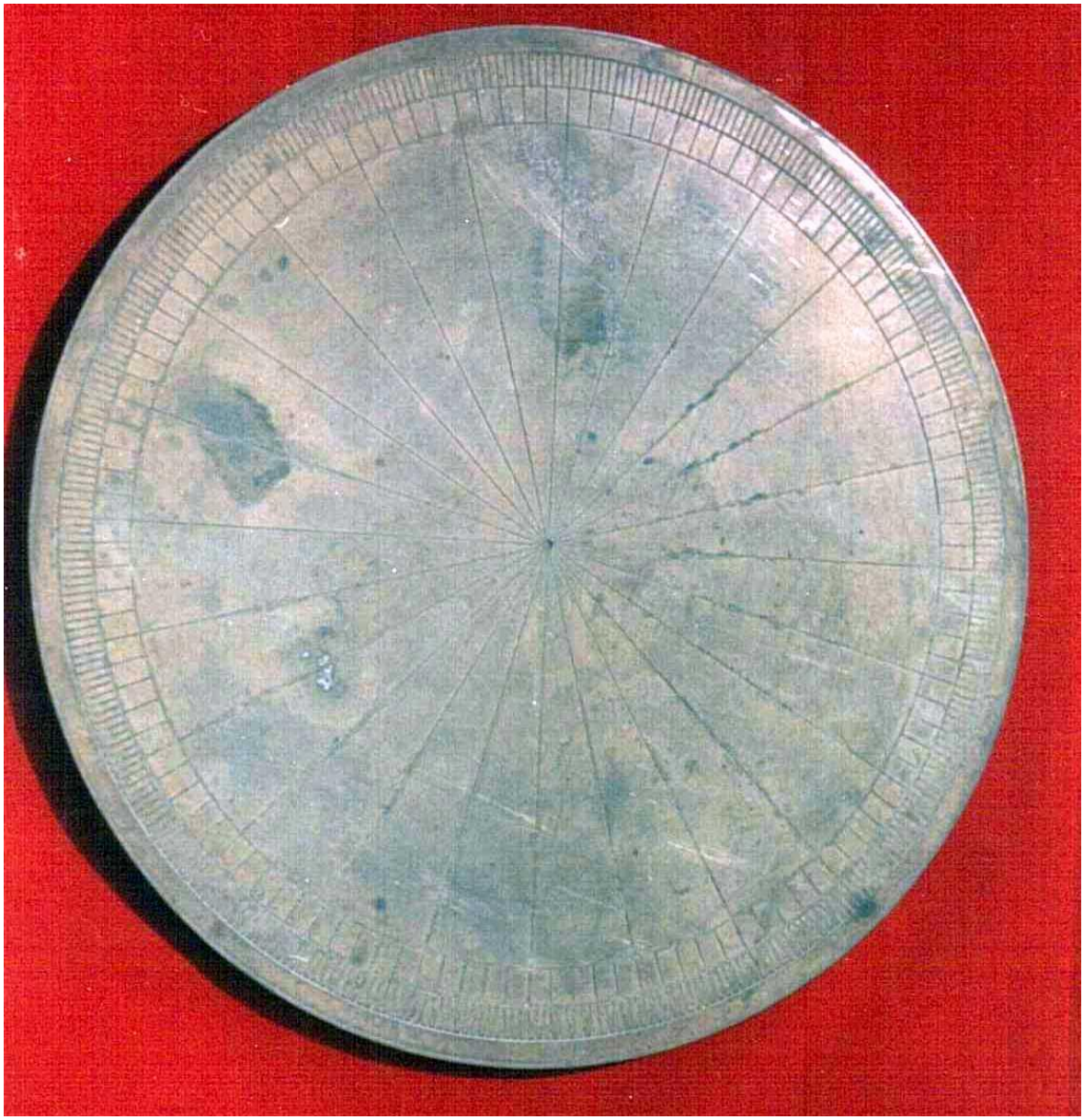


Figure D085.1. Unfinished limb of an astroabe (photo by S. R. Sarma)

A heavy circular plate, with a diameter of 260 mm and a thickness of 8 mm. twelve diameters cut the surface into 24 sectors. On the rim are engraved two scales. Very unusually the outer scale is divided in 1° and the inner scale in 3° but not labelled. Probably this was intended as the limb of an astrolabe plate.

D086⦿ UNFINISHED RETE OF AN ASTROLABE

18th century, Jaipur

Diameter 268 mm, thickness 12 mm

Jaipur, Jai Singh's Observatory



Figure D086.1 – Unfinished rete of an astrolabe (photo by S. R. Sarma)

A circular disc on which the instrument maker began to engrave the projections for an astrolabe rete. He drew horizontal and vertical diameters, two concentric circles for a thin band Tropic of Capricorn, single circles for the equator and the Tropic of Cancer. He completed the Zodiac ring in three annuli. The inner annulus is divided into the 12 signs and labelled with their names coorecty, but Leo is named *Siṃhana* (instead of *Siṃha*) and Sagittarius as *Dhana* instead *Dhanu*. In the middle annulus each sign is divided into five parts and labelled as 6, 12, 18, 24, 30. In the outer annulus the each of the parts is divided into single degrees.

D087 ⊙UNFINISHED RETE OF AN ASTROLABE

18th century, Jaipur

Diameter 268 mm, thickness 12 mm

Jaipur, Jai Singh's Observatory



CAPTION?

Like the previous piece, here also just the zodiac circle was completed. It has the same size and the same thickness. Here also Leo is named *Siṃhana* (instead of *Siṃha*) and Sagittarius *Dhana* (instead of *Dhanu*).

D088⊙ UNCUT RETE OF AN ASTROLABE

18th century, Jaipur

Diameter 258 mm, thickness ?

Jaipur, Jai Singh's Observatory



Figure D088.1 – Uncut rete of an astrolabe (photo by S. R. Sarma)

A circular disc on which the projections of the rete are engraved but not cut out. The rim of the lower left quadrant carries a degree scale which is not continued. The three rings of the Tropic of Capricorn, equator and Tropic of Cancer are drawn as double circles. They are joined by the complete equinoctial and solstitial bars. The ecliptic ring is divided into the 12 signs and labelled with their names: *Meṣa, Vṛṣa, Mithuna, Karka,*

Siṃha, Kanyā, Tala (sic ! *Tulā*), *Vṛścika, Dhana* (sic! *Dhanu*), *Makara, Kuṃbha* and *Mīna*. Each sign is subdivided into five units and numbered as 6, 12, 18, 24, 30. Each unit is further subdivided into single degrees.

Twenty-five star pointers are drawn, apparently by rough estimation. Some are straight like daggers and some others curved like tiger's claws. Six of these are not named; two others carry wrong names.

Table D088-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samadapa*	*Samudrapakṣī*	β Ceti
2	*Rohiṇī*		α Tauri
3	(not named)	*Brahmahṛdaya*	α Aurigae
4	(not named)	*Ārdrā*	α Orionis
5	*Prajāpati*		δ Aurigae
6	*Lubdhaka*		α Canis Majoris
7	(not named)	*Lubdhaka-bandhu*	α Canis Minoris
8	(not named)	?	?
9	*Mahāpuruṣa*[945]		α Hydrae
10	(not named)	*Maghā*	α Leonis
11	(not named)	*Pūrva-phālgunī*	δ Leonis
12	*Siṃhapuccha*		β Leonis
13	*Hasta*		δ Corvi
14	*Citrā*		α Virginis
15	*Svātī*	*Svāti*	α Bootis
16	*Viśākhā*		α Librae

[945] Wrongly positioned.

	Star Name as engraved	Full/Correct Form	Identification
17	*Abhijit*		α Lyrae
18	*Śravaṇa*		α Aquilae
19	*Dhaniṣṭhā*		α Delphini
20	*U.bhā.*[946]	*Uttara-bhādrapadā*	γ Pegasi
21	*Matsyaudara*[947]	*Matsyodara*	β Andromedae
22	*Śatabhiṣā*		λ Aquarii
23	*Kākapakṣa*	*Kukkuṭapuccha*	α Cygni
24	*Pūrvabhādra*	*Pūrva-bhādrapada*	β Pegasi
25	*Raṃjitakara*		β Cassiopeiae

The star name *Siṃha-puccha* occurs for the first time for β Leonis. It is the literal translation of the Arabic *Dhanab al-Asad,* 'the lion's tail'. It is otherwise designated as *Uttara-phālgunī.*

946 The correct name of this star is *Kukkuṭa-cañcu* (β Cygni)

947 This star should be correctly named as *Aśvamukha* (ε Pegasi)

D089⦿ UNFINISHED ASTROLABE PLATE

18th century, Jaipur

Diameter ca. 280 mm

Jaipur, Jai Singh's Observatory



Figure D089.1 – Front side of the plate (photo by S. R. Sarma)

On this plate, three concentric circles are drawn on the rim for a degree scale. There is the vertical diameter and a horizontal line below the centre. From the point of their intersection, lines are traced up to the periphery, four to the left of the vertical diameter and one to the right. Was this a discontinued effort to draw shadow squares?

THREE SPECIAL ASTROLABES

This section concludes with three extraordinary astrolabes; the first two were designed by the astronomer Gaṅgāsahāya in 1870 and 1895 respectively and the third by the computer specialist James E. Morrison in 2011.

Gaṅgāsahāya

D090 is a very large astrolabe with a diameter of 664 mm. On the back of this astrolabe is engraved the fifth chapter of Mahendra Sūri's *Yantrarāja,* a chapter which describes the use of the astrolabe for solving diverse kinds of problems. If astrolabe can be called the computer of the Middle Ages, this one can be regarded as a computer with a built-in manual. Besides the large extract from the *Yantrarāja,* there are also engraved on the back a sine table for each degree of arc and a table of shadow lengths of the 12-digit gnomon. The rete is also engraved with much astronomical information and several erudite remarks.

The crown carries a long versified inscription which states that the astrolabe was fabricated by the artisan Śivalāla according to the design by Gaṅgāsahaya-śiśuka. The second part of this name means 'small-child' or 'infant'. It is intriguing why he qualifies the name as *śiśuka.* It cannot be an addition made for the sake of metre because the name occurs once again in this manner in another verse with a different metre. Can this mean the 'son of Gaṅgāsahāya'? There is an astrolabe (D091) designed by a certain Gaṅgāsahāya in 1895 for the latitude of Tonk at 26°. While Gaṅgāsahāya-śiśuka states that he designed the astrolabe at the behest of Ramasiṃha, the ruler of Bundi, and completed it on 25 December 1875 which is the birthday of the said ruler, the Gaṅgāsahāya who designed the astrolabe of 1895 says that he was honoured by the ruler of Bundi who must be the same Rāmasiṃha. The astrolabe of 1895 is much smaller with a diameter of 334 mm, but it too displays certain amount of 'erudition,' in the design of the reverse side of the plate as a combination of three instruments. It also contains legends naming and explaining certain components of the astrolabe. More important, the retes of both instruments have pointers only to the stars known to the Sanskrit astronomical tradition (*siddhānta*) and not to the stars of Islamic tradition (*yavana-mata*) such as *Samudrapakṣī* (sea bird, β Ceti)*, Kukkuṭapuccha* (tail of chicken, α Cygni). Therefore, it is certain that the Gaṅgāsahāya-śiśuka who designed the astrolabe of 1870

and the Gaṅgāsahāya who designed the astrolabe of 1895 are one and the same. Probably Tonk was the place of his residence while Bundi was that of his patron Rāmasiṃha. Still the attribute *śiśuka* remains an enigma. We do not know whether it was an expression of humility, or whether Gaṅgāsahāya was very young in 1870.

Be that as it may, Gaṅgāsahāya's two extant astrolabes are the most outstanding specimens of Sanskrit astrolabes, more so because Gaṅgāsahāya was fortunate in obtaining the services of two literate and capable artisans (which was indeed rare) Śivalāla and Rāmapratāpa, who engraved the long and difficult Sanskrit inscriptions on the two astrolabe with very correct, even pedantically correct, Sanskrit orthography, even employing *avagraha* symbols.

James E. Morrison

He revolutionized the astrolabe construction by creating a computer program called 'The Electronic Astrolabe' where he married the ancient design of the astrolabe with the modern technique of computer animation. At the beginning of his paper bearing the same name, he says:

> 'Some ideas are so good that they never changed very much. The astrolabe is such an idea, having been a widely used astronomical instrument for over 1000 years without significant changes in its basic form. Despite embellishments to improve its utility in different cultures and epochs, a tenth century astrolabe would have been instantly recognized by a nineteenth century user. This spectacular success is a result of the uniquely concise, complete and useful view of the heavens that the astrolabe provides. This advantage is retained when the ancient science of the astrolabe is combined with modern computer graphics and new possibilities emerge that were not possible on classical instruments. The combination of old and new technologies is synergetic, enhancing both.'[948]

He also designed a card-board version about which he wrote as follows:

> 'I have considered The Personal Astrolabe to be a community service by offering an accurate and usable astrolabe very inexpensively. I've shipped

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948 Morrison 1994a, p. 55.

> nearly 8,000 of them to individuals and schools since 1994. My objective of generating what interest I can in astrolabes to the general public has never changed.'[949]

In 2007 came out his *The Astrolabe,* the most comprehensive book treating the history, construction and use of the astrolabe with a wealth of diagrams. After reading my *The Archaic and the Exotic,* he became interested in Sanskrit astrolabes. Since 2010, we have had regular correspondence and he was very prompt with his helpful replies. He was also much interested in the progress of my Descriptive Catalogue. I regret very much that I cannot show him now the online Catalogue, as he passed away in April 2016.

In 2010 he made for me a Personal Astrolabe 'in Sanskrit style'. As a personal tribute to this remarkable promotor of the astrolabe, I close the section with this astrolabe 'in Sanskrit style'.

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[949] Personal communication of 27 January 2016. See also www.astrolabes.org [last accessed in September 2016]

D090⊙ ASTROLABE FOR LATITUDE 25;30°, MAGNUM OPUS DESIGNED BY GAṄGĀSAHĀYA, MADE BY ŚIVALĀLA

1870, Bundi, Rajasthan

Diameter 664 mm

London, Science Museum (# 1897-541)

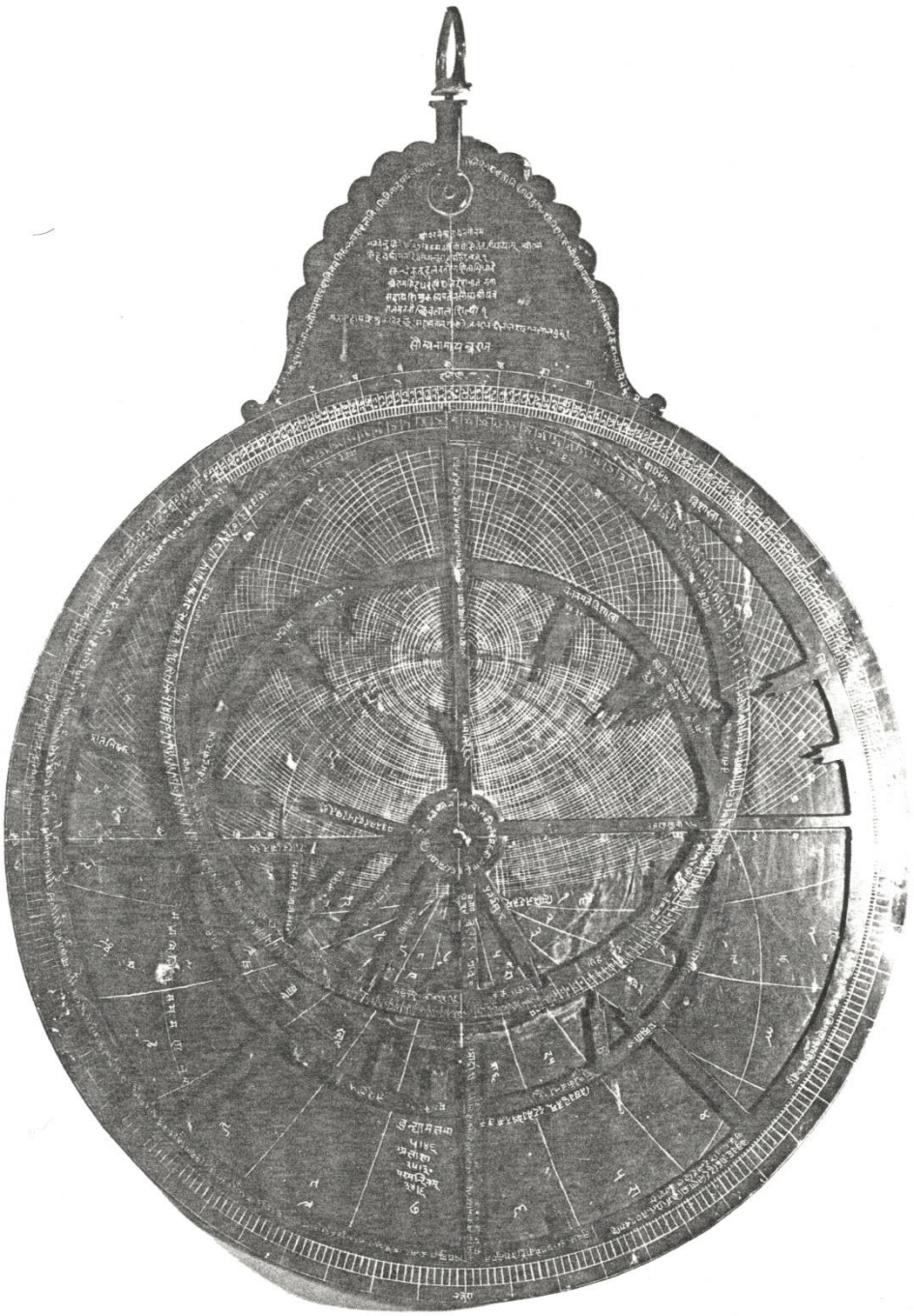


Figure D090.1 – Front of the astrolabe (from a photocopy kindly given by Anthony J. Turner)

This astrolabe, with a diameter of 664 mm, is the third largest Indian astrolabe which is extant.[950] It is made of copper (or of brass with high copper content) and the engraved lines and letters are filled with a white substance.

The inscription on the crown informs that this astrolabe was fabricated by the artisan (*śilpin*) Śivalāla at Bundi (25;27° N; 75;41° E) in Rajasthan according to the instructions of Gaṅgāsahāya-śiśuka. It was completed on Sunday, 25 December 1870, precisely on the birthday of Rāmasiṃha, the ruler of Bundi from 1821 to 1889. It may have been presented to Ramasiṃha on this day. It has a single plate calibrated for the latitude of Bundi at 25;30°.

Besides its enormous size, the astrolabe contains a large number of interesting legends, inscriptions and tables. The most notable is that on the upper half of the back is engraved a large part of the fifth chapter of Mahendra Sūri's manual on the astrolabe entitled *Yantrarāja.* This chapter, entitled *Yantravicāraṇādhyāya,* teaches how to use the astrolabe for observation and for solving diverse kinds of problems. Above this extract, immediately below the altitude scale is engraved a large sine table for each degree in the left half and a table of shadow lengths of the gnomon of 12 digits in the right half. On the latitude plate in the front and on the rete there are several legends naming and describing the various components of the astrolabe.

The rete contains much astronomical information. On the ecliptic ring, the names of the 12 zodiac signs are followed by their *kālāṃśa-s,* 'degrees of [rising] times' at the equator, i.e. their right ascensions. On the star pointers, the names of stars along with their celestial latitudes (*śara*) are engraved. Here a distinction is made between the star positions according to Sanskrit astronomical tradition (*siddhānta*) and those according to the Islamic astronomical tradition (*yavana-mata*). On the Capricorn ring are engraved the declinations (*krānti*) of the various stars. In short, the engraved material on this astrolabe comprises a large portion of what can be treated as a manual on the astrolabe.

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950 The largest is the Great Astrolabe of Jai Singh with a diameter of 2115 mm (D001) and the second largest is an anonymous Indo-Persian Zarqālī astrolabe with a diameter of about 920 mm (B030).

COMPONENTS

Plate with crown (d. 664, h. 831), shackle and ring, rete (d. 606) for 30 stars, alidade (length 611), modern nut and bolt.

FRONT

The crown is high. Its profiles are formed with ogees at the base followed by five tiered lobes. There is no separate finial at the top. A simple stirrup-shaped shackle is attached to the top of the crown by means of a rivet. The ring does not pass through the shackle, but is attached to the top of the shackle by means of a bolt and nuts on both sides, so that the astrolabe can move freely all around when it is suspended by means of the ring.

The rim of the plate is divided in 1/2°, 1°, 6°. Single degrees are numbered from 1to 90, separately for each quadrant, from the east point onwards as 1—90; 90—1; 1—90; 90—1. Groups of 6° are not numbered.

The crown is filled with the main inscription in 8 lines, providing the names of the persons involved in the production of this astrolabe and the date and context of its manufacture.



Figure D090.2 – Inscription on the crown (photo by S. R. Sarma)

Inscription on the Crown

śrīparameśvarāya namo namaḥ
bhanavendumite 1927 vikrama-
varṣe pauṣe site tṛtīyāyāṃ [|]
śrī-rāmasiṃha-varddhāpana-
divase yantrarāja-pūrttir abhūt [‖][951] [metre: Gīti]
skandhe kutūhalavato gaṇitābhidhāne
śrīrāmasiṃha-dharaṇīśa-nideśabhājaḥ |
gaṃgāsahāya-śiśukasya matena saumyaṃ
śrīyaṃtrarājam atanoc chivalāla-śilpī [‖] [metre: Vasantatilakā]
gaṃgāsahāya-śiśuka-khedaccheda-sahāyatāṃ [|]
gaṇite 'bhajad ānandīlālaś chaganalāla-yuk [‖] [metre: Anuṣṭubh, irregular]

'Salutation, salutation to the glorious Parameśvara. In the Vikrama year measured by the lunar mansions (*bha* = 27), nine (*nava* = 9) and the moon (*indu* = 1) (i.e. 1927), on the third day of the bright fortnight in the month of Pauṣa, on the birthday (*vardhāpana-divasa*) of the illustrious Rāmasiṃha, this instrument was completed.

'The artisan (*śilpin*) Śivalāla constructed this excellent northern (*saumya*) astrolabe (*yantrarāja*) according to the design (*mata,* lit. view) of Gaṅgāsahāya-śiśuka who was interested in the branch called mathematical astronomy (*gaṇita*) and who received orders [to construct this astrolabe] from the illustrious king Rāmasiṃha.

'Ānandīlāla, accompanied by Chaganalāla, rendered assistance by removing the worries (*kheda-cheda*) of Gaṅgāsahāya-śiśuka concerning mathematical computations (*gaṇita*).

On the crown, immediately below the main inscription, is the label mentioning the name of the instrument:

saumya nāma yantrarājaḥ
'Astrolabe by name "northern",' that is to say, 'this is a northern astrolabe'.

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951 Here and below, instead of the double *daṇḍa,* the engraver employs a symbol which resembles the Devanāgarī numeral 1.

Below this, there is another label, each letter of which is spaced apart along the marks of 6° divisions of the scale below, mentioning the name of this plate:

idaṃ patraṃ koṣṭhakāgāram

'This plate [is] the mater.'

In the band of 6°, at the four cardinal points their names are inscribed in Sanskrit. Thus, at the top, at the south point, across the meridian, is written *dakṣiṇā [dik]*; at the north point below, across the meridian *uttarā [dik].* Likewise *paścimā [dik]* at the west point and *pūrvā [dik]* at the east point.

The innermost circle in the scale is the Tropic of Capricorn; it carries the label, engraved at the bottom, *idaṃ sarvatobhrāmitam makara-vṛttam,* 'this is the circle of Capricorn, which is made to go all around (i.e., it encircles the entire instrument).' Inside this circle there are the two concentric circles of the equator and of the Tropic of Cancer. The equator is labelled as *viṣuvad-vṛttam. idam eva meṣa-tulā-vṛttam,* '[This is] the circle of the celestial equator. This is also the [diurnal] circle of Aries and Libra. Under the Tropic of Cancer is engraved the label *karka-vṛttam,* 'the circle of Cancer'. The oblique horizon bears the label *kṣitija-vṛttam,* 'the circle of horizon' and the prime meridian the label *idaṃ khamadhyamilitaṃ samamaṇḍalam,* 'this is the prime vertical passing through the zenith (*kha-madhya*)'.

Along the edge of the crown is a long inscription:

> *atra kṣitijād uparitanāny anyonyam aspaṣṭāni navatir unnatāṃśa-vṛttāni | kṣitijād upary eva khamadhya-militāni digaṃśa-vṛttāni | etāni tu sā'śītiśata 180 yogyatāyām api mātum aśakyatvād ekaikāntarāṇy eva |*
>
> 'Here above the horizon, there are 90 altitude circles (*unnatāṃśa-vṛtta*) which are indistinguishable from one another (because they are densely packed in a limited area?). Also above the horizon are [drawn] azimuth circles (*digaṃśa-vṛtta*) which converge at the zenith (*kha-madhya*). Even though it is proper to draw 180 of them, but, because it is impossible to measure [all of them], only alternate (*ekaikāntarāṇi*) [circles, viz. 90 are shown here].'

Accordingly, altitude circles are drawn for each single degree, highlighting every sixth circle with dots. These are numbered on both sides of the meridian. Azimuth circles are marked only above the horizon for each 2°; every third of these are

highlighted with dots. These circles are numbered along the east-west diameter. Below the oblique horizon are drawn the lines of seasonal hours. These are numbered from 1 to 12 from the western horizon onwards. This is done three times: once between the Tropic of Capricorn and the equator, the second time between the equator and the Tropic of Cancer and the third time between the Tropic of Cancer and the oblique horizon. In the second row there is a label in which each syllable is engraved between two hour lines: *etāni horākhya-sthānāni,* 'these are the intervals called the "hours".'



Figure D090.3 – Latitude plate of the astrolabe (photo by S. R. Sarma)

Finally, in the segment of the hour 7, to the left of the meridian, are engraved the specifications of this latitude plate thus:

bundyām akṣabhā 5/64 akṣāṃśāḥ 25/30 paramadinam 34/6

'At Bundi, the equinoctial shadow [is] 5;64 [digits], the degrees of latitude 25;30, the longest day 34;06 [*ghaṭīs*].'



Figure D090.4 – Latitude plate, detail of the lower half. Note (1) the specifications of the plate and the labels of (2) the Tropic of Capricorn, (3) the celestial equator, and (4) the Tropic of Cancer. (photo by S. R. Sarma).

RETE

The three circles of Capricorn, equator and ecliptic are almost complete, except at the intersections. These are held together by the horizontal equinoctial bar with one counter change and the vertical solstitial bar which is interrupted for a short distance between the equator and the ecliptic. Furthermore, the equator and the ecliptic are also connected by two bars in the lower half.

On the ring of Capricorn, starting at its the intersection with the equinoctial bar in the west and proceeding clockwise, is engraved the following text:

idaṃ samagrapatraṃ bhacakra-patra-saṃjñam [|] tadantaḥ sarva-rāśi-yukta-cakraṃ krāntimaṇḍalaṃ rāśicakrañ cāhuḥ |

viṣuvavṛttād bahir dakṣiṇā krāntir madhye tūttarā [|] evaṃ rāśicakrasya bahir antar dakṣiṇottarau śarau |

‘This whole plate is called the plate of the stellar circle (*bha-cakra-patra*). Inside this there is a ring with all the signs; it is called the ecliptic (*krānti-maṇḍala*) and also the zodiac circle (*rāśi-cakra*).’

‘Outside the circle of the celestial equator, the declination is south, inside north. Likewise, outside the zodiac circle, the celestial latitude (*śara*) will be south and inside north.

On the upper half of the vertical bar is the inscription:

jyeṣṭhādi-catuṣkasyātra yantre sthānan nāsti makaravṛttād-bahir-bhūtatvāt.

‘The quartet beginning with *Jyeṣṭhā* (i.e., *Jyeṣṭhā* α Scorpii, *Mūla* λ Scorpii, *Pūrvāṣāḍhā* δ Sagittarii and *Uttarāṣāḍhā* σ Sagittarii) have no place in this instrument as they are situated outside the circle of Capricorn.’



Figure D090.5 – Rete, detail showing the central disc and several star pointers (photo by S. R. Sarma)

Around the central disc is engraved the following:

idaṃ madhyagañ chidran dhruvasthānan tat protaṃ kīlaṃ ca merukīlam āhuḥ ||

‘This hole at the centre is the place of the [North] Pole. The pin which pierces (i.e., passes through) it is called the pin of North Pole (*meru-kīlaka*).

The ecliptic ring is divided into signs and labelled with their names, each sign is divided into 30 degrees and groups of 2° are numbered anticlockwise from 2 to 30. The names of the signs are followed by their *kālāṃśa-s,* ‘degrees of [rising] times’ at the equator, i.e. their right ascensions; e.g. *meṣaḥ ‖ kālāṃśāḥ 27/50*.[952] These values are shown in the following table.

Table D090-1 Rising Times of the Signs at the Equator[953]

Meṣa	*Kanyā*	*Tulā*	*Mīna*	27;50°
Vṛṣa	*Siṃha*	*Vṛścika*	*Kumbha*	29;54°
Mithuna	*Karka*	*Dhanuḥ*	*Makara*	32;16°



Figure D090.6 – Ecliptic ring on the rete, detail showing the segmant of Virgo; its name is followed its rising times at the equator; on the left is the star pointer of *Pūrvaphālgunī. (*photo by S. R. Sarma)

There are 30 named star pointers which are formed by long rectangular bars with triangular tips. On these the names of the stars are inscribed along with their celestial

---

952 In the rete, the lengths occupied by the zodiac signs on the ecliptic ring are in proportion to their right ascensions. Therefore, these are necessary in the construction of the rete.

953 Cf. C. Introduction, 3.6.2.

longitudes (*śara*). Here the direction south or north is not given; but this can be inferred by their location relative to the ecliptic circle.

Elsewhere, on the Capricorn ring, starting from its intersection with the meridian and proceeding clockwise up to the eastern tip of the Capricorn ring, is an enumeration of the declination of the stars, preceded by the label *atha spuṭā krāntayaḥ,* 'now the true declinations'. In this enumeration, often the first syllables of the star names are engraved; but a few times the full names in genitive case. Below the names are the respective declinations. At the end of this enumeration are given the declination of three stars according to the Islamic tradition in these words:

> *yavanamatarkṣa-krāntayaḥ aśvi[nyāḥ] 18/48 u[ttarā], svā[teḥ] 20;24 [u] vi[śākhāyāḥ] 24/11 u*
>
> 'The stellar declinations according to the Islamic tradition are; *Aśvinī 18;48* north, *Svāti* 20;24 north, *Viśākhā* 14;11 north.'

The declination of a fourth star *Pūrva-bhādrapāt* is mentioned in the enumeration itself as 31. The stars, their celestial latitudes and declinations are shown in the following table.

Table D090-2 Stars, their Celestial Latitudes and Declinations

	Star Name	Identification	Celestial Latitude (*śara*)	Declination (*krānti*)
1	*Revatī*	ζ Piscium	0 s	
2	*Aśvinī*	β Arietis	10 n	21;32 n
	Aśvinī (Y)[954]		7;20 n	
3	*Bharaṇī*	41 Arietis	12 n	27;34 n
4	*Kṛttikā*	η Tauri	5 n	24;25 n
5	*Rohiṇī*	α Tauri	5 s	16;58 n
6	*Agniḥ*	β Tauri	8 n	30;49 n

[954] Declination according to the Islamic tradition (Y= *Yavana-mata*).

	Star Name	Identification	Celestial Latitude (*śara*)	Declination (*krānti*)
7	*Brahma-hṛd*	α Aurigae	30 n	53;21 n
8	*Prajāpatiḥ*	δ Aurigae	29 n	62;35 n
9	*Mṛgaśiraḥ*	λ Orionis	10 s	13;23 n
10	*Ārdrā*	α Orionis	11 s	12;32 n
11	*Lubdhakaḥ*[955]	α Canis Majoris	40 s	17;2 s
12	*Lubdhaka-bandhuḥ*	α Canis Minoris	16;19 3	4;37 n
13	*Punarvasuḥ*	β Geminorum	6 s	26;43 n
14	*Puṣya*	δ Cancri	0	17;35 n
15	*Aśleṣā*	ζ Cancri	7 s	10;2 n
16	*Maghā*	α Leonis	0	10;6 n
17	*Pūrva-phālgunī*	δ Leonis	12 n	16;16 n
18	*Uttara-phālgunī*	β Leonis	13 n	14;22 n
19	*Hastaḥ*	δ Corvi	11 s	16;8 s
20	*Citrā*	α Virginis	2 s	11;19 s
21	*Apāṃvatsaḥ*	θ Virginis	3 n	6;2 s
22	*Svātiḥ*	α Bootis	37 n	24;24 n
	Svātiḥ (Y)		31;30 n	
23	*Viśākhā*	α Librae	1 s	21;12 s

[955] Here Gaṅgāsahāya remarks *ayam evārdreti yantrarājaḥ,* 'the Yantraraja [calls] this [star] *Ārdrā*.' Thus Gaṅgāsahāya refers to the fact that in his *Yantrarāja*, Mahendra Sūri names the star *Ārdrā*, which is otherwise known as *Lubdhaka.*

	Star Name	Identification	Celestial Latitude (*śara*)	Declination (*krānti*)
	Viśākhā (Y)		44;30 n	
24	*Anurādhā*	α Scorpii	2 s	23;16 s
25	*Abhijit*	α Lyrae	62 n	38;51 n
26	*Śravaṇaḥ*	α Aquilae	30 n	10;4 n
27	*Dhaniṣṭhā*	β Delphini	36 n	19;5 n
28	*Śatabhiṣak*	λ Aquarii	0	6;23 s
29	*Pūrva-bhādrapāt*	β Pegasi	24 n	20;52 n
	Pūrva-bhādrapāt (Y)		31 n	
30	*Uttara-bhādrapāt*	γ Pegasi	26 n	26;56 n

BACK

The rim of the upper half carries altitudes scale divided in 1° and numbered from the east point as1—90; 90— 1. The rim of the lower half is blank.

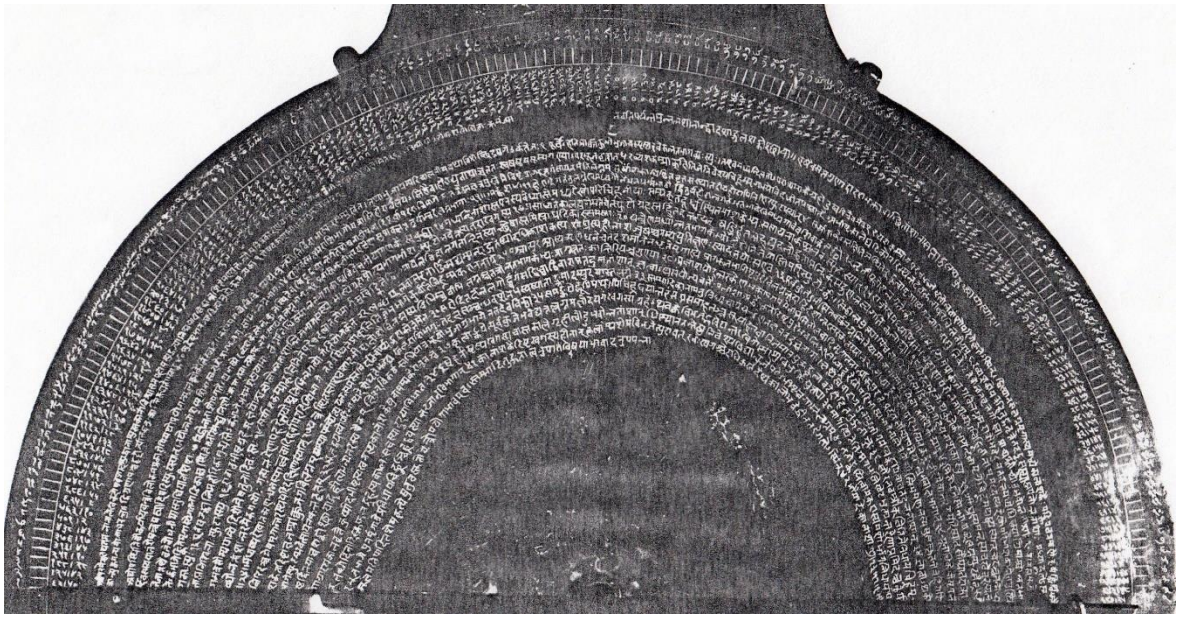


Figure D090.7 – Back of the astrolabe, upper half where the fifth chapter of Mahendra Sūri's *Yantrarāja* is engraved (photo by S. R. Sarma)

Below the altitude scale, on the upper left quadrant is a sine table for each degree from 1° to 90°. It is reproduced below.

Table D090-3 Table of Sines[956]

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
62;50	125;42	188;28	251;10	313;45	374;17	438;43	501;2	563;10	625;8
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
686;55	748;29	809;51	870;56	931;45	992;18	1052;33	1112;28	1172;3	1231;17
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
1290;7	1348;35	1406;39	1468;15	1521;25	1578;9	1634;22	1690;7	1745;19	1800;00
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
1854;9	1907;45	1960;42	2013;7	2064;53	2116;1	2166;31	2216;26	2265;35	2314;4
41	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**
2361;49	2408;5	2455;11	2500;46	2545;35	2589;37	2632;53	2674;19	2716;57	2757;43
51	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
2797;42	2836;47	2875;6	2912;27	2948;56	2984;33	3019;13	3052;59	3085;48	3117;41
61	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**
3148;38	3178;38	3207;38	3235;40	3262;45	3288;45	3313;45	3337;53	3360;53	3382;53
71	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**
3403;53	3423;48	3442;4	3460;34	3477;20	3493;4	3507;46	3521;21	3533;52	3545;19
81	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**
3551;40	3564;57	3573;10	3580;16	3586;19	3591;15	3595;4	3597;49	3599;28	3600;00

956 There are slight differences between this table and the table in Mahendra Sūri, pp. 2-6.

Below the sine table is the following text:[957]

śrīparameśvarāya namaḥ | nānā-lekhaka-doṣavaśād aśuddhānāṃ pustakānāṃ viśvāsam apahāya śuddhajyā-niścayāya śiddhānta-śiromaṇyukta-jyotpatti-prakāreṇa yantrarāja-grantha-kartrabhīṣṭa-khābhrāṅgaguṇamita 3600 trijyāyāṃ pratyekāṃśa-sādhitāḥ kramajyāḥ [‖] krānty-utkrama-jyaye (sic! read *-jyayoḥ*) *sādhanaṃ tu | dviguṇā pañca-hṛd dorjyā tad-dhanuḥ krāntir ucyate ‖ khāṅka 90 suddheṣṭabhāgajyā trijyā-śuddhotkramajyakā ‖* [metre, *Anuṣṭubh*][958]

śeṣacakrāṇāṃ tu mule spaṣṭam ‖

'Salutation to the glorious Parameśvara. Having lost faith in the manuscripts (*pustaka*) because of the errors committed by various scribes, a sine table has been created [here by me] for each degree in [a circle with] the radius (*trijyā*) of 3600, for the determination of accurate sines (*śuddha-jyā*)—which is desired by the author of the *Yantrarāja*—according to the method of *Jyotpatti* as taught in the *Siddhāntaśiromaṇi* [of Bhāskarācārya].[959]

'The determination of the sine of declination (*krānti-jyā*) and versed sine (*utkrama-jyā*) [is as follows]:

'The *R*sine [of the longitude] (*dorjyā*) multiplied by two and divided by five is called [the sine of] declination corresponding to that arc.

'The Radius diminished by the *R*sine of [the remainder of] 90 diminished by the desired degrees, is the versed sine.

'About other circles (*śeṣa-cakra ?*), it is clear in the original.'

The second line of the verse gives the formula:

$R \quad R\cos\theta = R \quad R\sin(90-\theta)$.

Below the altitude scale on the upper right quadrant is the following table of shadows thrown by the gnomon of 12 digits:

---

957 I am grateful to Professor Takao Hayashi for his help in translating this text.

958 The source of this verse cannot be located; is it Gaṅgāsahāya's own verse?

959 The purport of this involved sentence seems to be the following: the sine table is engraved on this astrolabe, because sine tables in manuscripts are liable to be full of scribal errors.

Table D090-4 Shadows of the 12-digit Gnomon[960]

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
687;25	343;48	228;55	171;34	137;9	114;10	97;44	84;22	75;45	68;3
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
61;43	56;27	51;58	48;7	44;40	41;50	39;14	36;55	34;41	32;58
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
31;15	29;42	28;16	26;57	25;44	24;36	23;33	22;34	21;39	20;47
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
19;58	19;12	18;29	17;47	17;8	16;31	15;55	15;21	14;49	14;18
41	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**
13;48	13;19	13;12	12;25	12;--	11;35	11;11	10;48	10;25	10;4
51	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
9;43	9;22	9;2	8;43	8;24	8;5	7;47	7;29	7;12	6;55
61	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**
6;39	6;22	6;6	5;51	5;35	5;20	5;5	4;50	4;36	4;22
71	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**
4;7	3;53	3;40	3;26	3;12	2;59	2;46	2;33	2;19	2;6
81	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**
1;54	1;41	1;28	1;15	1;3	0;50	0;37	0;25	0;12	0;0

Under the table of shadows occurs the following comment:

> *navati-paryantam unnatsaṃśānāṃ (sic! unnatāṃśānāṃ) dvādaśāṅgulaśaṅkoś chāyā | eṣaiva saptaguṇā dvādaśabhaktā vāñchitāṃśānāṃ saptāṅgula-śaṅkucchāyā syāt |*
>
> '[These are] the shadows of the 12-digit gnomon up [from 1°] up to 90° of altitude. The same, multiplied by 7 and divided by 12, will give the shadows of the 7-digit gnomon for the desired number of degrees [of altitude].'

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960 Cf. Mahendra Sūri, *Yantrarāja,* pp. 49-51; there are slight differences between these two tables.

Mahendra's *Yantrarāja,* Fifth Chapter

Below these two tables is engraved the fifth chapter of Mahendra Sūri's *Yantrarāja* in 17 semi-circular lines which span the two upper quandrants. The lines are numbered serially on the left-hand side. The text is preceded by the following introductory remark:

> *athopasthiti-saukaryāya yantravilokana-prakāro[']pi agropayogam mūlaślokair likhyate* |
>
> 'Now for the convenience of consultation (*upasthiti*), the method of observation with the instrument also is written [below] in original verses, so that it will be of use henceforth.'

By strangely the names of the text and of its author are not mentioned here. In the edition of Raikva 1936, the fifth chapter consists of 67 verses. Of these, however, only 42 verses (viz. 1-11, 13, 22-28, 32-45, 55-63) are engraved with continuous serial numbers. The reason for this omission requires further research. There are about 100 manuscript copies are available now. Raikva's edition is based on just 3 manuscripts. Perhaps Gaṅgāsahāya is following a manuscript tradition different from that followed by Raikva.

This text is immediately followed by the following passage, which is rather obscure:

> *bhaumādeḥ kālāṃśāḥ 27/13/11/10/15. mūlapratipādita-śeṣakṛtyeṣu vastuto nye [?ya] ntropayogābhāvaṃ ca* | *stambhādi-tuṅgatā tv anupāta-viṣayābhāvād anupapannaḥ* |
>
> 'The degrees of the rising times of Mars and others are 27|13|11|10|15. (Does it mean Mars 27, Mercury 13, Jupiter 11, Venus 10, Saturn 15 ?). The remaining tasks enunciated in the original text [of the *Yantrarāja*] have no application /utility elsewhere [therefore they are ignored here?]. The height of the pillar and others [can be derived] from proportion. Therefore it is not presented here (?).'

The rest of the plate, which constitutes more than one half of the plate, is totally blank.

D091 ASTROLABE FOR LATITUDE 26°, DESIGNED BY GAṄGĀSAHĀYA, MADE BY RĀMAPRATĀPA[961]

1895, Tonk, Rajasthan

Diameter 334 mm

PLU

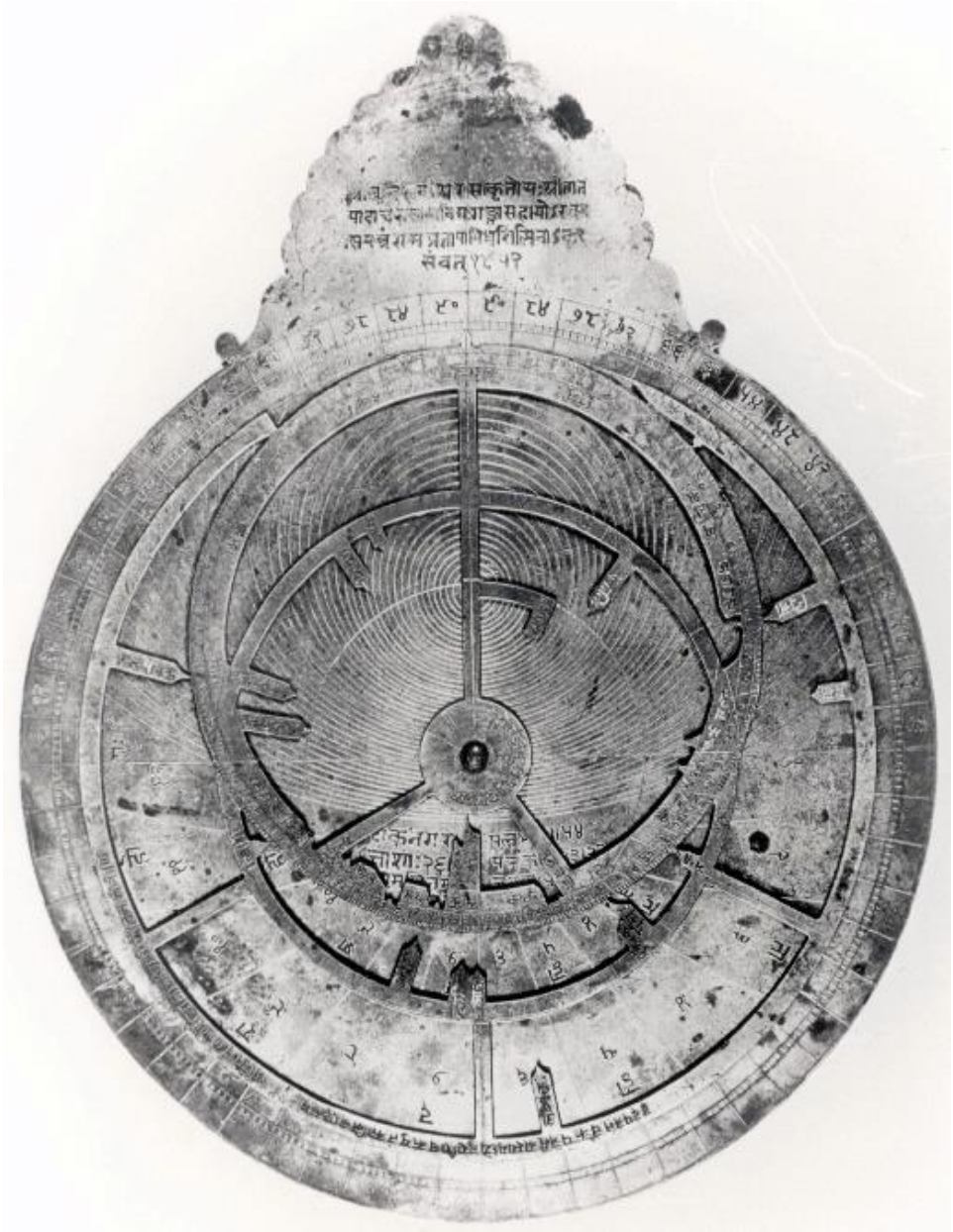


Figure D091.1 – Front of the astrolabe (courtesy Museuem of the History of Science, Oxford)

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961 Entry based on photos in the archives of the Museum of the History of Science, Oxford. Anthony J. Turner gave me some photocopies of these photos on which Alain Brieux noted that the diameter of the astrolabe is 334. The inscriptions on this astrolabe were discussed in Sarma 2010, s. v. Gaṅgāsahāya.

This remarkable astrolabe was designed by Gaṅgāsahāya and made by the artisan Rāmapratāpa at Tonk (26;11° N; 75;50° E, Rajasthan) in VS 1952 (AD 1895-96). While the obverse side of the plate is calibrated for the latitude of 26°, the reverse is designed as a compendium of three instruments. There are several interesting inscriptions which will be discussed at the appropriate places.

COMPONENTS

Plate with crown, rete, alidade, pin and wedge. Ring and shackle are missing.

FRONT

The crown is rather high with lobed profiles. The scale on the rim consists of three bands. While the narrow middle band is divided in 1°, the two wider bands are divided in 6°. In the outer band, groups of 6° are numbered from the east point onwards in this manner: 6—90; 90—6; 6—90; 90—6. The inner band is empty. Altitude circles are drawn for every 2°. In the photo, it is cannot be seen whether these are numbered. There are no azimuth arcs. Lines are drawn for unequal hours. Close to the Tropic of Capricorn, the intervals between these lines are numbered from 1 to 12, starting from the western horizon. There is a label in which each syllable is written separately and far apart from one another: *[e]tā dvādaśa horāḥ,* 'these are the twelve hours'. The intervals seem to be numbered once again close to the Tropic of Cancer, again with the same label.

Below the oblique horizon is engraved the following information, which is partially obscured by the rete in the photo.

> *ṭākanagare palabhā 5|54*
> *[a]kṣāṃśāḥ 26 pala[karṇa]*
> 'In the city of Ṭāka [Tonk] the latitude degrees are 26; equinoctial shadow 5|54, equinoctial [hypotenuse 1362.'

RETE

The rete consists of the three complete rings of the Tropic of Capricorn, the equator and the ecliptic. These are not held together by the equinoctial bar, as in most of the astrolabes of this group, but by the segments of the solstitial bar and other supports. The upper half of the solstitial bar connects the ecliptic ring, the equatorial ring and the central disc. A segment of the solstitial bar joins the equatorial ring with

the Capricorn ring below; the same is done by the two straight bars situated on either side of the solstitial bar at equal distances. The central disc is joined to the ecliptic ring by two straight bars which are placed asymmetrically on either side of the meridian.

Two open ends of the Capricorn ring are not uniform; the end on the right is longer and tapering to a point, while the end on the left is cut abruptly.

There appear to be 24 star pointers. Most of them are rectangular bars with a pointed tip. A few of them are created by notches inside the ecliptic ring.

On the lower rim of the rete is engraved the following inscription:

> *idaṃ patraṃ bhacakrapatraṃ | asya madhye tu rāśicakrayutaṃ krāntimaṇḍalaṃ | asmin patre siddhāntānusārāṇy eva nakṣatrāṇi |*
>
> 'This plate [is called] the plate of the stellar sphere (*bhacakra-patra*). In it is [situated] the ecliptic ring (*krānti-maṇḍala*) together with the circle of the zodiac (*rāśi-cakra*). On this plate the star positions are [marked] strictly according to the *Siddhāntas* (i.e. Sanskrit astronomical treatises).'

That is to say, this astrolabe avoids the stars known from the Islamic tradition with their outlandish names like *Samudrapakṣī* ('sea bird', β Ceti), *Kukkuṭapuccha* ('tail of chicken', α Cygni) and employs only those stars which are known to the Sanskrit tradition, i.e., mainly the junction stars of the lunar mansions. Because of the poor quality of the available photo, all the star names marked on the rete cannot be deciphered, but *Samudrapakṣī, Kukkuṭapuccha* do not occur here. Those names which can be seen clearly are *Rohiṇī* (α Tauri), *Ārdrā* (α Orionis) *Lubdhaka* (β Canis Majoris), *Hasta* (δ Corvi), *Citrā* (α Virginis), *Svāti* (α Bootis), *Anurādhā* (α Scorpii) and *Śatabhiṣā* (λ Aquarii).

Back

As in the front, the scale on the rim on the back also consists of three concentric bands which are divided as in the front. Groups of 6° are numbered in the outer band only in the two upper quadrants thus: 6—90; 90—6.

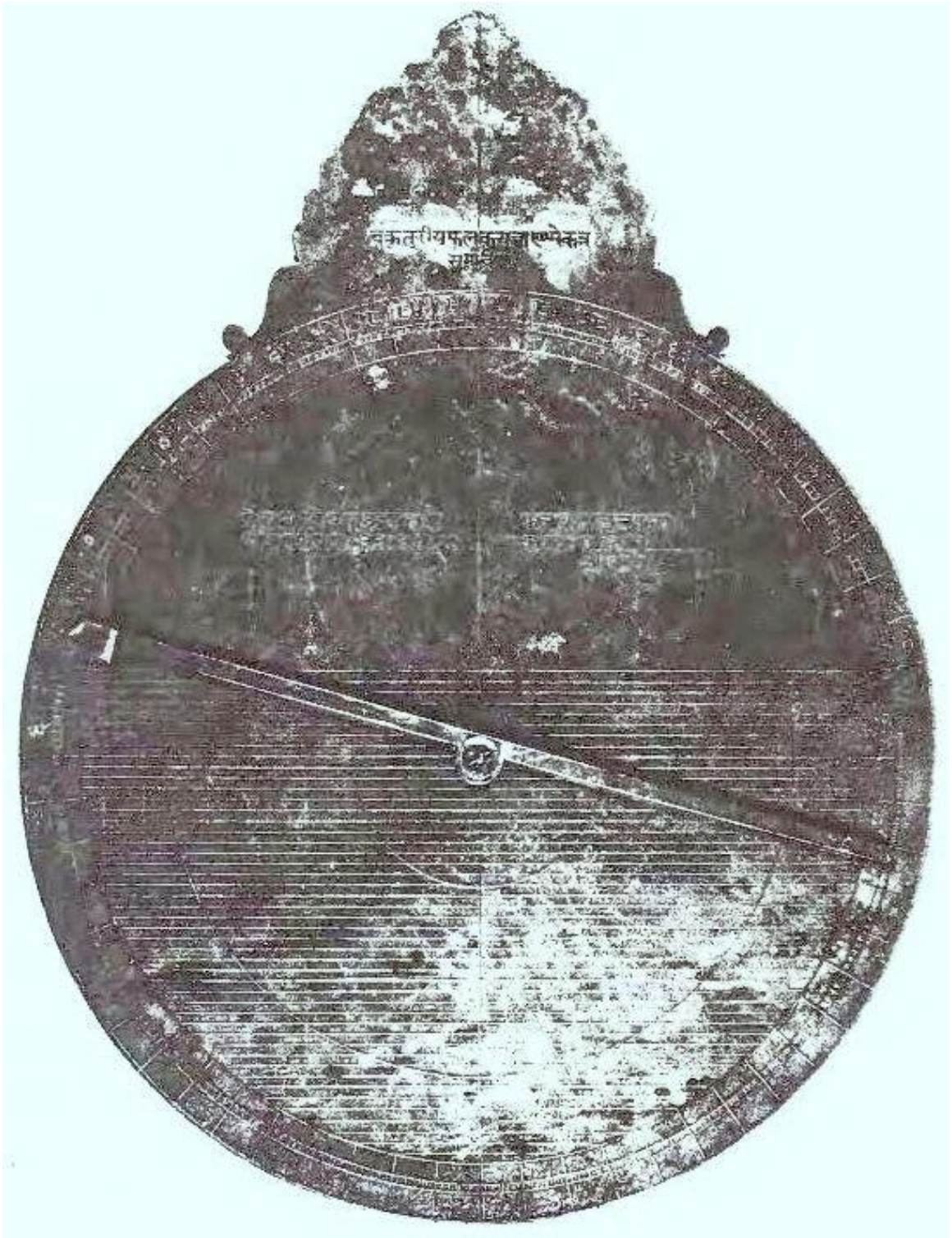


Figure D091.2 – Back of the astrolabe (photo courtesy of Museum of History of Science, Oxford)

The projections on the back are unusual. An inscription on the crown states thus:

cakra-turīya-phalaka-yantrāṇām ekatra samāveśaḥ.

‘[Here is an] assemblage at one place of the *Cakra-yantra,* the *Turīya-yantra* and the *Phalaka-yantra*.’

Turīya-yantra is the sine quadrant, which is normally incorporated on the back of the astrolabe. *Cakra-yantra* is a graduated circular disc with an upright peg at the centre.[962] The back of every astrolabe can be employed as a *Cakra-yantra.*

But a *Phalaka-yantra* is not a part of the astrolabe. Invented by Bhāskarācārya in the idle of the twelfth century, it is a rectangular board on which are drawn a number of horizontal parallels. A peg is attached at the centre of the board at right angles to the surface and a circle is drawn with the peg as the centre. The shadow of the peg falling on the circle and on the parallel lines enables the astronomer to determine graphically time and other elements.[963] However, there is hardly any extant specimen of the *Phalaka-yantra*.[964] Therefore Gaṅgāsahāya's attempt at using the back of the astrolabe as a *Phalaka-yantra* is historically valuable. Starting a little above the centre, about 45 equidistant horizontal parallels are drawn up to the lower periphery on this astrolabe. Two concentric circles with different radii are drawn from the centre; these could be the equatorial circle and the Tropic of Cancer. The alidade of the astrolabe can, of course, function like the index required for the *Phalaka-yantra,* and can also measure the altitude of the sun. However, there is no circle divided into 60 *ghaṭikās* and 360 degrees of arc.

There are two more inscriptions providing the necessary parameters for using the *Phalaka-yantra.* An inscription on the upper left quadrant reads *ṭoṃkanagare phalaka-yantra-yogya | paramā yaṣṭiḥ 36|34,* 'In the city of Tonk, the maximum *yaṣṭi* appropriate for the *Phalaka-yantra* is 36|34.' The upper right quadrant bears the inscription *phalaka-yantra carajyā-khaṇḍāḥ 3|2|2 6|18|2,* 'the segments of the sines of accensional differences for the *Phalaka-yantra* are 3|2|2 and 6|18|2.'

Inscription

On the front side of the crown is engraved the following verse in *Indravajrā* meter.

---

962 It was described by Brahmagupta in his *Brāhmasphuṭasiddhānta* 22.18 and also by subsequent astronomers.

963 *Siddhāntaśiromaṇi*, Golādhyāya, Yantrādhyāya 16-22; cf. Wilkinson & Sastri 1861, pp. 212-218; Rai 1985, Ôhashi 1988, Ôhashi 2008.

964 The few surviving specimens and other details will be discussed in the section P on the *Phalaka-yantra.*

śrībundi-pṛthvīśvara-satkṛto yaḥ
śrītātapādārcanalabdhavidyaḥ |
gaṃgāsahāyo 'racayat sayatnaṃ
rāmapratāpābhidaśilpinādaḥ ||1||
Saṃvat 1952.

'Gaṅgāsahāya, who was honoured by the illustrious king of Bundī and who obtained [all] the learning through the worship of [his] father's feet, [caused to be] constructed this [astrolabe] with [great] effort through the artisan (*śilpin*) named Rāmapratāpa. VS 1892 [= AD 1895-96].'

BIBLIOGRAPHY

Wilkinson & Sastri 1861, pp. 213-218.
Rai 1985.
Ôhashi 1988.
Ôhashi 2008.
Sarma (forthcoming).

D092⊙ PERSONAL ASTROLABE MADE BY JAMES E. MORRISON ‘IN SANSKRIT STYLE’

April 2010, Rehoboth Beach, DE, USA

Diameter 178 mm

Düsseldorf, S. R. Sarma

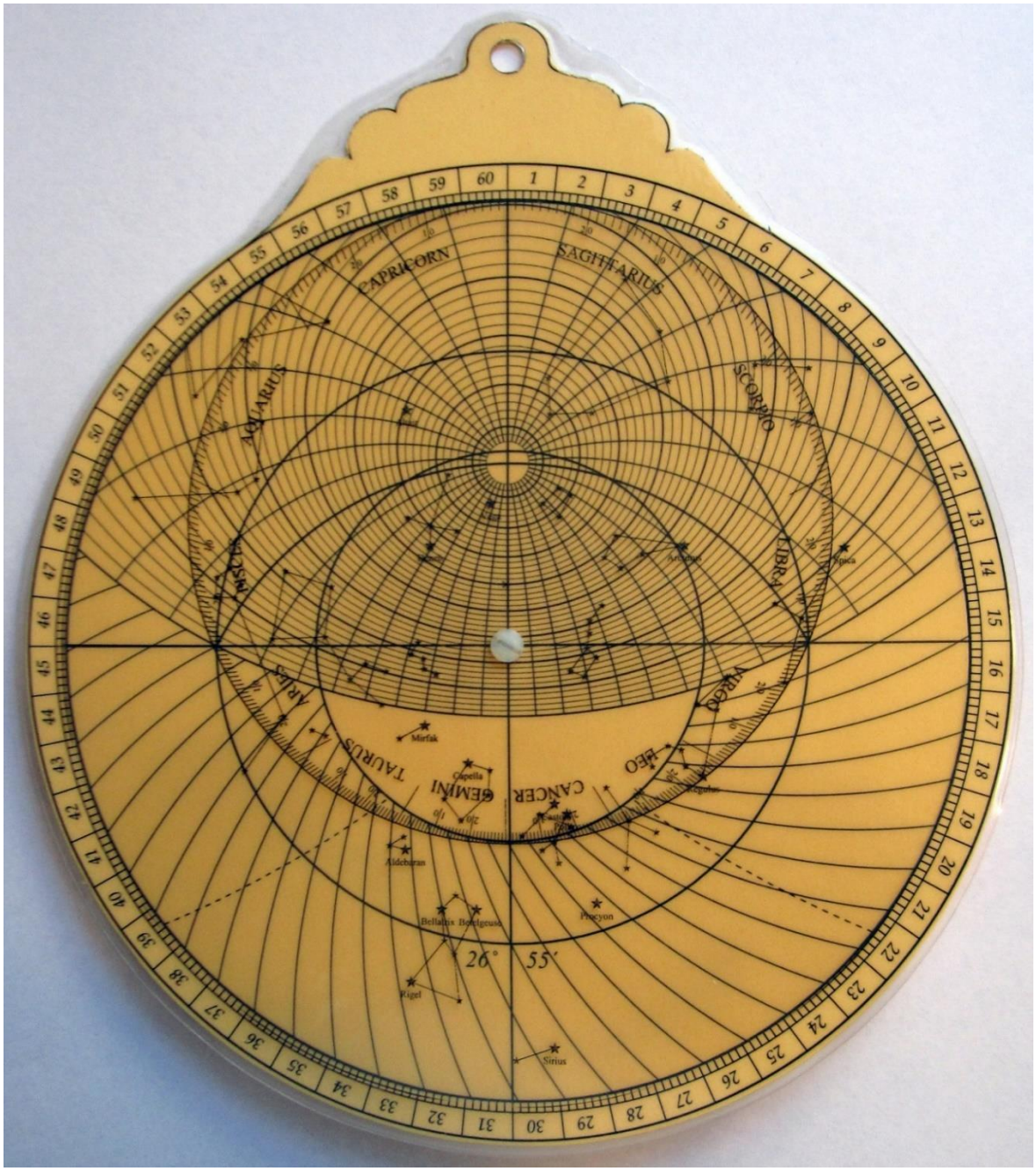


Figure D092.1 – Front of the astrolabe made for the latitude of Jaipur at 26;55°
(photo by S. R. Sarma)

James E. Morrison can be regarded as the most prolific maker of astrolabes in history; between 1994 and 2016, he produced over 8,000 copies of ‘The Personal

Astrolabe’, an inexpensive computer-created astrolabe reproduction on laminated card-board.[965] It was supplied along with a companion volume entitled *The Personal Astrolabe: Classic Edition,* which contains a brief history of the astrolabe, its construction and use.[966] These personal astrolabes were designed after European astrolabes with calendar scales and lines for seasonal hours on the back.

After reading my book *The Archaic and the Exotic,* he became interested in Sanskrit astrolabes. In early 2010 he created for me a personal astrolabe ‘in Sanskrit style’, which is a unique specimen.[967] Before describing it, I shall first let Morrison speak about the personal astrolabes:

> ‘It is called the Personal Astrolabe because, unlike most classical or reproduction instruments, your astrolabe is designed for your exact location and for the current year. … The Personal Astrolabe has grown out a sincere belief that the study of astronomy is made more fun and interesting by learning about the history and instruments that helped shape the science.’[968]
>
> ‘The Personal Astrolabe is computer created for a specific location and year. … Following is a partial list of the astrolabe elements that are customized for a location and date:
>
> Stars are precessed from their J2000.0 coordinates to the date of the instrument.
>
> The obliquity of the ecliptic is a key astrolabe design element and is calculated for the instrument date. The value of the obliquity affects the position of the tropics, the altitude and azimuth arcs and the declination scale on the rule.
>
> The location of the aphelion and perihelion are accurate for the instrument.
>
> The time of the vernal equinox is adjusted for your longitude on both the rete and the back. This can vary up to half day depending on the location.
>
> The equation of time is calculated for the year of the instrument.

---

965 Personal communication, 27 January 2016.

966 Morrison 2010; see also Watson 2016.

967 He also gifted me a Personal Astrolabe designed for the latitude of Düsseldorf at 51;13°.

968 Morrison 2010, preface.

Janus Personal Astrolabes are very likely the most accurate astrolabes ever made.'[969]

COMPONENTS

Main plate with crown (d. 178, h. 205), two rings for suspension (not shown in the photo), rete (d. 163) for 124 stars, alidade.

FRONT

The crowns in Morrison's personal astrolabes are rather simple without any ornamentation. But in the present specimen, the low crown is endowed with ornate profiles, made up of ogees at the base, followed by lobes and again ogees at the top.

The limb carries a *ghaṭī* scale, divided in 1° and 6° and numbered in 6s from 1 to 60. The plate is designed for Jaipur at the latitude of 26;55° in the year 1609.[970] The altitude circles are drawn for every 2° and each fifth is marked in bold lines. Azimuth arcs are drawn above the horizon for each 10° and the prime vertical is marked with a bold line.

Morrison's main innovation is in the hour lines. Although time was reckoned in *ghaṭīs* in India, lines for *ghaṭīs* were never drawn on the latitude plates of Sanskrit astrolabes. One is expected to use the degree scale on the limb as taught by Mahendra Sūri. But *ghaṭī* lines in the lower half of the plates would have been an additional help. Instead, some Sanskrit astrolabes have lines for equal hours and occasionally also lines for seasonal hours in the lower half. Morrison wondered why lines for seasonal hours are drawn which are primarily related to Islamic prayer times. I explained that in popular usage, the day time is divided into four *prahara-s* and the night into four *yāma-s*; therefore, the lines for seasonal hours can be used for determining the *prahara-s* and *yāma-s.* Accordingly, Morrison drew lines for equal *ghaṭīs* between the two tropics in the lower half and also dashed lines to indicate the *prahara-s* or *yāma-s.*

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969 Morrison 2010, p. 36.

970 From the time of Sawai Jai Singh, Jaipur has been a major centre of astronomical activity. Therefore it is entirely appropriate to make this Sanskrit astrolabe for the latitude of Jaipur. But the reason for the choice of the year eludes me.

> The arcs below the horizon are (equal) ghatis from sunrise. In use, the rete is set to a time and the point on the ecliptic opposite the sun is the corresponding ghati from sunrise. … The dashed arcs show prahara/yama which, with the meridian, divide the day/night into quarters.[971]

The 34 *ghaṭī* lines drawn from the western horizon up to the eastern horizon indicate that the maximum duration of daylight at this latitude is a little over 34 *ghaṭīs* or 13;36 hours. In this respect, it is an improvement over all the existing Sanskrit astrolabes.

RETE

The rete with a diameter is 163 mm is made of transparent plastic so that the lines on the plate underneath are visible. On the rete are drawn the peripheral circle of Capricorn and the circle of the ecliptic. The latter is divided into the 12 signs and labelled with their names in English. Each sign is divided on the rim into 1° and 10° and numbered as 10, 20, 30, separately in each sign. The line at the first point of Aries is extended up to the Tropic of Capricorn. When this line is made to coincide with the east west diameter, the rete shows the stellar heaven at the vernal equinox, and the sidereal time is counted from this point.

On the rete are marked the positions of 124 stars which are arranged in constellation figures for easy identification. Prominent stars are marked with large symbols. On the transparent rete, the names of just a few stars are printed and not all these which are seen in the figure above. The constellation figures are not named, for it is assumed that the user gradually learns to recognize them without names.

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971 Personal communication, 3 April 2011.

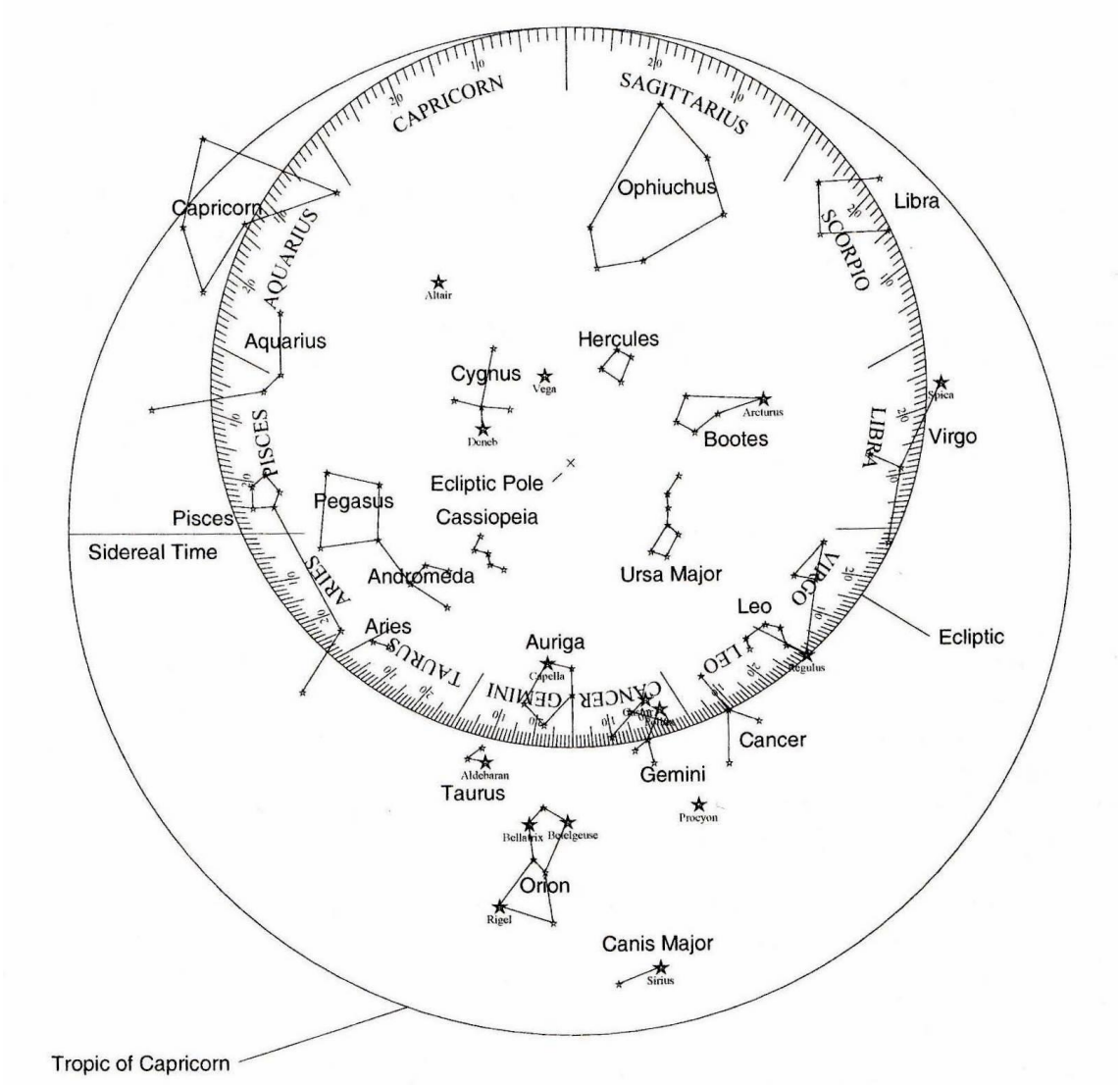


Figure D092.2 – Rete of the astrolabe (from Morrison 2010)

BACK

On the back, the rim of the two upper quadrants carries two altitude scales, divided in 1°, 5° and 10° and numbered in 10s as 10—90; 90—10. The rim of the lower half is blank.

A trigonometric quadrant occupies the upper left. On this are drawn 60 horizontal and 60 vertical parallels with each fifth emphasized by bold lines. There are also declination arcs for each 6°.

The sin/cos quadrant has quarter circles for each six divisions. There's no solid logic behind this, only that the arcs divide the quadrant into 10 sectors.

> With sixty divisions on each axis, each line is for 1.5 degrees so the arcs are for each nine degrees.[972]

The arc with the radius of 24° is shown as a bold line; it indicates the obliquity of the ecliptic. Moreover, radial lines drawn from the centre to each 15° on the arc.

> ‘The sin/cos radials are for each 15 degrees (1 hour). The only real function of the radials, as far as I know, is to make it easier to find specific angles. They could be drawn using any other value. They could be for each six degrees or 1 ghati.’[973]

On the upper right is the solar quadrant with declination arcs for each 10° of solar longitude, with each third (30°) highlighted with bold lines. The corresponding signs are marked with their symbols in two bands along the horizontal diameter. On this are superimposed three graphs of the solar meridian altitude at latitudes 17°, 25°, 29°. The latitudes are so chosen that the lines do not run too close to one another. Latitude 29° indicates, needless to say, Delhi. The southern-most latitude 17° is for Hyderabad, called Golconda on the gazetteers of Indo-Persian astrolabes and Tilinga by Malayendu Sūri.[974] The middle latitude 25° represents Bundi and Kota in Rajasthan.

The lower half is occupied by shadow squares, on the left for the 7-digit gnomon and on the right for the 12-digit gnomon. Within the shadow squares are two semi-circular rows showing the interrelation between the 12 zodiac signs and the 28 lunar mansions.

ALIDADE

The ungraduated alidade is straight without counter change. The two ends are curved to match the profile of the throne.

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[972] Personal communication, 2 April 2010.

[973] Personal communication, 2 April 2010.

[974] Malayendu Sūri, pp. 18-19.

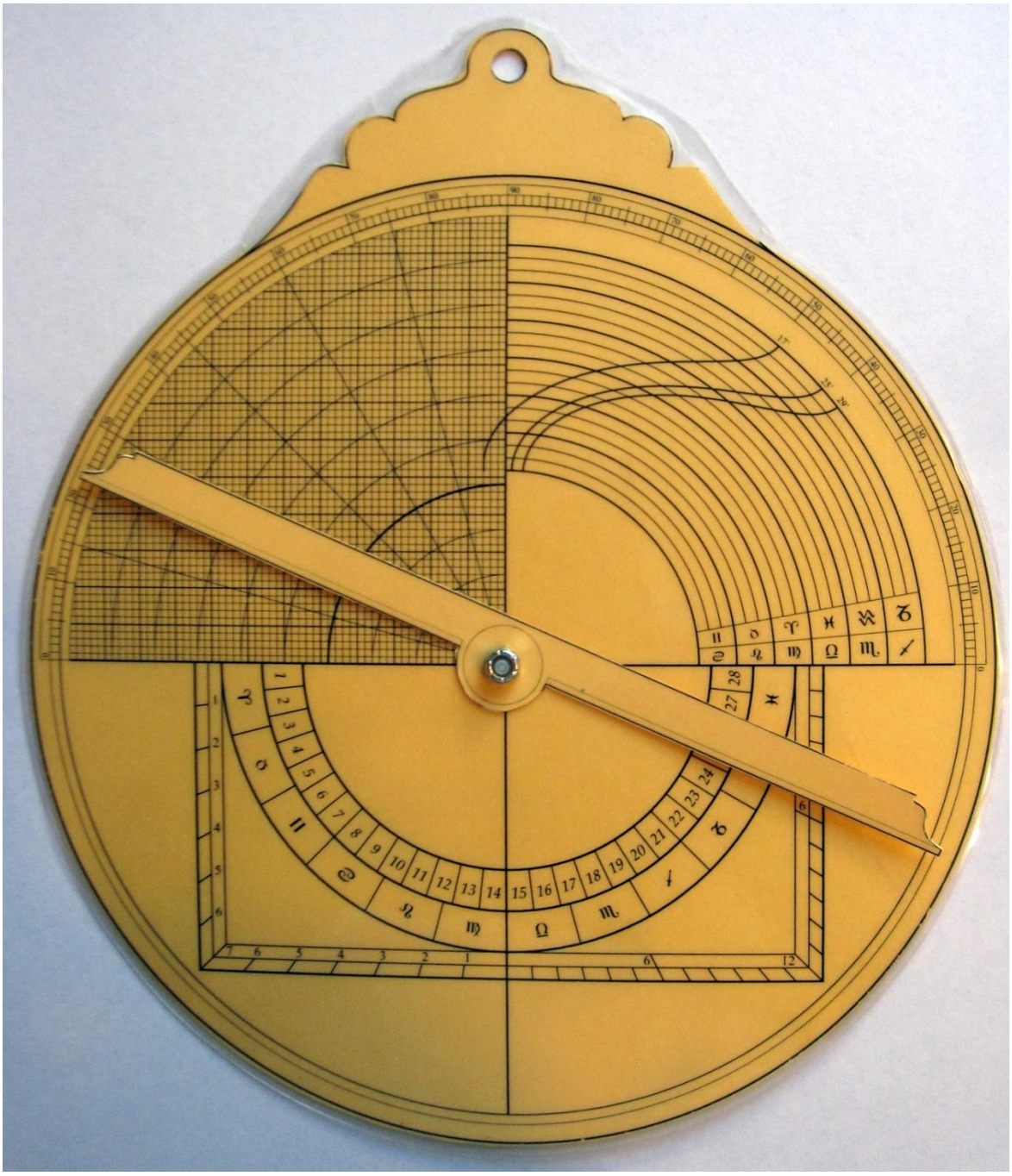


Figure D092.3. Back of the astrolabe (photo by S. R. Sarma)

BIBLIOGRAPHY

Morrison 2007.

Morrison 2010.

Watson 2016.

E. ASTROLABES REWORKED IN SANSKRIT

When the Hindu and Jaina astronomers encountered the astrolabe, they adopted three strategies to incorporate it into their knowledge systems. As we have shown in the earlier sections, they composed manuals on the construction and use of the astrolabe and produced some 130 Sanskrit astrolabes. A third strategy was to rework the Islamic astrolabes with additional legends and numerals in Sanskrit so that these could be used by astronomers who did not read the Arabic script.[975]

As early as 1856, William H. Morley drew attention to one such reworked astrolabe, which came to be known as 'Professor Wilson's astrolabe'.[976] In 1983, Margarida Archinard devoted a full-length monograph to another specimen, now preserved at the Musée d'Histoire des Sciences de Genève.[977] I came across a few more reworked Arabic astrolabes and also celestial globes.

These instruments constitute an interesting chapter in the dissemination of Islamic instruments in India. The reworking required a close cooperation between the Muslim astronomer who explained to the Hindu astronomer the meaning and significance and the original Arabic legends on the astrolabe and between the Hindu astronomer who commissioned the reworking and provided the text of the Sanskrit additions to the artisan who engraved the additions in Devanagari script.

The additions in Sanskrit are not all uniform. While some astronomers were content with marking with Sanskrit labels just those latitude plates which were useful to them, others attempted to render every single Arabic legend into Sanskrit.

Sawai Jai Singh collected some of the finest astrolabes produced by the Lahore family of astrolabists and also other portable instruments engraved with Arabic/Persian or Sanskrit legends. In some Mughal astrolabes, he caused minor additions to be in Devanagari script for the convenience of his Hindu astronomers who could not read the Arabic script.

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975 In Europe also, additions in Hebrew, Latin or Spanish were engraved on Arabic astrolabes; cf. King 2002-03.

976 Morley 1856, pp. 32-34.

977 Archinard 1983.

Thus on the zoomorphic astrolabe A051, the latitude degrees are duplicated in Devanagari script on certain plates. There is one plate calibrated for the latitude of 28;39,20 which is the latitude of Delhi. On this plate was engraved *dilī 28/39.* Dillī is spelt incorrectly and seconds are omitted in the value of the latitude. Also on the plates projected for the latitudes of 23;30°, 27° and 32°, the latitude degrees are duplicated in Devanagari, for these plates are of immediate interest as they represent the latitudes of Ujjain, Agra /Jaipur and Lahore.

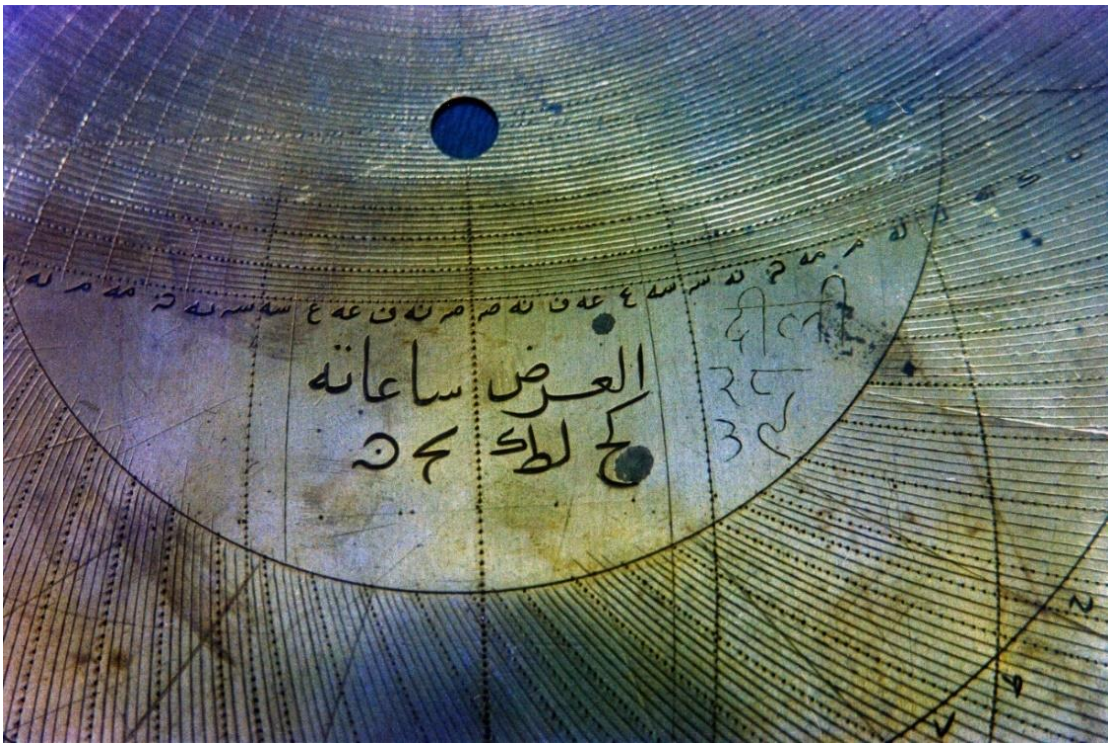


Figure E1 – Plate designed for Delhi in A051 (photo by S. R. Sarma)

Jai Singh's collection also includes the *Zarqālī* universal astrolabe fashioned by Ḍiyā' al-Dīn Muḥmmad of Lahore in 1680-81 (A091). At Jai Singh's orders, a Sanskrit name was engraved in Devanagari script at the back of the crown of this astrolabe: *yaṃtra jarakālī sarvadeśī*. The first syllables of the Sanskrit names of the zodiac signs were engraved at appropriate places on both sides of the ecliptic. Several star positions were marked with simple dots and their Sanskrit names were inscribed. Moreover, a copper plaque was attached to the astrolabe on which all the functions of this universal instrument were enumerated in Rajasthani.

Likewise, Sanskrit labels were engraved on two Indo-Persian celestial globes. On a celestial globe made in 1663 by Muḥammad Ṣāliḥ of Thatta, the astronomer Nandarāma caused the additions of several Sanskrit names in 1767. The original globe will be described in section G and the Sanskrit additions in section H. On a celestial

globe made in 1690 by Ḥāmid of the Lahore family, the 28 lunar mansions are serially numbered in Devanagari at some later point by an unknown person; this globe will be discussed in section G.

In the present section are treated 5 Islamic astrolabes which are thoroughly reworked in Sanskrit. The first three were originally produced outside and reached India where they were given a Sanskrit coating. The last two were fabricated at Lahore by Ḍiyā' al-Dīn Muḥammad, sometime after 1648, and were reworked in Sanskrit in about half a century thereafter.

E001 'PROFESSOR WILSON'S ASTROLABE', KUFIC ASTROLABE BY MAḤMŪD BIN ᶜALĪ BIN YŪSHAᶜ AL--RĪ, 669 AH (AD 1271)

Diameter 95 mm

PLU

CCA 67

This astrolabe was described by William H. Morley in an appendix to his celebrated *Description of a Persian Astrolabe constructed for Shah Husain Safawi*.[978] According to him, the astrolabe was acquired by the well-known Sanskrit scholar, Professor Wilson at Benares. Horace Hayman Wilson (1786-1860) went to India as the assistant surgeon of the East India Company in 1809 and worked there in various capacities, such as the assay master of the mint and, more important, the secretary of the Asiatic Society. In 1819 he was sent by the government to reorganize the Sanskrit College at Benares. He must have obtained this astrolabe during his stay at Benares. In 1832 he was appointed to the newly created Boden Chair of Sanskrit at Oxford and returned to England.[979] He must have brought the astrolabe with him the England, where Morley appears to have seen it before 1856. What happened to it thereafter is not known. In 1932, Gunther included it in his *Astrolabes of the World,* under no. 67, but did not mention its location. No photos or drawings of this astrolabe are available, except the drawing of one of the latitude plates (Figure E001.1).

The numerals and legends on the astrolabe are in Kufic script. There are four inscriptions containing the year of manufacture and the names of the maker and of the dignitary for whom the astrolabe was made. The year of manufacture is given in four eras: Mālikshāhī 193 (= 21 March 1271 – 20 March 1272), Yazdegird 640 (= 10 January 1271- 9 January 1272), Byzantine Era of Alexander 1582 (= 8 October 1270 -7 October 1271) and Hijrī 669 (= 26 August 1270 – 14 August 1271). Therefore, the astrolabe was made sometime between 21 March 1271 and 14 August 1271.

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978 Morley 1856, pp. 18, 32-34, plate xix, fig. 12.

979 Cf. *Oxford Dictionary of National Biography,* s.v.

The name of the astrolabe maker is inscribed on the rim of the lower left quadrant on the back: ‘Constructed by Maḥmūd bin ᶜAlī bin Yūshaᶜ Al--rī, in the year 669 Hijrī.’ (two characters in the last part are indecipherable).[980] Across the middle of the two lower quadrants on the back is a long dedicatory inscription:

> ‘For the Museum of the Honoured Prime Minister, the Supreme Lord, the Assisted [by God], the Wise, the Just, the King of the Amírs, the Khusrú of the quarters of the World, the Splendour of the State, and of the Faith, the Sun of the Islám and of the Muslims; the Succour of princes and lords, Al-Hasan Ben ’Alí, Ash-Shadíd: may God glorify his friends and double his dignity.’[981]

Morley conjectures that the patron was ‘Sáhib Bahá ad-Dín Abú al-Hasan ’Alí Ben Muhammad Ben Salím Ben Hinna, who was the chief Wazír of the Sultan Bíbars, and who died in A. H. 677 (A.D. 1278).’ Therefore, the astrolabe must have been produced in Egypt; the maker is also probably from Egypt.

COMPONENTS

Mater with *kursī* (d. 95.25), shackle and ring, rete for 22 stars, 2 plates; two other plates are missing; alidade, pin and wedge are of ‘modern workmanship’

FRONT

The limb is graduated in 1° and 5° and numbered in 5s as 5, 10, 5, 20, 5 … 5, 350, 5, 360.

RETE

The rete exhibits the tropic of Capricorn and the ecliptic, the latter divided into 12 signs, each further sub-divided into 6 parts. There are 22 star pointers. Morley lists separately the 11 stars which are inside the ecliptic and the 11 which are outside. Here they are rearranged by the increasing right ascension.

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980 CCA records under # 3657 one more astrolabe by Mahmud b. ‘Ali, made in 675/1276, with diameter of 84 mm. The collection code is PBC = Paris, Alain Brieux, which means that the astrolabe passed through the hands of Alain Brieux before 1973. It is impossible to say where the astrolabe is now. Emilie Savage-Smith thinks that the last part of the name is ‘al-Tabārī’; cf. Maddison & Savage-Smith 1997, I, no. 123, pp. 212-213.

981 Morley 1856, p. 34.

Table E001-1 Stars on the Rete

	Star Name	Identification
1	*ᶜAyn al-Thawr*	α Tauri
2	*al-ᶜAyyūq*	α Aurigae
3	*al-Rijl*	β Orionis
4	*Yad al-Jawzā'*	α Orionis
5	*al-Yamānī*	α Canis Majoris
6	*al-Shāmī*	α Canis Minoris
7	(*Fard al-Shujāᶜ*)	α Hydrae
8	*Qalb al-Asad*	α Leonis
9	*al-ᶜAnāq*	ζ Ursae Majoris
10	*al-Qafzah*	γ and μ Ursae Majoris
11	*al-Aᶜzal*	α Virginis
12	*al-Rāmiḥ*	α Bootis
13	*al-Fakkah*	α Coronae Borealis
14	*Qalb al-ᶜAqrab*	α Scorpii
15	*al-Ḥawwā*	α Ophiuchi
16	*al-Wāqiᶜ*	α Lyrae
17	(*al-Ṭā'ir*)	α Aquilae
18	*al-Ridf*	α Cygni
19	*Qayṭus*	ι Ceti
20	*al-Faras*	β Pegasi
21	*Kaff al-Khaḍīb*	β Cassiopeiae
22	*al-Ẓalīm*	α Piscis Austrini

PLATES

The recess inside the limb can accommodate four plates, of which only two are extant. In the first plate, the two sides are calibrated for the latitudes of 36° (14;30 hours) and 37° (14;33 hours); both sides are engraved with altitude circle for each 6°, lines of equal and unequal hours (the former numbered, the latter dotted), but no azimuths. The second plate has double projections on each side; for latitudes 24° and 30°, on one side and for latitudes 27° and 32° on the other; both sides exhibit altitude circles for each 6°, lines of unequal hours and the prime vertical drawn below and above the horizon.

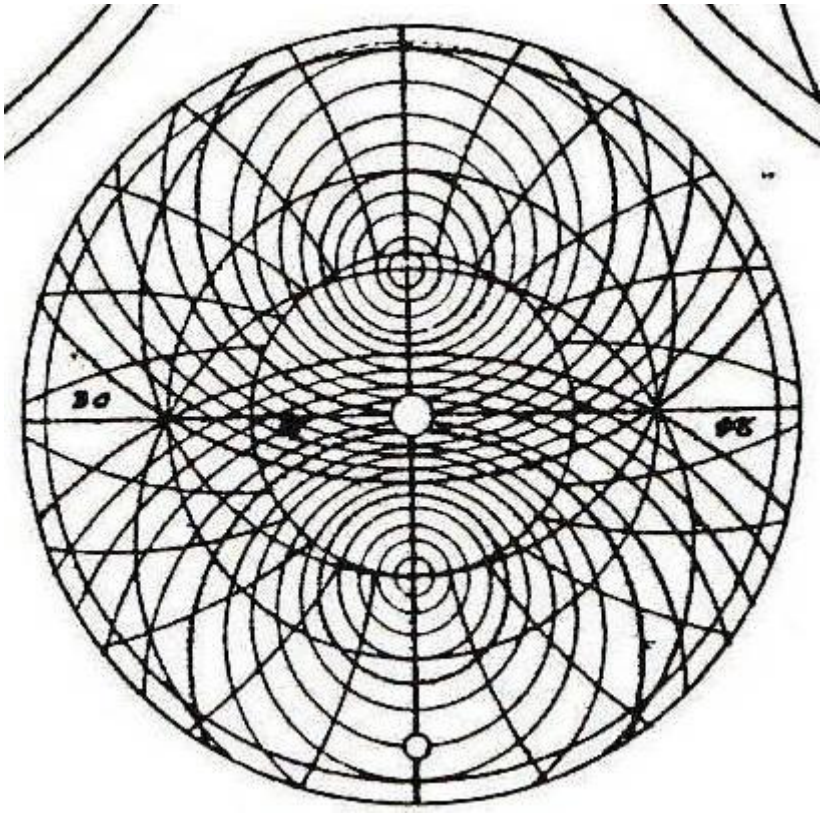


Figure E001.1 – Latitude plate with projections for latitudes 24° and 30°
(Morley 1856, Plate xix, fig. 12)

BACK

The upper half of the rim is occupied by altitude scales, numbered from 5 to 90, commencing from either end of the horizontal diameter and numbered as 5, 10, 5, 20, … 5, 90. Both the upper quadrants were originally engraved with 90 horizontal parallels, but at a later point, those in the upper left quadrant were rubbed off and replaced with 60 parallels, for unknown reasons.

The rim of the lower left quadrant bears, as mentioned above, the signature of the astrolabe maker; the rim of the lower right quadrant is engraved with a cotangent scale, numbered as 5, 10, 5, 20 … 40, 5, followed by the label *ẓill al-aṣābiᶜ*. There are

apparently no shadow squares in the two lower quadrants; these are occupied by the long dedicatory inscription which has been cited above.

The alidade is a modern replacement; it is marked with divisions corresponding to the sexagesimal arrangement of the cosines in the upper left quadrant.

REWORKING

The major element of reworking is the geographical gazetteer engraved in Devanagari script on the inner side of the matter. Probably it was left blank by the astrolabe maker Maḥmūd. The gazetteer consists of the names and the latitudes of 12 cities.

Table E001-2 Geographical Gazetteer in Sanskrit

	Place Name	**φ**
1	Dillī	28;39
2	Āgarā	26;43
3	Mulatāṃ	29; 40
4	Kābula	33;45
5	Ajamera	26;--
6	Ahamedābāda	23;--
7	Bījāpūra	16;20
8	Bhāganagara	19;20
9	Siraumja	24;10
10	Buhrānapura	20;40
11	Ujjenaḥ	22;20
12	Lāhora	31; 50

Here Delhi and Lahore have the traditional values of latitudes. Bhāganagara at latitude 19;20° is problematic. One possibility is that it refers to an old name of Hyderabad. Legend has it that Muḥammad Qulī Quṭb Shāh, the founder of Hyderabad, named it first Bhāgyanagar or Bhāgnagar after Bhāgmatiī, a local *nautch* girl, of whom

he was enamoured. But the name Bhāgnagar not known in north India, nor does the latitude 19;20 match with Hyderabad’s latitude of 17;20°. More probable is Ahmednagar which was founded by Aḥmad Nizām Shāh in 1494 at the site of a village called Bhingar.[982] If it is admitted that Bhāgnagar on the astrolabe is a corruption of Bhingar, the latitude values match.

Besides this gazetteer, the only other addition are Devanagari numerals engraved on each face of the two plates to identify the latitudes for which the plates were made.

The astrolabe, produced originally in Egypt in 1271, must have reached India in course of time and a Hindu astronomer must have got it reworked with Sanskrit engravings most likely in Rajasthan, in the eighteenth or the nineteenth century. It is certain that it contained the full complement of plates when it was reworked. From Rajasthan the astrolabe reached Benares. During this travel or later in Benares, two plates were lost with the result that when Professor Wilson acquired it around 1819 the astrolabe was incomplete with just two plates.

BIBLIOGRAPHY

Morley 1856, pp. 18, 32-34, Plate xix-fig. 12.
Gunther 1932, no. 67, pp. 186-187.

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982 Cf. Radhey Shyam, *The Kingdom of Ahmednagar,* Delhi 1966, p. 38.

E002 KUFIC ASTROLABE BY ᶜALĪ IBN IBRAHĪM, 724 AH (AD 1324) [983]

Diameter 130 mm

Geneva, Musée d'histoire des sciences (# 1051)



Figure E002.1 – Front of the astrolabe (courtesy Musée d'histoire des sciences, Geneva)

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983 Entry based on Archinard 1983.

This astrolabe carries an inscription on the back which reads: 'made by ᶜAlī ibn Ibrahīm, Muezzin at Taza, may God protect him, the twelfth day of the month Rajab (?), year 724.' Thus it was made in Taza in Morocco on ca. Thursday, 5 July 1324.[984]

In 1983 Margarida Achinard made it the subject of a full length monograph, where she discussed first the principles of the astrolabe and its use in astronomy and geodesy and then, against this background, described the present astrolabe. [985]

What survives of this astrolabe is just the mater with a low *kursī* and a shackle. The other parts were either lost on the way from Morocco and India, or it was brought to India with all the components intact, was used here for some centuries, during the course of which the loose components got degenerated or lost, and there remained only the mater. Since the manufacture of the mater is more difficult than the production of other parts, the Hindu astrologer who found it in the seventeenth or eighteenth century, decided to make it the basis for a Sanskrit astrolabe and added freshly made rete, plates, alidade, pin and wedge. He was lucky to find a skilled brass-worker who manufactured these parts well.

Components

Mater with *kursī* (d. 130) and shackle is original. Additions in Sanskrit are the rete for 21 stars, 3 plates, alidade, pin and wedge.

Mater

The shackle is plain. The *kursī* is very low. The limb is divided in 1° and 5°. On the inner side of the mater is engraved the projection for the latitude 66° degrees, i.e. the plate for the ecliptic coordinates. Here the ecliptic circle is drawn, but not divided into 12 zodiac signs. Above the ecliptic circle, which is the local horizon at this latitude, are drawn equal altitude circles at intervals of 6°; these are numbered along the upper half of the meridian line. Arcs of longitude, which radiate from the zenith, are drawn at intervals of 10°; these are numbered along the ecliptic circle. Astrological houses are

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984 A universal astrolabe made by this ᶜAlī ibn Ibrahīm in 728 / 1327-28 is with the Museum of the History of Science, Oxford; CCA 3579.

985 Archinard 1983.

marked and numbered in the lower half. In the space between the ecliptic circle and the equator is engraved *ʿarḍ 66*.



Figure E002.2 – Inner side of the mater with projection for latitude 66°
(courtesy Musée d'histoire des sciences, Geneva)

BACK

The rim is graduated in 1° and 5° and numbered from 5 to 90, separately in each quadrant. Inside the degree scale there are four concentric rings which display the zodiac calendar. The second ring carries the names of the 12 zodiac signs; in the first ring each sign is divided into 30 degrees. The fourth ring is engraved with the Arabic names of the months in a year, while the days in each month are marked in the third ring. With the help of this calendar, the sun's position on the ecliptic on any day of the year can be determined.

Immediately below these rings, the maker's signature is engraved in the two upper quadrants.

Two lower quadrants carry shadow squares. Surprisingly both sides are designed for the 12-digit gnomon; all the four scales are divided first into four parts and numbered; each part is then subdivided into 3 units.



Figure E002.3 – Back of the astrolabe (courtesy Musée d'histoire des sciences, Geneva)

SANSKRIT COMPONENTS

RETE

The newly added rete in Sanskrit is well crafted and displays the so called ‘bird in the cage’ pattern.[986] The three almost complete rings of Capricorn, equator and ecliptic, and also the small central ring, are held together by the equinoctial bar which has no counter change. The ecliptic ring is divided into the 12 signs and labelled in Sanskrit: *Meṣa, Vṛṣa, Mithu[na], Karka, Sisa [sic! Siṃha], Kanyā, Tulā, Vṛści[ka], Dhana [sic! Dhanuḥ], Makara, Kumbha* and *Mīna.* Each sign is subdivided into 5 parts of 6° each, and labelled in Devanagari numerals as 6, 12, 18, 24, 30. There are 21 named star pointers, 8 outside the ecliptic and 12 inside.



Figure E002.4 – Rete in Sanskrit (courtesy Musée d'histoire des sciences, Geneva)

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986 C. Introduction 3.3.1.

Table E002-1 Stars on the Rete

	Star Name as engraved	Full/Correct Form	Identification
1	*Samudra*	*Samudrapakṣī*	β Ceti
2	*Manma*	*Matsyodara*	β Andromedae
3	*Prerata*	*Pretaśira*	β Persei
4	*Kra*	*Kṛttikā*	η Tauri
5	*Rohiṇī*		α Tauri
6	*Vrasa*	*Brahma-hṛdaya*	α Aurigae
7	*Ādrā*	*Ārdrā*	α Orionis
8	*Labdhaka*	*Lubdhaka*	α Canis Majoris
9	*Luba*	*Lubdhaka-bandhu*	α Canis Minoris
10	*Mahāpu*	*Mahāpuruṣa*	α Hydra
11	*Puph*	*Pūrva-phālgunī*	δ Leonis
12	*Hasta*		δ Corvi
13	*Catra*	*Citrā*	α Virginis
14	*Marci*	*Marīci*	η Ursae Majoris
15	*Svāti*		α Bootis
16	*Sarapadha*	*Sarpadhārīśira*	α Ophiuchi
17	*Abha*	*Abhijit*	α Lyrae
18	*Śravaṇa*		α Aquila
19	*Aśvamukha*		ε Pegasi
20	*Pubha*	*Pūrva-bhādrapada*	β Pegasi
21	*Śatabhi*	*Śatabhiṣā*	λ Aquarii

Archinard measured the right ascension and declination of the stars and concluded that the star map was produced around 1863.

PLATES

They are three plates with the following specifications:

Table E002-2 Plates in the Astrolabe

	φ	Equinoctial Shadow as engraved	Equinoctial Shadow as computed[987]
1a	24°	5;21	5;21
1b	26°	6;0	5;51
2a	28°	6;20	6;23
2b	30°	6;59	6;56
3a	36°	8;49	8;43
3b	Plate of Horizons		

On the plates 1a-3a, altitude circles are traced for every 6° and numbered in Devanagari numerals on both sides of the meridian; on the plate for 28° the altitude circles are drawn for every 3°, but numbered in 6s as on other plates. Azimuth arcs are traced below the horizon at every 15°, but not numbered. Likewise, the lines of seasonal hours are not numbered. In the middle of the plate, just below the oblique horizon, are engraved the latitude (*akṣāṃśa*) for which the plate is designed and the length of the midday equinoctial shadow (*chāyā*) at this latitude.[988]

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987 Added by Archinard 1983, p. 27.

988 Here the orthography is not consistent; on plate 1a for 24° *akṣāṃśa* is abbreviated to *akṣāṃ*; on plate 3a for 36° the first letter *a* is represented by *S*-like glyph which is commonly used for *avagraha.*

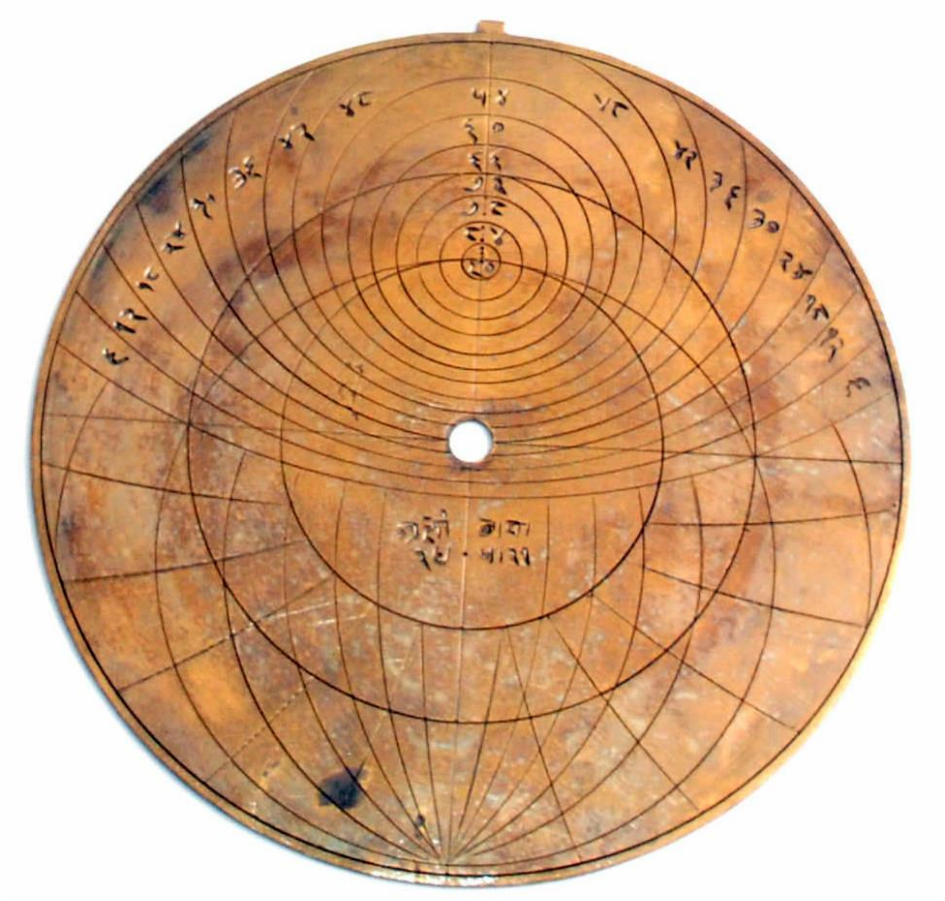


Figure E002.5 – Plate 1a for latitude 24°(courtesy Musée d'histoire des sciences, Geneva)

Plate of Horizons

The horizon plate carries the label, *sarvadeśī patraṃ,* meaning the ‘plate for all latitudes’ or the ‘universal plate’. In each quadrant, half-horizons for 7 different latitudes are drawn and labelled near the circumference where each half-horizon begins and near the diameter where it ends. But the half-horizon for the latitude of 84˚ is missing and that for the latitude of 61˚ is correctly labelled near the diameter but wrongly as 65 near the circumference. The latitudes represented by these half-horizons are as follows:

10	22	34	46	58	70	82
11	23	35	47	59	71	83
12	24	36	48	60	72	84
13	25	37	49	61	73	85

There are no declination scales.

ALIDADE

The alidade is fitted with a sighting tube, at one end of which there are spiral grooves. The wedge is shaped like a horse's head.

BIBLIOGRAPHY

Archinard 1983.

E003 ASTROLABE MADE BY WAFĀ’ BIN MUNAJJIM, 1017 AH (AD 1608-09)

Diameter 123 mm

Qatar, Doha, Museum of Islamic Art (# MW.381.2007), ex-Linton 179



Figure E003.1 – Front of the astrolabe (from Linton 1980)

This astrolabe was formerly in the private collection of Leonard Linton. He bought it with five plates in Iran in 1960; '10 years later, a single astrolabe-plate, also bought in Iran, in a lot of miscellaneous astrolabe-plates, was found to belong to this astrolabe.' Linton sold off his collection in an auction at Paris on 9-10 October 1980.[989]

The astrolabe was displayed in July 1989, as part of the exhibition 'Saudi Arabia, Yesterday and Today' in Washington D.C., by the High Commission for the Development of Arriyadh and published in the catalogue issued on that occasion.[990] It is not known where the astrolabe is now, whether in some museum in Saudi Arabia, or elsewhere.

The astrolabe was originally engraved in Kufic script; Sanskrit additions were made later in India. The inscription on the back along rim of the lower left-hand quadrant states that the astrolabe was made by Wafā' bin Munajjim in the year 1017 AH (=AD 1608-09).

COMPONENTS

Mater with *kursī* (d. 123) shackle and ring, rete for 29 stars, 5+1 plates, alidade, pin and wedge

FRONT

The ring and shackle are plain. The *kursī* is elegantly reticulated. The limb is divided in 1° and 5°. Originally it must have been numbered in Kufic as in the altitude scales on the back. In India, the outer rim was ground to remove the Kufic numerals and in their place Devanagari numerals from 1 to 60 were engraved very neatly.

RETE

The rete closely imitates the rete of the astrolabe made by al-Khujandī in 984-85. As in Khujandī's astrolabe, the rete here contains the two rings of Capricorn and ecliptic which are held together by the east-west equinoctial bar without any counter change. The equator ring is represented as a small segment in the lower half. There are 29 named star pointers. In al-Khujandī's rete, four star pointers are shaped like heads of birds with

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989 Linton 1980, no. 179, pp. 121-123.

990 Anon 1989.

long beaks, the tips of the beaks constituting the star positions. In the present rete, in addition to these four pointers, several others are also shaped like the curved beaks of birds

Surprisingly no Sanskrit additions are made on the rete to identify any of the 29 stars marked there in Kufic

PLATES

There are 6 plates to serve the following latitudes.

1. 15° and 18°
2. 21° and 24°
3. 27°and 30°
4. 33°and 36° (recovered separately in Iran; it is now split in two)
5. 39°and 42°
6. 0°+ 90°; and tablet of horizons (engraved completely in Devanagari)



Figure E003.2 – Detail of Figure E003.1, showing the Sanskrit additions

In the photo of the front, through the interstices of the rete, one can see parts of a plate, apparently calibrated for the latitude of 24°. Here altitude circles are drawn for

every 6° and numbered in Kufic on both sides of the meridian. There are no azimuth arcs. In the lower half are traced plain lines for seasonal hours and dotted lines for equal hours drawn from the western horizon. Both these sets are numbered in Kufic script. All these Kufic numbers are duplicated with Devanagari numerals. One can also see that the expression *sā*^{c}*āt* (= hours, i.e. hours of the longest day) was merely transliterated as *sayata* and not translated.

It appears that all other latitude plates were designed in the same manner and reworked with additional Devanagari numerals.

Geographical Gazetteer

According to Linton 1980, the inner surface of the mater is engraved with a gazetteer of the latitudes and longitudes of 60 places in India. It is not known whether the surface was originally blank on which the Sanskrit gazetteer was engraved or whether there were engravings which were removed and in their place the Sanskrit gazetteer. Whatever may be the case, Sanskrit gazetteers generally contain only latitudes, those with both latitudes and longitudes being rare. Therefore, a photo of the gazetteer would be of great interest.

Back

On the back, the rim of the upper half carries altitude scales, divided in 1° and 5° and numbered in *Abjad* in Kufic from each end of the horizontal diameter up to the south point thus: 5, 10, 5, 20 … 80, 5, 90. The rim of the lower right quadrant carries a cotangent scale, numbered as 5, 10, 5, 20 … 50, 5, 60. The rim of the left quadrant is engraved with the name of the maker and the date, as mentioned already. In the upper left quadrant are traced 90 horizontal parallels.

In the lower half are drawn 8 semi-circular rows, below the cotangent scales.

Rows 1 and 2 are engraved with the names of the 28 lunar mansions and those of the 12 signs. Rows 3 and 4 carry the table of limits and the next two rows the table of decans and their regents. The last two rows have some unidentified material; below these semi-circular rows, there are labels in each quadrant; It is not known what they contain.

Devanagari numerals are not added either to the latitude scales, or to the cotangent scales and or the astrological tables. The only addition on the back is the half shadow

square in the upper right quadrant. It is not known whether there were any other lines originally which were removed and in their place the shadow square is engraved or whether the upper right was originally blank. The Devanagari numerals are of the same style as on rest of the astrolabe.

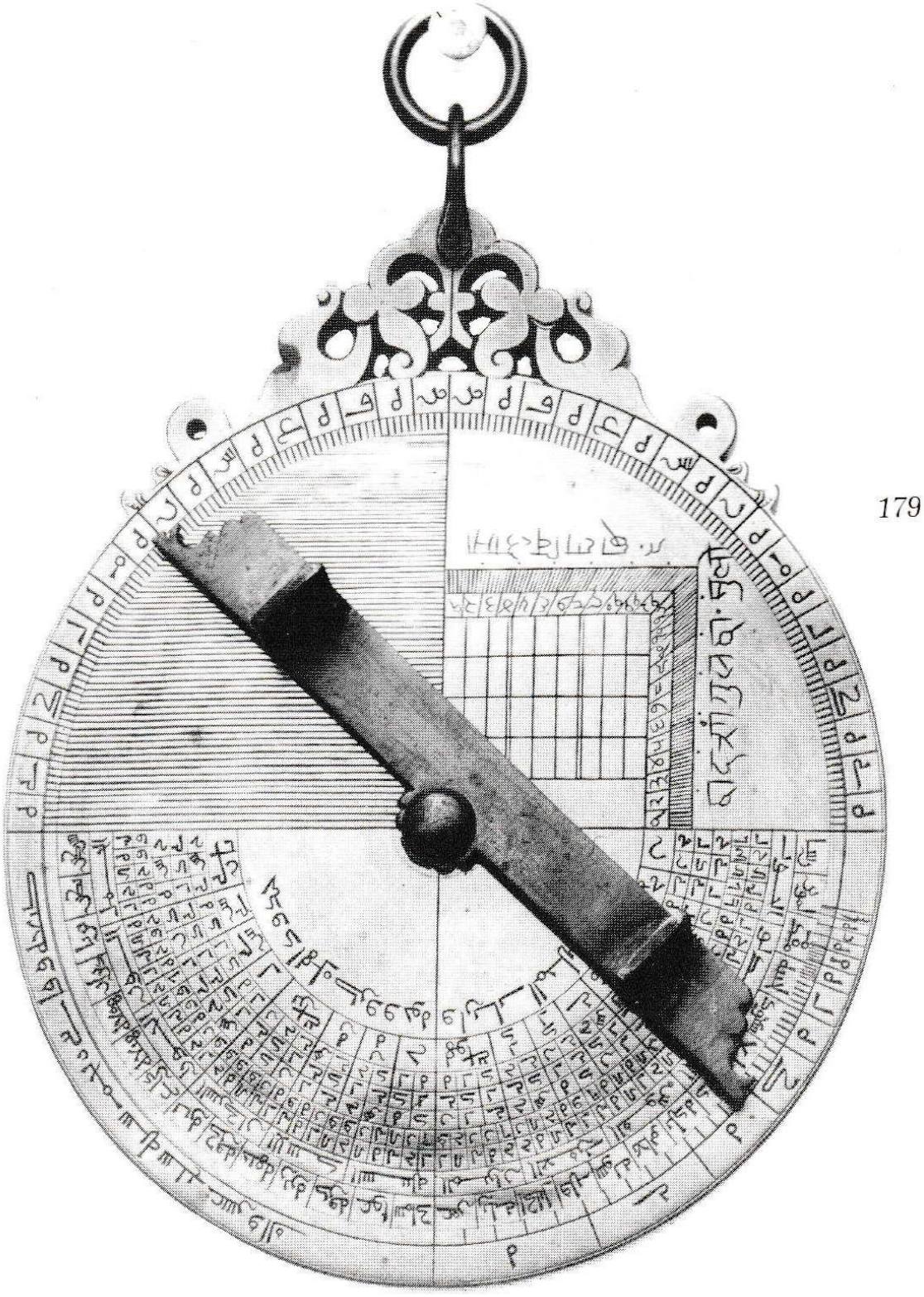


Figure E003.3 – Back of the astrolabe (from Linton 1980)

The shadow square shows the vertical and horizontal scales of the 12-digit gnomon. The scales are divided in 12 parts and numbered in Devanagari numerals from 1 to 12. Each part is further subdivided in 5 parts. The vertical scale is accompanied by the label *dvādaśāṃgula-chā[yā] sulo[mā],* 'shadow of [the gnomon of] 12 digits, straight.' The horizontal scale is given the label *chāyā vilomā,* 'shadow reverse'.[991] Inside the shadow squares there is a grid of 9 x 4 cells which are not filled in.

INSCRIPTION

On the edge of the astrolabe is an inscription in Sanskrit in Devanagari script which is reproduced in the catalogue. The calligraphy here is very poor, not at all comparable to the other Devanagari engravings. In fact, it is not engraved in flowing lines but rather etched in strokes. It is obvious that it was not engraved by the same artisan at the time of reworking of the astrolabe, but was added some time later, by a subsequent owner.

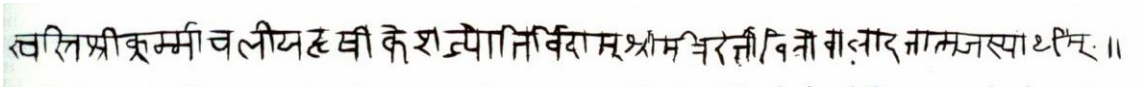


Figure E003.4 – Inscription engraved on the edge (from Linton 1980)

The inscription reads as follows:

> *svasti sri-kurmmācaliya-hṛsikeśa-jyotirvidām śrī-mantrarajo (sic! read yantrarājo)-vinovālādajātmajasyārtham*
>
> 'Let it be auspicious. Of the astrologer Hṛṣīkeśa from Kūrmācala the glorious astrolabe (i.e. this glorious astrolabe belongs to Hṛṣīkeśa of Kūrmācala). For the sake of Vinovālādatta's son.' [992]

The name Vinovālā-datta is badly transcribed and makes no sense as a personal name. Leaving this aside, the two sentences seem to contradict each other. The first sentence states that the astrolabe belongs to Hṛṣīkeśa. The second sentence implies that it was [made/ reworked/acquired] 'for the sake of' the son of Vinovālā-datta. If the astrolabe (in the reworked form) belonged to Hṛṣīkeṣśa and was acquired from him for

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991 Here the term *sulomā* is incorrect; it ought to be *samā.*

992 The person whom Alain Brieux consulted in Paris has a very rudimentary Sanskit and he translated it as follows:
'Hail to Hṛṣīkeśa of Kūrmmācala the astronomer, the good śrīmantarajī; [this instrument has been done] at the expense of the son of Vināvālādatta'.

the sake of Vinovālādaja's son, the syntax does not fit. Or, if the astrolabe was reworked with the additions in Sanskit for the sake of Vinovālādatta's son, and then it was acquired from him by Hṛṣīkeśa, even then the syntax is not correct.

REWORKING

Alain Brieux, who apparently drafted the description of the astrolabe for the Linton catalogue, states:

> 'No maker named Wafa' has been previously recorded, and if he was indeed working in 1608/9, it is far from clear how he came to make so closely resembling (at least as regards the highly individual rete design) an astrolabe made in A.D. 984/5 by the famous astronomer Ḥâmid b. al-Khaḍir al-Khujandî, …; by the seventeenth century, this design of astrolabe, as like the use of, in eastern Islam, Kufic script for scientific instruments, was no longer in use

Moreover, the Kufic inscriptions themselves

> 'appear to have been copied by someone not entirely at ease in Arabic or, perhaps, that form of Arabic script.'

Obviously perplexed by this astrolabe which is partly engraved in 'faulty' Kufic script and partly in Devanagari, Brieux offers various hypotheses, such as this one:

> 'A possible hypothesis, to reconcile these tiresome details would suggest than (sic! that) an Indian made a copy (poor as regards lettering, but the scales and lines are well done) of either manuscript illustrations of an Arabic astrolabe, or of such an astrolabe itself, through the inability to comprehend thoroughly the Arabic, and finally decided to finish in *nâgarî* script.'

Had the case been so, one wonders for whom such a mixed astrolabe was produced. The specimens described in this section clearly establish that in India Arabic astrolabes were occasionally reworked with Sanskrit additions just as they were reworked with Latin or Hebrew additions in Spain

Therefore, the only possible scenario is as follows. An astrolabe was made in 1608-09 somewhere in the Middle East by a man well trained in making astrolabes. The workmanship is of the highest order and the projections of the various circles appear to have been done quite accurately. Why he made the engravings in Kufic in the seventeenth century and why there are imperfections in his script I cannot say.

Thereafter the astrolabe reached India; either directly or through different stages. Either during the journey or in India itself, the plate calibrated for 33° & 36° got lost, perhaps also the alidade, pin and the wedge. In India, a Hindu astronomer acquired the astrolabe in this incomplete state. He was familiar with the theory of astrolabe but not with the Kufic script. He took the help of a Muslim astronomer who explained to him the meaning of the Kufic inscriptions. The Hindu astronomer rendered these into Sanskrit and got them engraved on the astrolabe in Devanagari script by a competent metal worker. The metal worker

(1) ground off and removed completely the Kufic numerals in the degree scale on the limb and engraved Devanagari numerals in their space,

(2) ground off and removed whatever there was in the upper right quadrant on the back and engraved there half a shadow square for a gnomon of 12 digits and the corresponding numerals in the scales and the labels for these scales,

(3) engraved a gazetteer of 60 cities with their longitudes and latitudes on the inner face of the mater (which was either blank originally; or if it contained some engraving, it was removed),

(4) since one plate was missing,[993] he filled the gap with a new plate with the projections for 0°+ 90° on one side and a tablet of horizons on the other side, and

(5) on the rest of the plates he added Sanskrit numerals or labels next to the Kufic numerals and labels very systematically.

However, he made no additions at all on the rete and on the three quadrants on the back. Sometime after these additions were made, most likely in Rajasthan, Hṛṣīkeśa of Kumaun acquired it.

It is amazing how many journeys this astrolabe must have made: from the Middle East to India, losing plate 4 on the way; engraved with Sanskrit additions somewhere in Rajasthan; acquired by the astrologer Hṛṣīkeśa of Kumaun; again westward journey to Iran; acquired there by Leonard Linton and taken to the US; reunited with the long-lost

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[993] He did now throw away the plate for 33° and 36° because it was ‘of little use to the Indian astrolabist’ as Brieux assumed; then the Indian astrolabist would have still less use for the plate of 39° and 42° and thrown it away too, but he did not and reworked it with Sanskrit additions.

plate 4; auction at Paris in 1980; probably acquired by the present owner; exhibited in Washington DC in 1989; and then back to the present owner!

BIBLIOGRAPHY

Linton 1980, no. 179, pp. 121-123.

Anon 1989, p. 10.

E004 ASTROLABE ATTRIBUTABLE TO ḌIYĀ' AL-DĪN MHUAMMAD

Date not available, 17th century

Diameter ?

PLU; photos in the archives of the Museum of the History of Science, Oxford

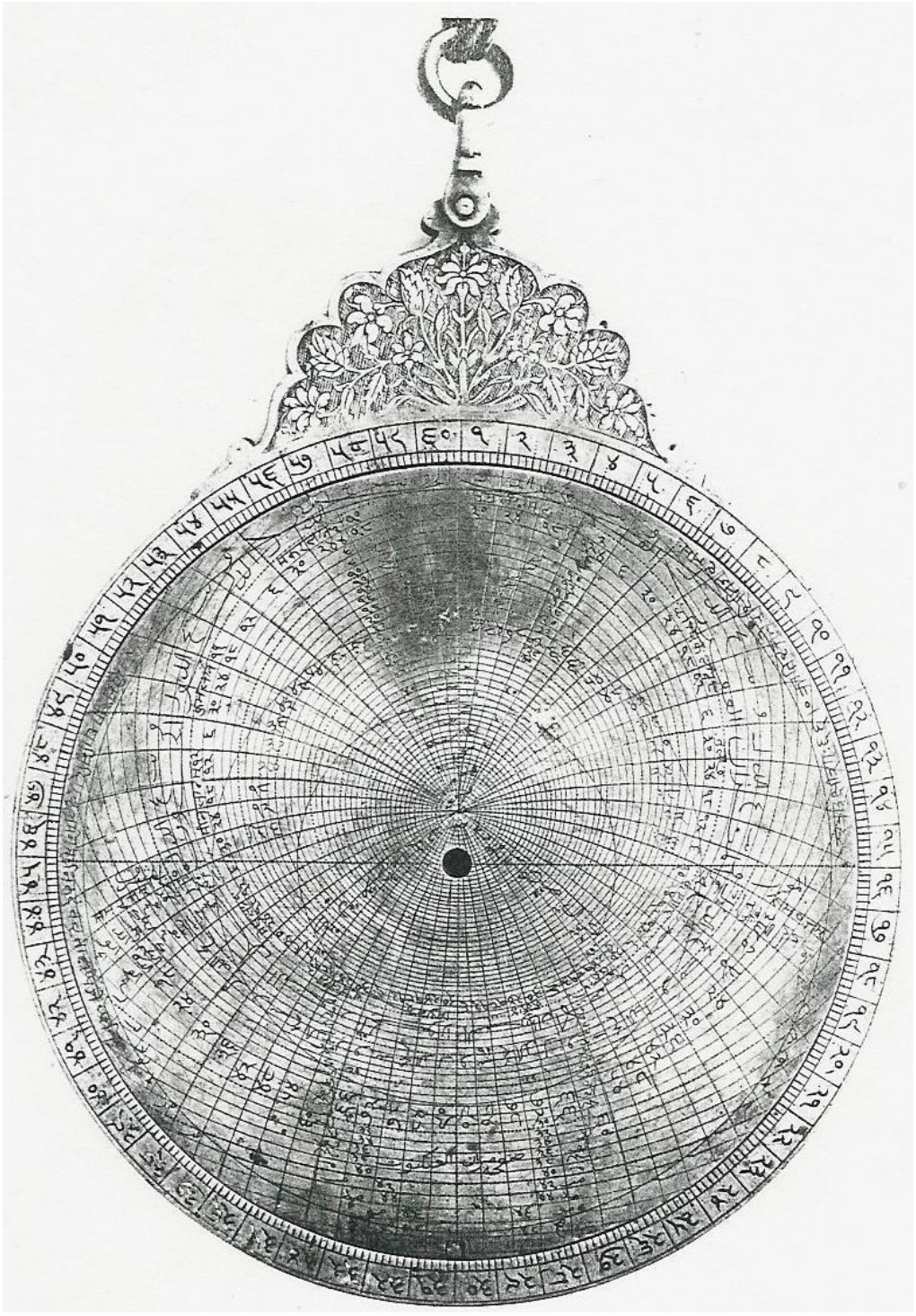


Figure E004.1 (= Figure A094.1) – Front of the astrolabe
(courtesy Museum of the History of Science, Oxford)

This Indo-Persian astrolabe has already been described under A094, where it was argued that it must have been made by Ḍiyā' al-Dīn Muḥammad sometime after 1648. Here its reworking in Sanskrit is discussed.

FRONT

As in the previous astrolabe (E003), here also the outer band of the degree scale on the limb was ground to remove the *Abjad* numbers for groups of 5°, and in their place Devanagari numerals were engraved from 1 to 60. The numerals here are exactly of the same style as in the previous astrolabe. Therefore, it is likely that the same person reworked both these astrolabes.

PLATE OF THE ECLIPTIC COORDINATES

In the plate of ecliptic coordinates, an attempt was made to duplicate each *Abjad* numeral and each Arabic label with the corresponding Sanskrit versions in Devanagari script. Besides, some explanatory remarks also were engraved.

Along the ecliptic circle, Sanskrit names of the zodiac signs were inscribed below the original Arabic names, sometimes with the suffix *°lagna* (ascendant), but always with a serial number: *Meṣa-lagna 1, Vṛṣa-lagna 2, Mithuna 3, Karka 4, Siṃha 5, Kanyā 6, Tulā 7, Vṛścika-lagna 8, Dhanur-lagna 9, Makara-lagna 10, Kuṃbha-lagna 11, Mīna-lagna 12.*

Below these names, the subdivisions of the signs, as divided by the arcs of longitudes drawn for every 6°, are numbered in as 6, 12, 18, 24, 30, separately for each sign. These numbers are duplicated in Devanagari. Longitude arcs are numbered once again in Devanagari from 6 to 90 four times, each time starting from the prime vertical in the east or west and reaching up to upper half of the meridian or the lower half. The prime vertical is labelled *sama-kṣetra* in the east as well as in the west.

Latitude circles are drawn for every 2° above and below the ecliptic circle, with every fifth highlighted with dots. These are numbered in *Abjad* once in each of the four quadrants. Devanagari numerals are added next to these *Abjad* numbers.

On the edge of the upper right quadrant is engraved: *asmin patre (?)'kṣāṃśāḥ 66 /0. krānti-vṛttam eva kṣitija-vṛttam* (The latitude on this plate is 66;0 degrees. [Here] the ecliptic circle itself is the circle of horizon). There is another inscription on the edge on the left hand side; but much of this cannot be deciphered: … *vṛttāni kadamaba-vṛttād*

eva jñeyāni (?) (… circles should be known only from the circle of the pole of the ecliptic). However, the name of the plate *ṣafīhat mīzān al-ᶜankabūt* was not rendered into Sanskrit.

BACK

On the back the original altitude scales in the upper half and the cotangent scales in the lower half were not rubbed off as in the front, but Devanagari numerals were added above the *Abjad* numerals.

No additions were made to the sine quadrant in the upper left; but to the right of the quadrant, just above the central hole, is inscribed: *turīyam idam* (this is [a sine] quadrant).

In the upper right is the solar quadrant with the names of the corresponding zodiac signs engraved along the two radii. Above or to the right of the Arabic sign names are inscribed their subdivisions from 5 to 30 of each sign. These are duplicated in Devanagari, in tiresome thoroughness.

In the case of the three graphs of solar altitudes at noon, their respective labels were not added in Sanskrit translation; instead a collective designation was given for the three with the words *ākāśagaṃgeyam,* 'This is the celestial Ganga'. *Ākāśa-gaṅgā* is generally understood as the 'milky way'; is it employed here in the sense of the line of the midday altitude of the sun?[994]

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994 In Sanskrit astrolabes, these lines are engraved only on C008 and C009; in both cases for the latitude of Surat at 22° with the label *madhya-rekhā* in the sense of *madhyāhna-rekhā* (line of midday).

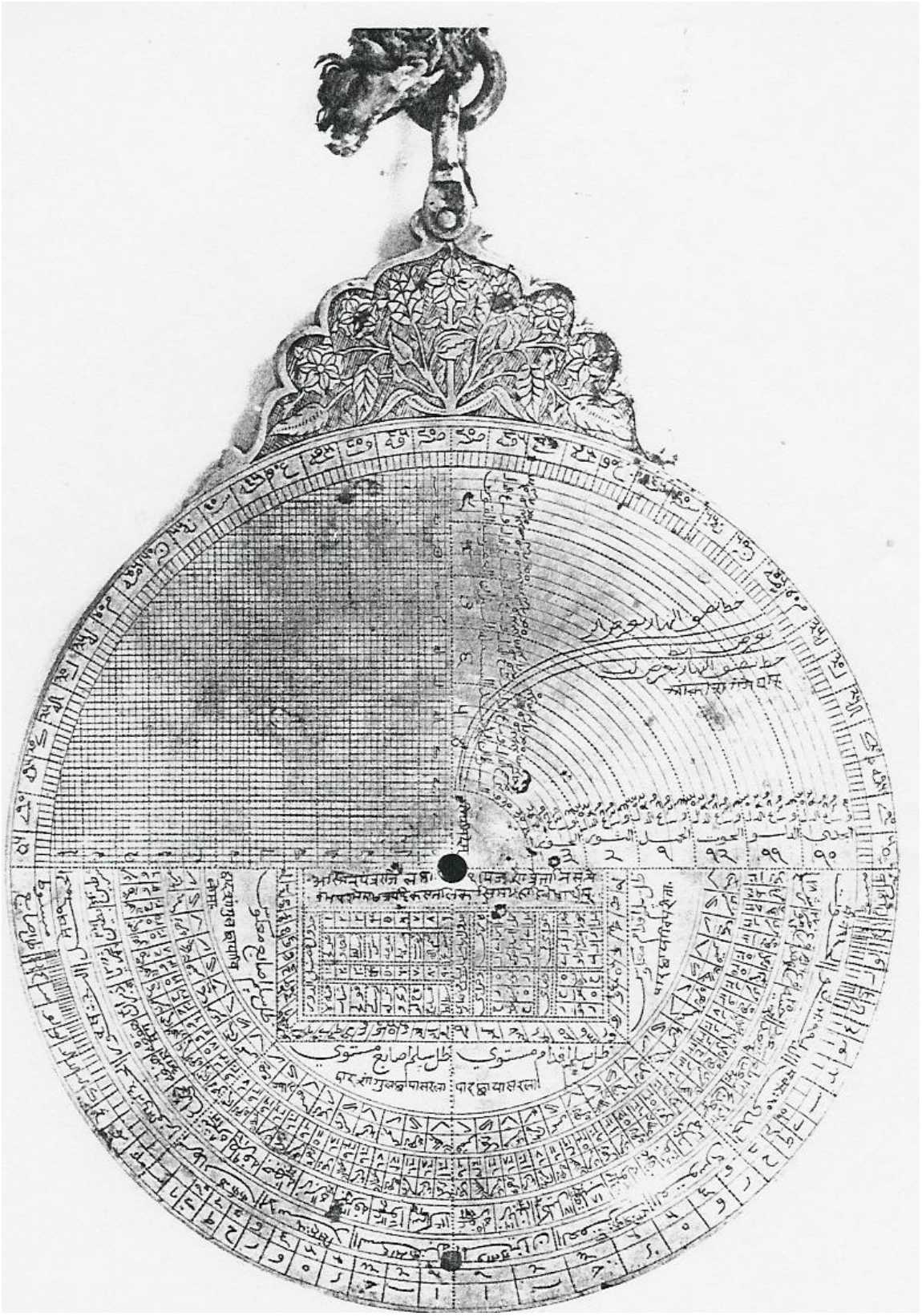


Figure E004.2 (= Figure A094.2) – Back of the astrolabe
(courtesy Museum of the History of Science, Oxford)

Below the horizontal diameter are drawn shadow squares, on the left for a gnomon of twelve digits and on the right for gnomon of 7 feet. To the horizontal and vertical

scales on the left are added the labels and *dvādaśāṃgula-chāyā saralā* (shadow of twelve digits, straight) and *dvādaśāṃgula-chāyā vilomā* (shadow of twelve digits, reverse) respectively. The horizontal and vertical scales on the right receive the Sanskrit labels *pādachāyā saralā* (shadow of [seven] feet, straight) and *pādachāyā viparītā* (shadow of [seven] feet, reverse).

As stated in the Introduction to section C, Sanskrit astrolabes do not maintain the distinction between the shadows cast by a gnomon of 12 digits (*ẓill aṣābiʿ*) and those of a gnomon of 7 feet (*ẓill aqdām*), and do not render direct shadow correctly into Sanskrit. This is one of the two rare instances where all the four scales are correctly labelled in Sanskrit.

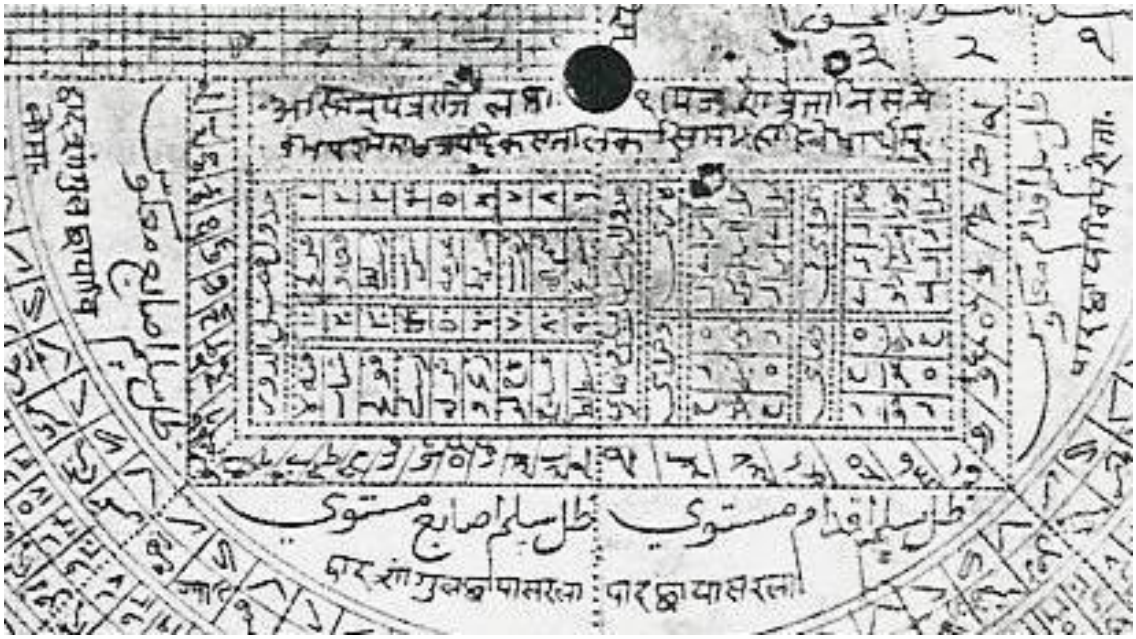


Figure E004.3 – Shadow Squares (detail of Figure E004.2)

The shadow squares are enclosed by nine semi-circular rows. The first two rows, as counted from the outside, carry cotangent scales and their subdivisions. Here the *Abjad* numbers are duplicated in Devanagari

Row 3 is engraved with the Arabic names of the 12 zodiac signs; above these Arabic names are added the Sanskrit names and the serial numbers. In the ninth cell, there was no space above the Arabic name *al-Qaws;* therefore, just the serial number 9 is inscribed in Devanagari. In Row 4 are the Arabic names of the 28 lunar mansions. As there is no adequate space here for additions, the initial syllables of the Sanskrit names are incised in some cells

Rows 5-7 contain the table of the limits and the rows 8-9 the decans and their regents. No additions were here made for want of space.

The Lahore astrolabe makers generally engrave their names, together with those of the ancestors, and the year of manufacture, on the back just below the horizontal diameter. Unfortunately, this important inscription was rubbed off and in its place was engraved two lines of Devanagari which are difficult to read in parts:

> *asmin yantrarāje saptākṣapatrāni protāni saṃty e-*
> *kaṃ bhapa[t]ram ema ? trayam dvika satalika sima grahānāṃ vedhārtham*
> This would roughly mean: 'In this astrolabe (*yantrarāja*), seven latitude plates (*akṣa-patra*) are strung [together], one rete (*bha-patra*), triad … pair … for observing the planet.'

Thus the astrolabe appears to have been originally equipped with 7 latitude plates and one rete and these were extant at the time of reworking. It is not known whether all the plates were available when the astrolabe was photographed for Kaye ca. 1918.

E005 ⊙ ASTROLABE ATTRIBUTABLE TO ḌIYĀ’ AL-DĪN MUḤAMMAD

Between 1648 and 1658

Diameter 526 mm

London, Nasser D. Khalili Collection of Islamic Art (#SCI 53)



Figure E005.1 (= Figure A093.1) – Front of the astrolabe
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 53
Photo courtesy of the Khalili Family Trust © Nour Foundation

Like the previous astrolabe, this very large Indo-Persian astrolabe was also thoroughly reworked in Sanskrit, effacing in this process the inscription at the back which contains the name of the astrolabe maker and the date of manufacture. Even so, it is possible to establish that this astrolabe was produced sometime between 1648 and 1658 by Ḍiyā’ al-Dīn Muḥammad of Lahore for the Mughal emperor Shāh Jahān. Within half a half a century of its production, it was acquired by a certain Nayanānanda of Delhi, who caused every Arabic word and every *Abjad* numeral on this huge astrolabe to be duplicated in Sanskrit in 1701.

The full description of the original astrolabe as produced by Ḍiyā’ al-Dīn has already been given at A093.[995] Here will be discussed the additions made in Sanskrit at the behest of Nayanānanda. It looks as if he sat next to the brass worker and made him engrave each word. The brass-worker sometimes wrote Sanskrit words from right to left in Arabic fashion; his orthography is rather poor. The Sanskrit used here has a heavy mixture of the local Hindi.

Limb

In the outer band on the limb, the degree scale is numbered clockwise in 3s from 3 to 360. Devanagari numerals are added wherever space was available, sometimes to the left of the abjad numerals, sometimes to the right and sometimes above, also in 3s, but from 3 to 90, separately in each quadrant.

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995 The original engravings and the Sanskrit additions are treated together in Sarma 2017.



Figure E005.2 – Additions in Sanskrit on the limb, on the rim of the ecliptic ring and on star pointers (detail of Figure E005.1)

RETE

On the ecliptic ring, the Arabic names of the zodiac signs and below them the names of the 28 lunar mansion are written in low relief. Next to the Arabic names of the signs, Sanskrit names are incised, but unusually with the syllables reversed so that these can be read from right to the left along with the Arabic names: *ṣa-me* instead of *Meṣa* (Aries), *ṣa-vṛ* instead of *Vṛṣa* (Taurus); *na-thu-mī* (sic!) for *Mithuna* (Gemini); *ka-ka* (sic!) for *Karka* (Cancer); *ha-sīṃ* (sic!) for *Siṃha* (Leo); *nyā-ka* for *Kanyā* (Virgo); *la-tu* (sic!) for *Tulā* (Libra); *ka-ści-vṛ* for *Vṛścika* (Scorpio); *na-dha* (sic!) for *Dhanuḥ* (Sagittarius); *ra-ka-ma* for *Makara* (Capricorn); *ma-ku* (sic!) for *Kumbha* (Aquarius); and *na-mī* for *Mīna* (Pisces).

The Sanskrit names of the signs are incised once more on the leaves adjacent to the zodiac signs, but this time in the correct sequence from left to right. Owing to the constraints of space, some of the names are written partially: thus *ṣa* for *Meṣa*, *vṛ* for *Vṛṣa*, *rka* for *Karka*, and *ka* for *Kanyā.* Other names are written in full. Sanskrit names of the lunar mansions are not added, there being little space to do so.

Stars on the Rete

The pointed tips of the leaves and other projections on them constitute 53 star pointers. The Arabic star names are inlaid with silver on the leaves of the tracery. Next

to the Arabic names are engraved the Sanskrit names. Some of these are traditional and some are literal translations of the Arabic. The Sanskrit translator, of course, knew the Sanskrit names of certain stars already, but in some cases he appears to have rendered the Arabic names literally. Moreover, sometimes he employs *uttara* (north) for 'left' instead of the correct term *vāma*.[996] Six names are illegible; in three cases, there are no Sanskrit names.



Figure E005.3 – Stars on the rete; Arabic names are inlaid with silver and Sanskrit names incised next to them (photo by S. R. Sarma)

The stars are listed in the following table in the order of the increasing right ascension. Each entry contains (i) the serial number, (ii) the Arabic name, (iii) its

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[996] The Sanskrit term for 'south' is *dakṣiṇa;* it also means 'right'. But its antonym *uttara* for 'north' does not denote 'left'; the correct term for 'left' is *vāma.*

meaning,[997] (iv) the Sanskrit name as engraved, (v) the correct Sanskrit form, (vi) its meaning, and (vii) the identification of the star.

Table E005-1 Stars Names in Arabic and Sanskrit

	Star Name in Arabic	Meaning	Star Name in Sanskrit as engraved	Correct form in Sanskrit	Meaning	Identification
1	*Dhanab al-Qayṭus [Janūbī]*	The [southern] tail of Cetus	*Samudra-pakṣī*		The sea bird	β Ceti
2	*Baṭn al-Ḥūt*	The belly of the fish	*Matsyamuṣa*	*Matsya-mukha*	The mouth of the fish	β Andromedae
3	*Fam al-Qayṭus*	The mouth of Cetus	*Samudrapacchī muṣa*	*Samudrapakṣi-mukha*	The mouth of the sea bird	γ Ceti
4	*Ṣadr al-Qayṭus*	The breast of Cetus	nil			π Ceti
5	*Kaff al-Jadhmā'*	The cut-off hand	*Samudra Pacchīī taṭala* (?)	*Samudrapakṣī* ---	The sea bird ---	α Ceti
6	*Rās al-Ghūl*	The head of the ghoul	*Pretaśirā*		The head of the ghost	β Persei
7	*Mirfaq al-Thurayyā*	The elbow of Thurayya	*ka ta gā*	illegible		α Persei
8	*Tālī Masāfat al-Nahr*	The length of the river	*Nadyaṃtaka*		Belonging to the end of the river	γ Eridani
9	*ᶜAyn al-Thawr*	The eye of the bull	*Rohiṇī*		The fourth lunar mansion	α Tauri
10	*ᶜAyyūq*	untranslat-able	nil	(*Brahma-hṛdaya*)[998]		α Aurigae

997 The meanings of the Arabic star names are based on Savage-Smith 1992a.

998 Other astrolabes have the name *Brahma-hṛdaya* for this star.

	Star Name in Arabic	Meaning	Star Name in Sanskrit as engraved	Correct form in Sanskrit	Meaning	Identification
11	*Rizl Jawjā' Yusrā*	The left foot of *al-Jawzā'*	*Mithuna Pāda Uttara*	*Mithuna Pāda Vāma*	The left foot of Gemini	β Orionis
12	*Yad al-Jawzā' Yusrā*	The left hand of *al-Jawzā'*	*Mithuna Hasta Uttara*	*Mithuna Hasta Vāma*	The left hand of Gemini	γ Orionis
13	*Yad al-Jawzā' Yumnā*	The right hand of *al-Jawzā'*	*Mithuna pā… Dachina*	*Mithuna Hasta Dakṣiṇa*	The right hand of Gemini	α Orionis
14	*Rijl Jawjā' [Yumnā]*	The [right] foot of *al-Jawzā'*	*Mithuna Pāda Dakṣiṇa*		The right foot of Gemini	κ Orionis
15	*Shiᶜrā Yamānī*	The southern *shᶜrā*	*Lubdhaka-vaṃsa,* 'the hunter's family'!	*Lubdhaka*	The hunter	α Canis Majoris
16	*Shiᶜrā Shāmī*	The northern *shᶜrā*	*Sārdhā-lubdhaka* 'one and a half hunter' !	*Llubdhaka-bandhu*	The kinsman/ brother of the hunter	α Canis Minoris
17	*Ṭarfat Safīnah*	The extremity of the ship	*Naukāmuṣa*	*Naukā-mukha*	The face/ beginning of the ship	ρ Puppis
18	*Nathra Saḥābī*	The 8th lunar mansion	*karka mi 3* (?)	*Puṣya*	The 8th lunar mansion	
19	*Fard [al-] Shujāᶜ*	The isolated one of the serpent	*Mahāpuruṣa mu* (?)	*Mahāpuruṣa*[999]	The great man	α Hydrae
20	*Rās al-Asad*	The head of the lion	*Siṃha-śī[r]ṣa*		The head of the lion	μ Leonis
21	*Qalb al-Asad*	The heart of the lion	*Maghā*		the 10th lunar mansion	α Leonis

[999] This designation is generally employed in Sanskrit astrolabes, but the reason eludes us.

	Star Name in Arabic	Meaning	Star Name in Sanskrit as engraved	Correct form in Sanskrit	Meaning	Identification
22	*Ẓahr Dubb Akbar*	The back of the Great Bear	*ṛḍhapada* (?)	*Ṛkṣa-pṛṣṭha* (?)		α Ursae Majoris
23	*Qāᶜidāt al-Bāṭiya*	The base of the bowl	*Jāmapakṣī* (?)		The *Jāma* (?) bird	α Crateris
24	*Ẓahr al-Asad*	The back of the lion	*dhāma maṣa*	illegible		δ Leonis
25	*al-Ṣarfa*	The change of weather	*u nāṃ phā*	illegible		β Leonis
26	*al-ᶜAnāq*	The goat	*a la dha prā*	illegible		ζ Ursae Majoris
27	*Janāḥ al-Ghurāb*	The [left] wing of the raven	*kākaskandha* 'raven's shoulder'	*Kākapakṣa vāma*	The left wing of the raven	γ Corvi
28	*Simāk al-Aᶜzal*	unarmed *simāk*	*Citrā*		The 14th lunar mansion	α Virginis
29	*Simāk Rāmiḥ*	Armed *simāk*	*Svāti*		The 15th lunar mansion	α Bootis
30	*Kiffa J[anūbī]*	The southern pan [of the balance]	*Tulā kā Palaḍā*[1000] *Dachan*	*Tulāyāḥ dakṣiṇa-śikyam*	The southern pan [of the balance]	α Librae
31	*Kiffa Shamālī*	The northern pan [of the balance]	*Tulā kā Palaḍā Uttar*	*tulāyāḥ uttara-śikyam*	The northern pan [of the balance]	β Librae
32	*Nayyīr Fakkah*	The luminous one of *al-Fakkah*	*viśākhā*	*Viśkhā-mātṛ-maṇḍala*	A group of mother goddesses associated with the	α Coronae Borealis

[1000] The pan of the balance is denoted by the rare Sanskrit term *śikya.* Nayanānanda avoids the Sanskrit term and renders this and the next expression into Hindi.

	Star Name in Arabic	Meaning	Star Name in Sanskrit as engraved	Correct form in Sanskrit	Meaning	Identification
					16th lunar mansion	
33	*ᶜUnuq al-Ḥayyah*	The neck of the serpent	*Sarpagrīvā*		The neck of the serpent	α Serpentis
34	*Qalb al-ᶜAqrab*	The heart of the scorpion	*Jyeṣṭhā*		The 18th lunar mansion	α Scorpii
35	*Rukbat al-Ḥawwā al-Yusrā*	The left knee of the serpent charmer	*Dhanaṣakoṭi Jādha Vāma*	*Dhanuṣkoṭi*[1001] *Jaṅghā Vāma*	The left shank of the Dhanuṣ-koṭi	ζ Ophiuchi
36	*Rās al-Jāthī*	The head of the kneeling one	*dhanu pa ra jhā*	illegible		α Herculis
37	*Rās al-Ḥawwā*	The head of the serpent charmer	*dhanuṣa koṭi*	*Dhanuṣkoṭi*	extremity of Sagittarius	α Ophiuchi
38	*ᶜAyn al-Tinnīn*	The eye of the dragon	nil			γ Draconis
39	*Yad al-Ḥawwā al-Yumnā al-Muqaddam*	The forward right hand of the snake charmer	*Dhanuṣakoṭi Hasta*	*Dhanuṣkoṭi Hasta*	The hand of the Dhanuṣ-koṭi	δ Ophiuchi
40	*Nasr Waqīᶜ*	The falling eagle	*Abhīji*	*Abhijit*	The 22nd lunar mansion	α Lyrae

[1001] In his Sanskrit manual on the astrolabe of 1370, Mahendra Sūri rendered the Arabic star name *Ra’s al-Ḥawwā* (head of the serpent charmer) as *dhanuṣkoṭi,* ‘extremity of the bow’ (*Dhanuḥ*), i.e., ‘extremity of Sagittarius’ (Arabic *al-Qaws*; Sanskrit *Dhanuḥ*), because the star belongs to the zodiac sign Sagittarius; see Mahendra Sūri, *Yantrarāja,* 38, 43. This name is often used in Sanskrit astrolabes. But Nayanānanda seems to treat *Dhanuṣkoṭi* here and under no. 39 below, not as the name of a star, but as the Sanskrit name of the constellation Ophiuchus (Arabic *al-Ḥawwā*).

	Star Name in Arabic	Meaning	Star Name in Sanskrit as engraved	Correct form in Sanskrit	Meaning	Identification
41	*Minqār al-Dajājah*	The beak of the bird	*kruṃja sa ṣṣa ra*	*Krauñca-śīrṣa*	The head of the curlew	β Cygni
42	*Nasr Ṭā'ir*	The flying eagle	*Śravaṇa*		The 23rd lunar mansion	α Aquilae
43	*Dhanab al-Dulfīn*	The tail of the dolphin	*Kruṃja pachī*	*Krauñca-pakṣī*	The curlew bird	ε Delphini
44	*Dhanab al-Dajājāh*	The tail of the bird	*Kruṃja Pachī Pucha*	*Krauñca Pakṣi-puccha*	The tail of the curlew bird	α Cygni
45	*Fam al-Faras*	The mouth of the horse	*Aśvamuṣa*	*Aśvamukha*	The mouth of the horse	ε Pegasi
46	*Dhanab al-Jadī*	The tail of the goat	*Makarapu[c]cha*		The tail of Capricorn	δ Capricorni
47	*Mankib Sākib al-Mā'*	The shoulder of the water pourer	*Kuṃbhaskaṃdha*		The shoulder of Aquarius	α Aquarii
48	*Sāq Sākib al Mā' J[anūbiyya]*	The southern leg of the water pourer	*Kuṃbhapāda*		The foot of Aquarius	δ Aquarii
49	*Dhanab al-Qayṭus Sh[amālī]*	The northern tail of Cetus	*Samudra-pakṣī-pu[c]cha Uttara*		The northern tail of the sea bird	ι Ceti
50	*Mankib al-Faras*	The shoulder of the horse	*Aśvajaṃgha* 'shank of the horse'!	*Aśvaskandha*	The shoulder of the horse	β Pegasi
51	*Surrat al-faras*	The navel of the horse	*Aśvanā[bhi]*		The navel of the horse	δ Pegasi = α Andromedae
52	*Janāḥ al-Faras*	The wing of the horse	*Aśvapuṣa*	*aśvapuccha* (?)	The tail of the horse (?)	γ Pegasi

	Star Name in Arabic	Meaning	Star Name in Sanskrit as engraved	Correct form in Sanskrit	Meaning	Identification
53	*Dhāt al-Kursī*	The one who has a chair, i.e. Cassiopeia	*Caukī strī tana* (?)		seat woman --	β Cassiopeiae

PLATES

On the plates calibrated for different latitudes, Devanagari numerals are added to all the *Abjad* numbers of altitude circles, azimuth arcs and hour lines. Under the horizon are added the labels *pūrva* (east) and *paścima* (west); the latitude value and the duration of the longest day are duplicated with the prefixes *akṣāṃśa* (for *ᶜarḍ*) and *horā* (for *sāᶜāt*). Interestingly on the plate for 0° is written *patra laṅkā* (plate for the terrestrial equator).

On plate 6a, the plate of the ecliptic coordinates, the Arabic name of the plate *ṣafīḥat mīzān al-ᶜankabūt* is rendered literally, and partly in Hindi, *tulā bhā patra kā* (sic! read *tulā bha-patra kī,* 'the balance of the rete); and also as *patrā asāṃśa 66* (sic! read, *patra akṣāṃśa 66,* 'plate for latitude 66°).

Along the circle of the ecliptic, the Sanskrit names of the signs are written, once again, from the right to the left in the same manner as the Arabic names, with one syllable at the beginning of the sign and the other syllable/s at the end of the sign: *ṣa-me* (for *Meṣa,* Aries), *ṣa-vṛ* (for *Vṛṣa,* Taurus), *thana-mi* (sic! for *Mithuna,* Gemini), *ha-siṃ* (for *Siṃha,* Leo), *nya-ka* (*Kanyā,* Virgo), *la-tu* (sic! *Tulā,* Libra), *ści-vṛ* (for *Vṛścika,* Scorpio), *na-dha* (sic! for *Dhanuḥ,* Sagittarius), *kara-ma* (for *Makara,* Capricorn), *bha-kuṃ* (*Kumbha,* Aquarius) and *na-mī* (for *Mīna,* Pisces).

On plate 6b, the plate of horizons, the name of the plate *ṣafīḥa āfāqīya,* is freely translated into Sanskrit as *patrā sarvadesī* (sic! read *patra sarvadeśī,* 'plate for all localities/latitudes' or 'universal plate'). On the declination scales, Sanskrit labels are added which read *krāṃti aṃśa dakṣiṇa* (degrees of declination south) or *krāṃti aṃśa uttara* (degrees of declination north) according to the location.

The *Zawraqī* Plate

The *zawraqī* plate is divided into the 12 astrological houses for the two latitudes 29° and 32° and labelled with the Arabic names of the houses, to which Sanskrit names are added as in the table below. In Arabic, the first house is named *al-ṭālīᶜ,* 'the ascendant,' and the rest are ordinal numbers. In Sanskrit, the houses (*bhāva*) are named generally according to the area of influence of that particular house in the life of the native. Thus the first house is called *tanu,* "body," because it stands for the body and the physical appearance, behaviour and character of the person

Table E005-2 Astrological Houses in Arabic and Sanskrit

	Arabic Name	Sanskrit Name	Meaning of the Sanskrit Name
1	*al-ṭālīᶜ*	*tanu*	body
2	*al-thānī*	*dhana*	wealth
3	*al-thālith*	*sahaja*	sibling
4	*al-rābiᶜ*	*suhṛd*	friend
5	*al-khāmis*	*suta*	son
6	*al-sādis*	*ripu*	enemy
7	*al-sābiᶜ*	*jāyā*	wife
8	*al-thāmin*	*mṛtyu*	death
9	*al-tāsiᶜ*	*dharma*	religious life
10	*al-ᶜāshir*	*karma*	activity (profession)
11	*al-ḥādī ᶜashar*	*āya*	income
12	*al-thānī ᶜashar*	*vyaya*	expenditure

Two mutually intersecting oblique horizons are drawn across the plate for the two latitudes 29° and 32°. Where the arcs intersect with the equinoctial colure, there are labels at the end of each horizon. Thus at the two ends of the horizon for 29° are engraved *ufq sharqī ᶜarḍ 29* (Sanskrit: *kṣitīja pūrva akṣaṃśa,* correct: *kṣitija pūrva*

akṣāṃśa 29) on the east, meaning "eastern horizon latitude 29" and *ufq gharbī ᶜarḍ 29* (Sanskrit: *kṣitīja paści akṣaṃśa,* correct *kṣitja paścima akṣāṃśa 29*) on the west, meaning "western horizon latitude 29". Likewise at the two ends of the horizon for 32° are engraved *ufq sharqī ᶜarḍ 32* (Sanskrit: *kṣitīja pūrva akṣaṃśa,* correct: *kṣitja pūrva akṣāṃśa 32*) on the east and *ufq gharbī ᶜarḍ 32* (Sanskrit: *kṣitīja paści akṣaṃśa,* correct: *kṣitja paścima akṣāṃśa 29*) on the west (Figure 13).

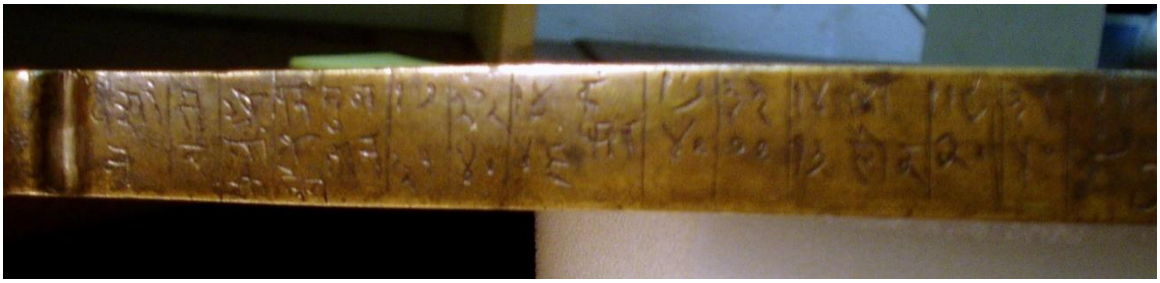


Figure E005.4 – Sanskrit gazetteer engraved on the edge of the astrolabe
(photo by S. R. Sarma)

GEOGRAPHICAL GAZETTEER IN SANSKRIT

On the inner face of the mater is engraved an Arabic gazetteer with the names, longitudes, latitudes and the duration of the longest day of 264 localities in five concentric annuli. This last item appears for the first time (and only time) in a Mughal astrolabe gazetteer. The plate is so completely filled with these details that there is hardly any space for additions in Devanagari script. So a separate Devanagari gazetteer is engraved all along the thick edge of the astrolabe, starting from the base of the *kursī*. This gazetteer is much shorter than the Arabic gazetteer. The first 23 cities are from India. These are an exact copy of the fifth annulus of the Arabic gazetteer. The remaining cities (Mecca etc.) are selected (at random?) from different annuli of the Arabic gazetteer. Leaving aside a few well known names like Mecca, Medina, Misr, Maraghah, Shiraz, Mosul, Baghdad, Kufah, the rest of the names are so badly written that they cannot be easily deciphered. Wherever the coordinates differ from the Arabic gazetteer, the latter are given in parentheses in the following table

Table E005-3 Geographical Gazetteer in Sanskrit

	Place Name (*deśanāma*)	**Correct Form/ Modern Name**	**L (*śara*, read *deśāmtara*)**	**φ (*aksamsa*, read *akṣāṃśa*)**	**Duration of the longest Day (*paramadina*)**
1	Mulatāna	Multan	107;35	33;40 (29;40)	14;46 (13;46)
2	Kaṃdhāra	Qandahar	107;40	33;00	14;13
3	Lahaura	Lahore	119;20	31;50	14;19
4	Kanauja	Kannauj	115;50	26;35	13;42
5	Banārasa	Banaras	117;20	26;55	13;45
6	Ma-ladāpa	Siṃhaladvīpa Sri Lanka	130;00	10;00	12;40
7	Kasmīra	Kashmir	108;00	35;00	14;25
8	Tidyata	Tibbata Tibet	110;00	40;00	14;54
9	Āgarā	Agra	104;00	27;00	13;45
10	Dillī	Delhi	113?;35	28;39	13;52
11	Ajamera	Ajmer	111;50 (112; 05)	26;00	13;31
12	Gvāliyara	Gwalior	115;00	26;29	13;42
13	Burahānapura	Burhanpur	109;00	20;34 (20;31)	13;14
14	Sūrata	Surat	110;50	20;15	13;14
15	Dolatābāda	Daulatabad	110;00	20;30	13;14 (13;24)
16	Ujena	Ujjain	102;0	22;30	13;24
17	Vījā[pura]	Bijapur	15;30 (115; 30)	17;20	13;4
18	Gulakuḍā	Golconda Hyderabad	115;40 (114 ;39)	18;4	13;9

	Place Name (*deśanāma*)	Correct Form/ Modern Name	L (*śara*, read *deśāmtara*)	φ (*aksamsa*, read *akṣāṃśa*)	Duration of the longest Day (*paramadina*)
19	Ḍhākā Vaṃgāla	Dhaka	130;0	27;0	13;45
20	Paṭanā	Patna	110;45 (120;45)	26;40	13;49 (13;44)
21	Jonapura	Jaunpur	115;6 (119;6)	26;36	13;44
22	Muṃgera	Mungher	121;45	26;40	13;44
23	Alāhābā[da]	Allahabad	115;24	26;50	13;44
24	Makā	Mecca	77;10	21;40	13;20
25	Madīnā	Medina	74;20 (75;20)	25;0	13;30 (13;35)
26	Tiphaka??	Taif	77;33 (77;30)	21;29 (21;20)	13;20
27	Traphagru??		76;11?	12;20?	3?
28	Misara	Misr = Cairo	63;20	30;20	14;1
29	Phakaparīṣa	Iskandariyā Alexandriya	61;54	30;58	14;35 (14;32)
30	Rahatavava-raphaka	??	65;0	14;0	12;54
31	Mahadāsā	Mahdiyyah	42;0	32;30	14;11
32	Keravāṃ	Qayrawan	41;7 (41;0)	31;40 (31;30)	14;73 (14 7)
33	Tabaja	Tabriz	102;5 (82;5)	38;0	14;40 (14;42)
34	Marāgaha	Maragha	102;0 (82;0)	37;20	14;28 (14;38)
35	Naravajanvā	Nakhichevan	81;15	38;40	14;46

	Place Name (*deśanāma*)	**Correct Form/ Modern Name**	**L (*śara*, read *deśāmtara*)**	**φ (*aksamsa*, read *akṣāṃśa*)**	**Duration of the longest Day (*paramadina*)**
36	Ghoy	Khoy	79;40	37;40	14;40
37	Amada	Amid	33;40 (73;40)	38;0	14;40 (14;42)
38	Mūsa	Mosul	77;00	34;30	14;31 (14;21)
39	Ānaha	Ānah	76;30	34;00	14;19
40	Tamasāva	Sumaysāṭ	72;35	40;00	24;54 (14;54)
41	Yatre	Yazd	89;00	32;00	14;8
42	Sīrāja	Shīrāz	88;00	29;36	13;15 (13;55)
43	Śāhapura	Shābūr	86;55	30;00	13;58 (13;18)
44	Namarā	Basra	84;00	30;00	13;58
45	Kūphaha	Kūfah	79;30	31;30	14;6

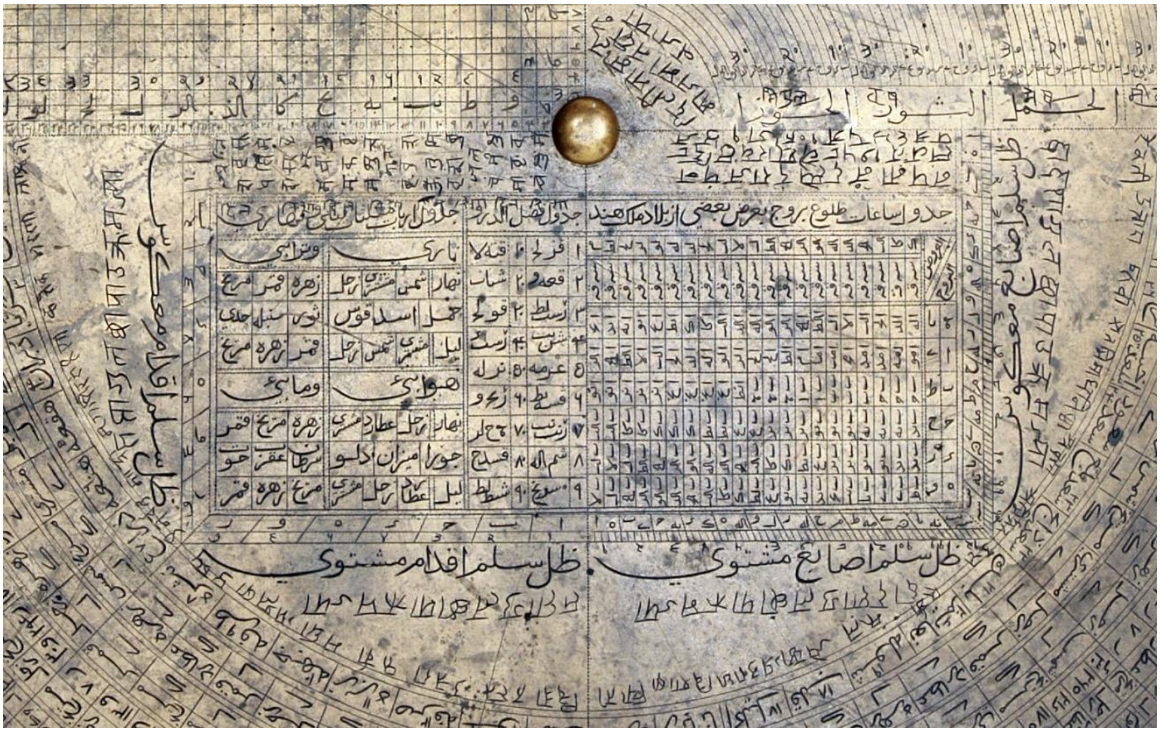


Figure E005.5 – Detail of the back showing additions in Sanskrit.
Sanskrit names of lunar mansions can be seen along the semi-circular frame; on the three sides of the shadow squares are labels related to them; above the shadow squares on the left is the table of triplicities and on the right is Nayanānanda’s signature (upside down) (detail of Figure A093.11)

BACK

On the back, Devanagari numerals are added to the altitude scales in the upper half of the rim and to the cotangent scales in the lower half. The upper left quadrant is engraved with 60 horizontal and 60 vertical lines and these are numbered along the two radii; next to these, Devanagari numerals added in 3s.

In the upper right quadrant are drawn 90 declination circles and the names of the corresponding signs are engraved along the two radii. Under each sign, the declination arcs are numbered serially from 1 to 30. Next to the Arabic names of the signs, Sanskrit names are engraved and the declination arcs are numbered in 10s, as 10, 20, 30, separately for each sign. Surprisingly, no Sanskrit labels are added to the three graphs of the solar midday altitude traced in this quadrant.

Lahore astrolabe makers engrave an inscription containing their name and the date of manufacture in the narrow space between the horizontal diameter and the shadow squares. This was completely effaced and filled with a table of triplicities on the left and with a mention of Nayanānanda and the date of reworking on the right.

Shadow Squares

The Sanskrit labels are added to the shadow squares drawn in the lower half as follows:

Vertical scale on the left:*saptāmgula-chāyā utkramajyā* (sic! read *chāyā vilomā*)
Horizontal scale on the left: *saptāmgula-chāyā kramajyā* (sic! read *chāyā samā*)
Horizontal scale on the right: *dvādeśāmgula-chāyā kramajyā* (sic! read *chāyā samā*)
Vertical scale on the right: *dvādaśāmgula-chāyā utkramjyā* (sic! read *chāyā vilomā*)

Tables inside the shadow squares

Inside the shadow squares, there are three tables. The first table from the right is designated as *Jadwal sāᶜāt ṭulūᶜ burūj bi-ᶜarḍ baᶜḍī az bilād mulk hind* (table of times of rising of the signs for the latitudes of some localities in India).[1002] The second table, named *Jadwal faḍl al-dawr* (table of excess of revolution), displays the multiples of differences, in minutes and seconds, between the approximately correct length of the tropical year and 365 days.[1003] The number of days is written in standard Arabic numerals and the difference in *abjad* notation. The Sanskrit version of this table is engraved on the edge of the astrolabe. The Sanskrit version misreads the Arabic numbers in a few cases. Both the Arabic and Sanskrit versions are shown in the following table. Where the Sanskrit version differs, the values are shown in italics.

[1002] This table occurs in A072 and A092.

[1003] This table is engraved frequently on Indo-Persian astrolabes, but on Sanskrit astrolabes only once; cf.

Table C023-2.

Table E005-4 Excess of Revolution

Numberof days	Excess Arabic	Excess Sanskrit	Numberof days	Excess Arabic	Excess Sanskrit
1	87; 33	87;33	**10**	155;31	155;31
2	175;6	175;6	**20**	61;2	*311;2*
3	262:39	*263;4*	**30**	106;33	106;33
4	350;12	350;12	**12**	262;10	262;4
5	77;45	77;45	**50**	57;35	*57;34*
6	164;19	*165;19*	**60**	213; 6	213;?
7	252;52	252;52	**70**	08;37	08;37
8	340;25	*340;20*	**80**	164;8	164;8
9	67;58	*66;58*	**90**	319;39	*309;39*

The third table inside the shadow squares, designated as *Jadwal arbāb al-muthallathāt laylī wa nahār* (table of regents of the triplicities by day and night), shows the signs grouped as triplicities and their planetary regents of the day and of the night. In the narrow space between this table and the horizontal diameter, the Sanskrit version of this table is engraved, using just the first syllables of the names of the signs and their planetary regents. Both the Arabic and Sanskrit tables are reproduced below. In the Arabic table, the signs are arranged from the right to the left; the Sanskrit version follows the same order.

Table E005-5 Triplicities of Signs and their Regents of the Day and of the Night

Arabic				**Sanskrit**			
nārī (fiery)				*agni* (fire)			
Zuḥal Saturn	*Mushtarī* Jupiter	*Shams* Sun	*nahār* day	*dina* day	*Śa[ni]* Saturn	*Bṛ[haspati]* Jupiter	*Sū[rya]* Sun
Qaws Sagattarius	*Asad* Leo	*Ḥamal* Aries			*Dha[nuḥ]* Sagittarius	*Si[ṃha]* Leo	*Meṣa* Aries
Zuḥal Saturn	*Shams* Sun	*Mushtarī* Jupiter	*layl* night	*niśā* night	*Śa[ni]* Saturn	*Sū[rya]* Sun	*Bṛ[haspati]* Jupiter
turābī (earthy)				*bhū* (earth)			

Mirrīkh Mars	*Qamar* Moon	*Zuhara* Venus	*nahār* day	*dina* day	*Maṃ[gala]* Mars	*Caṃ[dra]* Moon	*Śu[kra]* Venus
Jadī Capricorn	*Sunbula* Virgo	*Thawr* Taurus			*Ma[kara]* Capricorn	*Ka[nyā]* Virgo	*Vṛ[ṣa]* Taurus
Mirrīkh Mars	*Zuhara* Venus	*Qamar* Moon	*layl* night	*niśā* night	*Maṃ[gala]* Mars	*Śu[kra]* Venus	*Caṃ[dra]* Moon
hawā'ī (airy)				*vāta* (air)			
Mushtarī Jupiter	*ᶜUṭārid* Mercury	*Zuḥal* Saturn	*ahār* day	*dina* day	*Bṛ[haspati]* Jupiter	*Bu[dha]* Mercury	*Śa[ni]* Saturn
Dalw Aquarius	*Mīzān* Libra	*Jawjā'* Gemini			*Kuṃ[bha]* Aquarius	*Tu[lā]* Libra	*Mi[thuna]* Gemini
Mushtarī Jupiter	*Zuḥal* Saturn	*ᶜUṭārid* Mercury	*layl* night	*niśā* night	*Bṛ[haspati]* Jupiter	*Śa[ni]* Saturn	*Bu[dha]* Mercury
mā'ī (watery)				*jala* (water)			
Qamar Moon	*Mirrikh* Mars	*Zuhara* Venus	*nahār* day	*dina* day	*Caṃ[dra]* Moon	*Maṃ[gala]* Mars	*Śu[kra]* Venus
Ḥūt Pisces	*ᶜAqrab* Scorpio	*Saraṭān* Cancer			*Mīna* Pisces	*Vṛ[ścika]* Scorpio	*Ka[rka]* Cancer
Qamar Moon	*Zuhara* Venus	*Mirrīkh* Mars	*layl* night	*niśā* night	*Caṃ[dra]* Moon	*Śu[kra]* Venus	*Maṃ[gala]* Mars

Astrological tables

The space between the rim containing the cotangent scales and the two shadow squares is filled with seven semicircular scales; here each two rows are separated by a narrow band.

The first scale, as counted from the outside, consists of three rows. While the third row is filled with the 12 names of the signs of the zodiac, the first row is divided into single degrees and in the second row groups of 5° are numbered, separately for each sign (as, 5, 10, 15, 20, 25, 30). The names of the signs are repeated in Sanskrit, syllables arranged right to left above the Arabic names, and the *Abjad* numbers in the second row are repeated in Devanagari.

The remaining scales show various kinds of subdivisions of the signs and their regents or functions: one-twelfth parts (duodenaries), one-ninth parts (nonenaries); terms or limits, i.e., one-fifth parts of the signs and the strength of planets which preside over these limits (the name *ḥudūd miṣriyān* is engraved in the first cell of the row);

planets and their domiciles in one-thirds of the signs (the name *darjān kawākib* is engraved in the first cell); and finally the regents of the decans of 10° (the designation *wujūh kawākib* is engraved in the first cell) .

The very last semi-circular scale carries the names of 28 lunar mansions in Arabic followed by their serial numbers. Immediately below this, Nayanānanda caused the addition of the Sanskrit names of the lunar mansions. The following table shows the names of the lunar mansions in Arabic as engraved here and those added here in Sanskrit.

Table E005-6 Names of Lunar Mansions in Arabic and Sanskrit

	Lunar Mansions Arabic	Lunar Mansions Sanskrit	Sanskrit corrected
1	*Sharaṭān 1*	*Aśvinī*	
2	*Buṭayn 2*	*Bharaṇī*	
3	*Thurayyā 3*	*Kattaka*	*Kṛttikā*
4	*Dabarān 4*	*Rohiṇī*	
5	*Haqᶜa 5*	*Mṛgaśira*	*Mṛgaśirā*
6	*Hanᶜa 6*	*Ādrā*	*Ārdrā*
7	*Dhirāᶜ 7*	*Punarvasuha*	*Punarvasu*
8	*Nathra 8*	*Puṣya*	
9	*Ṭarf 9*	*Aślaṣā*	*Aśleṣā*
10	*Jabha 10*	*Maghā*	
11	*Zubra 11*	*Pūrvā*	*Pūrvā Phālgunī*
12	*Ṣarfa 12*	*Uttarā*	*Uttarā Phālgunī*
13	*ᶜAwwā’ 13*	*Hasta*	
14	*Simāk 14*	*Citrā*	
15	*Ghafr 15*	*Svātī*	
16	*Zubānā 16*	*Viśāṣā*	*Viśākhā*

	Lunar Mansions Arabic	Lunar Mansions Sanskrit	Sanskrit corrected
17	*Iklīl 17*	*Anurādhā*	
18	*Qalb 18*	*Jyeṣṭhā*	
19	*Shawla 19*	*Mūla*	*Mūlā*
20	*Na^{c}ā'im 20*	*Pūrṣā*	*Pūrvāṣādhā*
21	*Balda 21*	*Utta*	*Uttarāṣāḍhā*
22	*Dhābiḥ 22*	*Abhijita*	*Abhijit*
23	*Sa^{c}d Bula' 23*	*Śravaṇa*	
24	*Sa^{c}d Su^{c}ūd 24*	*Śatabhiṣā*	
25	*S^{c}ad Akhbiya 25*	*Dhaniṣṭhā*	
26	*Fargh Muqaddam 26*	*Pūrvā*	*Pūrvā Bhādrapadā*
27	*Fargh Mu'akkhar 27*	*Uttarā*	*Uttarā Bhādrapadā*
28	*Rishā' 28*	*Revatī*	

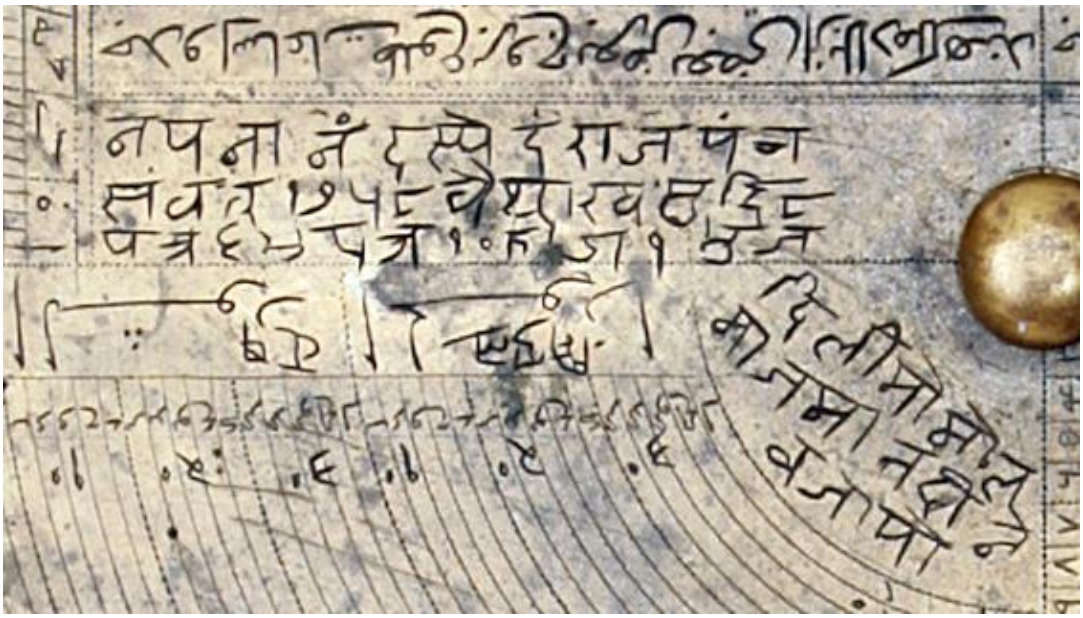


Figure E005.6 – Nayanānanda's inscription on the back
(detail of Figure A093.11)

INSCRIPTION

On the back, to the right of the central hole, there is an inscription in Sanskrit in three lines, which is engraved after removing the original engraving:

nayanānaṃdasyedaṃ rājayaṃtra (sic! yantrarājaḥ)

saṃvat 1758 vaiśākha sudi 8

patra 6 bhapatra 1 0 hajā 1 bhuja

This is continued at the apex of the upper right quadrant close to the central hole, again in three lines, but in Hindi:

dilī mo mol (dillī men mol ?)

mā jamānadī ne (jamānuddīn ne?)

bajāyā (banāyā ?)

'This is Nayanānanda's astrolabe (*yantrarāja*)

Saṃvat 1758 Vaiśākha bright fortnight [day] 8.

[There are] 6 plates (*patra*), 1 rete (*bhapatra*), [and] 1 alidade (*bhuja*).'

'In Delhi purchased (*mol*)

Jamāuddīn / Jamāluddīn has

made (has done the engraving?)"

The date of reworking, *Saṃvat 1758 vaiśākha sudi 8*, corresponds to Sunday, 15 May 1701 (Gregorian). The person who got the reworking done is Nayanānanda and there is a reference to Delhi. The name of the man who did the engraving is not correctly engraved. If my conjecture of Jamānuddīn or Jamāluddīn is correct, then the astrolabe appears to have made a full circle: originally made by the Muslim astrolabe maker of Lahore Ḍiyā' al-Dīn Muḥmmad for the Mughal emperor Shāh Jahān sometime between 1648 and 1658, it was acquired by the Hindu astrologer Nayanānanda of Delhi, who got reworked with additions in Sanskrit and Hindi in 1701, by the brass-worker Jamāluddīn who is again a Muslim.

Nayanānanda must have been a wealthy resident of the Mughal capital—probably an astrologer with important clientele— to have been able to acquire this monumental Mughal astrolabe within 50 years of its manufacture and to fill it so thoroughly with Sanskrit equivalents. His has a beautiful Sanskrit name which means 'delight to the eyes'. His interest in the astrolabe is no doubt laudable, but regrettably the additions in Sanskrit he caused to be incised on this Lahore masterpiece are not at all *nayanānanda.*

F. INDO-PERSIAN CELESTIAL GLOBES PRODUCED BY THE LAHORE FAMILY

INTRODUCTION

1. The Celestial Globe in Greek Antiquity

Next to the astrolabe, the celestial globe is the most important astronomical instrument in pre-modern times. While the vault of the fixed stars is represented in two dimensions on the rete of the astrolabe, it is shown in three dimensions on the celestial globe. This makes the representation of the stars in their relative positions visually more appealing on the celestial globe. Therefore, it is a more convenient tool for teaching and demonstration.

The celestial globe and its companion piece, the terrestrial globe, were also invented in Greek antiquity, much earlier than the astrolabe. Their invention is attributed respectively to Thales and Anaximander in the sixth century BC. It was, however, Claudius Ptolemy (ca. 150 AD) who provided in his works comprehensive and systematic data for both the globes. On the terrestrial globe, the location of a place is indicated by its geographical latitude and longitude. Similarly, on the celestial globe, the stars are plotted by their ecliptic latitude and longitude, or by their declination and right ascension. In his *Geographia,* Ptolemy enumerated the geographical latitudes and longitudes for about 8000 localities and thus provided the essential data for the construction of the terrestrial globe. Likewise, in his other major work, the *Almagest,* he described quite elaborately how to construct a celestial globe.[1004] He also gave the ecliptic latitudes and longitudes of some 1020 stars, arranging these stars in 48 constellations which include the twelve signs of the zodiac.[1005]

Since then it has been customary to show the positions of these 1020 stars on celestial globes. The globes also contain outlines of the pictorial representations of the 48 constellations in their zoomorphic, anthropomorphic and other forms as conceived in Hellenistic mythology, or as modified later in the Islamic world.

[1004] Ptolemy, VIII.3, pp. 404-407.

[1005] Ptolemy, VII.5-VIII.1, pp. 341-399.

In order to determine the positions of these stars, several reference circles are drawn on the globes, such as the celestial equator, the ecliptic, the ecliptic latitude circles, tropics and polar circles. The globe is set up on a stand with a graduated horizon ring and a graduated meridian ring. An axis passing through the two poles of the globe is affixed to the meridian ring. The globe can be so adjusted that it shows the stellar position for a given locality and for any given time. By turning the globe, the risings and settings of the stars can also be demonstrated.[1006]



Figure F1 – Farnese Atlas. Front view of the celestial globe with the constellation figures of (from left to right) Canis Major, Argo Navis, Hydra, Crater, Corvus, Centaurus, Lupus and Ara. (photo by Gabriel Seah, licensed under the Creative Commons Attribution-ShareAlike 3.0 License (CC BY-SA 3.0)).

[1006] On the use of the celestial globe for observation and measurement, see Kennedy 1989; Savage-Smith in: Maddison & Savage-Smith 1997, I, pp. 180-185.



Figure F2 – Farnese Atlas, side view of the celestial globe.
Upper row, left to right: Corona Borealis, Hercules, Lyra, Cygnus; middle row: Ophiuchus, Aquila, Delphinus; lower row on the ecliptic: Sagittarius, Capricorn, Aquarius. (photo by Sailko, licensed under the Creative Commons Attribution-ShareAlike 3.0 License (CC BY-SA 3.0)).

The earliest representation of the celestial globe can be seen in the marble statue of the Farnese Atlas, now in the National Museum of Naples in Italy. This statue depicts the Greek mythological figure Atlas carrying the celestial sphere on his shoulders. The sphere shows the equator, the ecliptic, the tropics, the polar circles, the colures and the figures of zodiac signs and several other constellation figures in the northern and southern hemispheres, but star positions are not marked on it. The ecliptic is represented by three parallel lines. The representation of the vernal equinox is similar to that in Ptolemy's *Almagest.* Therefore, it is assumed that the globe was made after 150 AD.[1007]

[1007] Dekker & Krogt 1993, pp. 12-13.

2. The Celestial Globe in Europe

Like the astrolabe, the celestial globe also reached Europe through the Arabic rendering of Greek texts. In the late tenth century, Gerbert of Aurillac, who is said to have written the first Latin treatise on the astrolabe, is also supposed to have been the first to write on the celestial globe in Latin; he is reported to have constructed a celestial globe which was covered with leather. Moreover, the *Libros del saber de astronomia* of about the thirteenth century includes the descriptions of celestial globes among other instruments. A notable work on the celestial globe of the early fourteenth century is by Accursius of Parma. By the fifteenth century Ptolemaic astronomy became well established in Europe; several tracts were composed on the celestial globe and its production became a specialized profession. Some of the earliest globes were those made by Hans Dorn in 1480 and those belonging to Cardinal Nicholas Cusa which were made in Nuremberg.[1008] During the Renaissance, automatically rotating globes with clockwork mechanism were made in large numbers and these represented the highpoint of technology as well as that of the goldsmith's craft. Some of the notable pieces were crafted by Eberhard Baldewein and Jost Bürgi under the patronage of the astronomer-prince Wilhelm IV (1532-1592), the Landgrave of Hesse-Kassel, who established the first European Observatory at Cassel and sponsored the compilation of the star catalogue of Cassel.[1009] Subsequently, with the spread of printing, sections of the globes are printed on paper and then pasted on wooden or papier-mâché spheres.

In Europe, the celestial globe came to be treated as the emblem par excellence of the astronomer just as the astrolabe was considered his chief symbol in the Islamic world. European portraits of the astronomer, like those of Copernicus or Kepler, usually show him plotting the star positions on the globe with a pair of compasses.

3. The Celestial Globe in the Islamic world

The celestial globe, along with the astrolabe, was transmitted to the Islamic world through Greek texts. In Arabic, the celestial globe is called *al-kurah,* 'the sphere', *al-bayḍah,* 'the egg' or *dhāt al-kursī,* 'that which is mounted on a stand'; its celestial

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1008 Zinner 1979, pp. 168-176; Dekker & Krogt 1993, p. 16.

1009 Drach 1894; Zinner 1979, pp. 173; Mackensen 1982, pp. 70-88; Gaulke 2007, pp. 177-197.

character is emphasized in terms like *kurah falakī, kurah raṣadī* or *kurah samāwī,* all denoting celestial globe as against *kurah arḍwī* which designates the terrestrial globe. As in the case of the astrolabe, so also on the celestial globe, several treatises were written in the Islamic world and innovations were made in its construction.

Though derived from the Greek or Ptolemaic tradition, the celestial globe in the Islamic world displays a fundamental difference as far as the constellation figures are concerned. In the Greek tradition, the constellation figures are conceived as facing the earth from the concave vault of the starry sky. When depicted on the convex surface of the globe, these figures seem to be looking into the globe, that is to say, the form shown on the surface of the globe is the back view of the human figures, as can be seen in the figures of Hercules, Ophiuchus, Sagittarius and Aquarius on the Farnese Atlas in Figure F2 above. In this manner, the relative position of the right and left is maintained. Thus, for example, Perseus holds the sword in his right hand. Also a star said to be on the right leg of a figure in the Ptolemaic catalogue can be found on the right leg of the figure on the globe.

For some unknown reason, this convention was reversed on the Islamic globes. Here the human figures are drawn on the globe as seen by an observer from outside the sphere and thus as the mirror images of the figures as seen from the earth. This has resulted in the strange situation that all the human figures on Islamic globes appear left-handed; Perseus holds the sword in his left hand, Hercules the sickle in his left hand and so on.[1010]

[1010] Dekker & Krogt 1993, p. 15.



Figure F3 – Constellation figure Orion on globe F013 (photo by Ghulam Mujtaba)

This peculiarity can best be seen in the figure of Orion (*al-Jabbār,* 'the Giant') as depicted on the Islamic globes. In this figure the star named *Yad al-Jawzā' al-Yumnā* (the right hand of *al-Jawzā',* α Orionis) is actually situated on what appears to us as the left hand and the star *Yad al-Jawzā' al-Yusrā* (the left hand of *al-Jawzā',* γ Orionis) on the right hand. Likewise the star with the name *Rijl al-Jawzā' al-Yumnā* (the right foot of *al-Jawzā',* κ Orionis) is situated on the left foot and the star *Rijl al-Jawzā' al-Yusrā* (the left foot of *al-Jawzā',* β Orionis) on the right foot.

Moreover, while the constellation of Orion is called *al-Jabbār* in Arabic, the star names mentioned above contain the term *al-Jawzā'* and this is also the name of the

constellation and the house Gemini. Savage-Smith explains that this confusion arose because the traditional Bedouin term for this region was *al-Jawzā',* of uncertain meaning, which encompassed also the house of Gemini. In this region of heavens, the Bedouin tradition conceived of a larger feminine figure, whose hands and feet are referred to in these star names. [1011]

Incidentally, Orion is regarded as a hunter, accompanied by his two dogs Canis Minor and Canis Major, chasing the hare Lupus. He is conceived as holding a staff in his right hand, a short dagger at his waist and a lion's skin draped over his left arm, and kneeling in the same manner as Hercules.[1012] In Islamic globes, the lion's skin is depicted as a long sleeve which accommodates nine stars. On Indo-Persian globes, the dagger at the waist is not always shown and the staff in his right hand is drawn in diverse shapes, often of unidentifiable weapons. Likewise, his hair is also depicted in various bizarre forms.

It is not known how this lateral reversion in the Islamic celestial globes came about and when. In the early ninth century, the city of Ḥarrān was said to be an important centre for the production of Islamic astronomical instruments. ᶜAbd al-Raḥmān al-Ṣūfī (AD 903-986), the court astronomer of ᶜAḍud al-Dawla at Isfahan, mentions in his treatise *Kitāb Ṣuwar al-Kawākib al-Thābitah* (Book of the Constellations of the Fixed Stars) that he saw many celestial globes made at Ḥarrān. It is probably on these globes that the lateral reversal took place for the first time which became established by the time of al-Ṣūfī. In the above-mentioned book which he composed in 974, Ṣūfī describes and illustrates the constellations as they are seen in the sky by an observer on the earth (*fī al-samā'*) and again as seen on the celestial globe (*fī al-kurah*) which is reversed right to left. There are extant some exquisitely illustrated manuscripts of this work, showing the constellation figures in the two styles as seen from the earth and as seen on the

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1011 Savage-Smith 1985, pp. 168, 189-191; .

1012 Savage-Smith 1985, p. 189.

globe.[1013] Al-Ṣūfī also composed a book on the astrolabe of which there exist three different versions.[1014]

In his treatise on the celestial globes, al-Ṣūfī updated Ptolemy's star catalogue. The coordinates of the stars were again updated in 1437 by Ulugh Beg in his astronomical tables. Accordingly, Islamic celestial globes contain the positions of about 1020 stars marked according to the coordinates given by al-Ṣūfī or by Ulugh Beg and updated to their own times.

Other important works on the celestial globe are those composed at the end of the ninth century AD by al-Battānī of Ḥarrān and Qustā ibn Lūqā al-Baʿlabakkī. In the early twelfth century, al-Khāzinī designed a globe that rotated automatically by means of a falling weight in a leaking reservoir of sand.[1015]

In 1985, Emilie Savage-Smith published a study and a catalogue of the extant Islamic celestial globes under the title *Islamicate Celestial Globes: Their History, Construction, and Use.*[1016] This work contains a comprehensive history of the celestial globe from Greek, Roman and Islamic sources, a masterly account of the various methods of production of the celestial globe, erudite explanations of the Greek myths and the Bedouin beliefs that led to the formation of the constellation figures on the globes, detailed analyses of the nomenclature of the stars, fine descriptions of the individual globes, besides a wealth of linguistic, art-historical and mythological information. This is the model every cataloguer of medieval scientific instruments would aspire to emulate. This catalogue contains information on 132 celestial globes. In subsequent publications, Savage-Smith has described some more globes.[1017]

1013 The oldest manuscript copy prepared by al-Ṣūfī's son in 400 AH (AD 1009-10) is extant in the Bodleian Library at Oxford (Marsh 144); cf. Wellesz 1965. A fifteenth century copy autographed by Ulugh Beg is with the Bibliothèque Nationale in Paris and was printed in Ṣūfī 1954. The treatise was rendered into Persian by Naṣīr al-Dīn al-Ṭūsī in 1260 and by Luṭfullah Muhandis in 1640 in India.

1014 Vafea 2006.

1015 Lorch 1980.

1016 Savage-Smith 1985.

1017 Savage-Smith 1990; Savage-Smith in: Maddison & Savage-Smith 1997, *Science,* I, Nos. 112-114, 134, 138, 140-141; II, Nos. 382-389.

3.1. Early Islamic Celestial Globes

In the ninth and tenth centuries, celestial globes were produced both in the Western and the Eastern parts of the Islamic world.[1018] The earliest extant globe in the Islamic world was manufactured by Ibrāhīm ibn Saʿīd al-Sahlī al-Wazzān together with his son Muḥammad in Moorish Spain in 473 AH/ AD 1080 (or in 478 AH / AD 1085). It is now preserved in the Museum of History of Science at Florence, Italy.[1019] Elly Dekker and Paul Kunitzsch read the date as 1 Ṣafar 478 AH (29 May 1085). Furthermore, they attribute an unsigned and undated globe in the Bibliothèque nationale de France, Paris, to this father-son duo and add that it is the earlier of the two globes. The former measures 220 mm in diameter and the latter 190 mm.[1020]

On these globes can be seen already many of the conventions which became the norm in subsequent times. The equator and the ecliptic are represented by double bands, one of which is graduated in 1°. In the second band groups of 5° are marked and numbered in *Abjad* notation, on the equator continuously from the vernal equinox from 5 to 360, but separately for each sign on the ecliptic from 5 to 30. Ecliptic latitude circles are drawn. Names of the zodiac signs are engraved along the ecliptic. The southern equatorial polar circle is drawn around which the signature is engraved. Equatorial poles, constellations and many stars are labelled. Stars are indicated by dots in circles.

The constellation figures are drawn in outlines. Human figures are represented in anatomically correct outlines. The faces are mostly in profile, marked by hair, nose, lips and chin. Eyebrows and eyes are drawn but without pupils. The five fingers in the hands are clearly shown. In the case of Cassiopeia and Virgo, however, the faces are not in profile, but looking to the front. The clothing is not generally indicated, but Andromeda is depicted with some sort of skirt.

1018 Savage-Smith 1985, pp. 23-34.

1019 Savage-Smith 1985, no. 1, p. 217; see also p. 24.

1020 Dekker & Krogt 1993, p. 155.

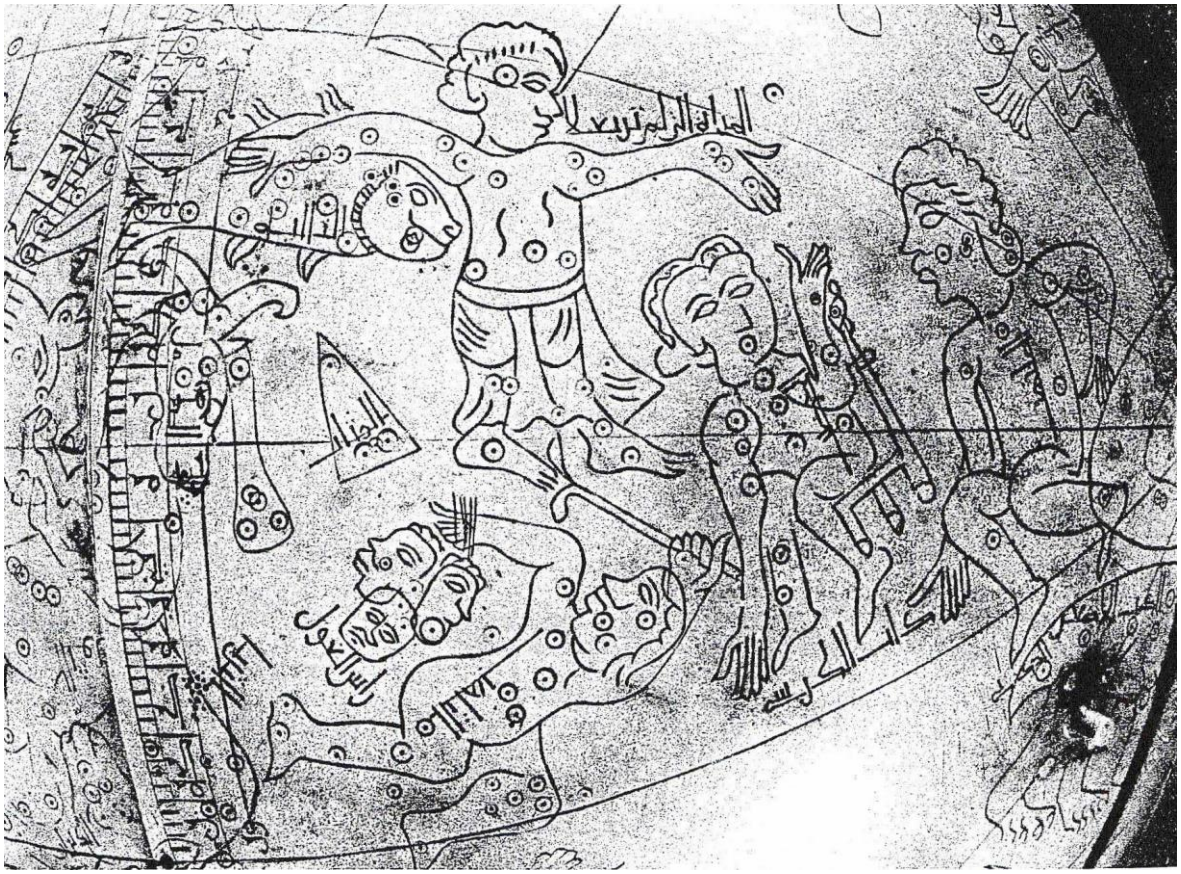


Figure F4 – Andromeda, Cassiopeia, Cepheus and Perseus on the Paris globe (from Dekker & Kunitzsch 2008)

An unusual feature is that Libra is depicted as a woman holding the scales on both the globes at Paris and Naples. Such a depiction does not occur in any other globe.

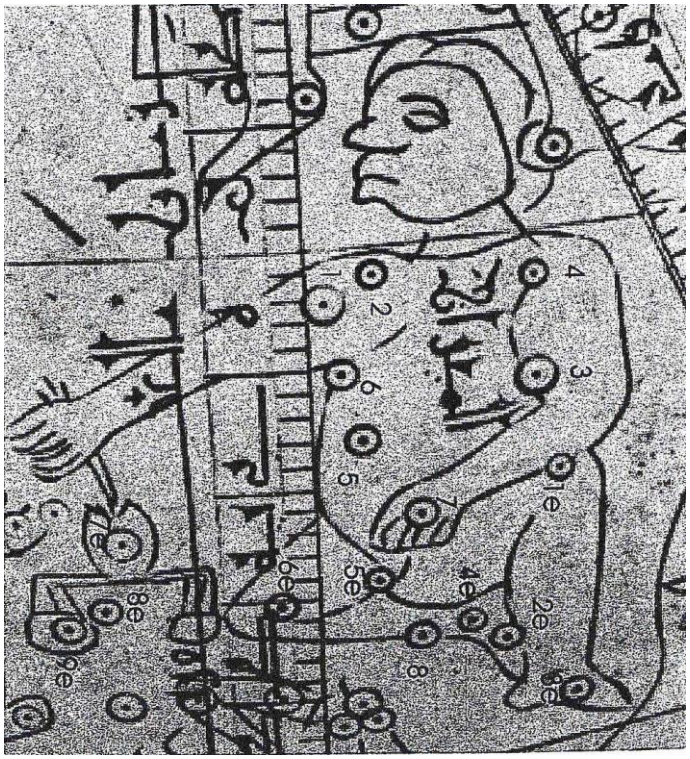


Figure F5 – Libra on the Naples globe (from Dekker & Kunitzsch 2008)

Chronologically the next extant celestial globe was made by Yūnus ibn al-Ḥusayn al-Asṭurlābī in 539 AH / AD 1144. The globe has a diameter of 175 mm. Here the equator and the ecliptic are drawn as in the globes at Paris and Naples. There are also ecliptic latitude circles. The names of the zodiac signs are engraved along the ecliptic, and the equatorial and ecliptic poles, the 48 constellations, 28 lunar mansions and 72 major stars are named. The globe-maker's signature is near the south equatorial pole.

Here for the first time, the star positions are indicated by inlaid silver points of different sizes. There is considerable improvement in the constellation figures, especially the human figures: the outlines are better, the faces are shown facing the front, fingers on the hands and toes on the feet is clearly marked, and clothing is indicated in simple but elegant strokes.

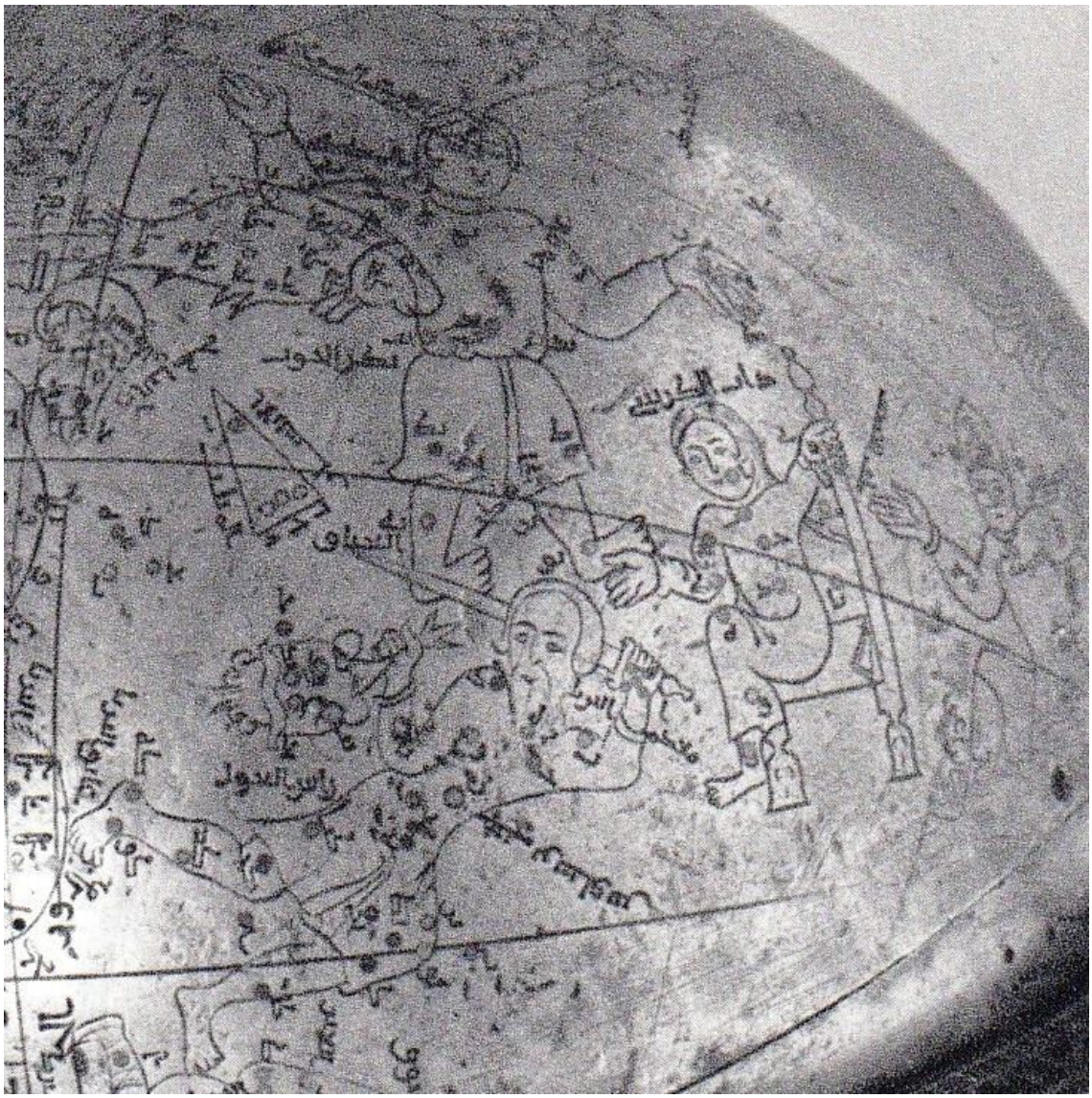


Figure F6 – Celestial globe by Yūnus ibn al-Ḥusayn al-Asṭurlābī, detail showing Andromeda, Cassiopeia, Cepheus and Perseus (detail from Guye & Michel 1971, no. 198)

4. Main Elements of the Celestial Globe

4.1. Reference Circles

For determining the positions of the stars, several reference circles are drawn on the globes, such as the celestial equator, the ecliptic, the ecliptic latitude circles, the tropics, polar circles, the equatorial and ecliptic poles. The equator and ecliptic are generally drawn as double bands, one band graduated in 1° and the other in 5°. The intervals of 5° are numbered continuously on the equator, but separately for each zodiac sign on the ecliptic. In a few cases, the numbering is done in 6s. The double bands of the equator and ecliptic intersect at the two equinoxes at an angle which is equal to the obliquity of the ecliptic, roughly 23;30°. These intersections of the two bands are drawn ingeniously so that there is no overlap of the degree scales. The ecliptic latitude circles are the six great circles drawn perpendicularly to the ecliptic at 30° intervals so that they divide the entire surface of the globe into twelve zones, each being the house of a zodiac sign. The points of their convergence in the northern and southern hemispheres are the ecliptic poles.

The Tropic of Cancer and the Tropic of Capricorn are drawn to the north and south of the equator and parallel to it at a distance of 23;30°. Again at a distance of 66;30 parallels are drawn to the equator in the north and south; these are equatorial polar circles; the northern one is called the Arctic circle and the southern one the Antarctic. At the centres of these circles are situated the celestial poles or equatorial poles. In a few cases, polar circles are drawn around the ecliptic poles as well.

The names of the zodiac signs are engraved along the ecliptic; in some cases, the names of the 28 lunar mansions are written on the other side of the ecliptic. Likewise, the names of the celestial poles are also engraved as *al-quṭb shamālī* (the North Pole) and *al-quṭb janūbī* (the South Pole).

4.2. Constellation figures

Ptolemy enjoins that the pictorial forms of the constellations as shown on the celestial globes should be as simple as possible so that these figures do not overshadow

the arrangement of the stars which constitute the constellations.[1021] But globe makers paid no heed to this suggestion and tried to display their artistic talents in fully delineating the figures in all the details; in animal figures, great attention is paid in drawing their fur; in human figures still greater attention in drawing their physical features, facial expressions, all the folds of the clothing and ornaments, including the patterns on their knee-length boots.

Some of the constellation figures are anthropomorphic, some are zoomorphic and the others represent inanimate objects. All these are forms are conceived in Greek antiquity and often connected to Greek mythology. The Arabs took over the forms of the figures wholesale, in some cases even the nomenclature (Cepheus = *Qīqā'ūs,* Perseus = *Barsā'ūs,* Delphinus = *Dālfīn,* Cetus = *Qayṭus* and Centaurus = *Qanṭūrus*), but more often they gave their own designations to these constellations.

On Islamic globes, the names of the constellation figures are inscribed next to the figures; these names are preceded by the prefix *ṣūra* (صورة) meaning 'figure' or 'form'. But on Indo-Persian celestial globes the tendency is to employ the Persianized or proto-Urdu form *ṣūrat* (صورت). Ḍiyā's al-Dīn employs consistently *ṣūrat* while his cousin Ḥāmid prefers *ṣūra.* Qā'im Muḥmmad uses both forms rather indiscriminately.

Following are the names of the constellations in the order as listed by Ptolemy.

Table F1 Ptolemaic Constellations on Islamic Globes

	Arabic Name	Translation	Modern Name	Abbreviation
	NORTHERN CONSTELLATIONS			
1	*al-Dubb al-Aṣghar*	the Lesser Bear	Ursa Minor	UMi
2	*al-Dubb al-Akbar*	the Greater Bear	Ursa Major	UMa
3	*al-Tinnīn*	the Dragon	Draco	Dra
4	*al-Qīqā'ūs*	Cepheus	Cepheus	Cep

[1021] Cf. Ptolemy, VIII.3, p. 406.

	Arabic Name	Translation	Modern Name	Abbreviation
5	*al-ᶜAwwā’/ al-Baqqār*	the Howler / the Ploughman	Bootes	Boo
6	*al-Fakkah*	the Crown	Corona Borealis	CBr
7	*al-Jāthī*	the Kneeling Man	Hercules	Her
8	*al-Shulyāq*	the Tortoise	Lyra	Lyr
9	*al-Dajājah*	the Fowl	Cygnus	Cyg
10	*al-Dhāt al-Kursī*	the One with a Chair	Cassiopeia	Cas
11	*al-Barsā’ūs wa Huma Ḥāmil Ra’s al-Ghūl*	Barsā’ūs, that is, Bearer of the Ogre’s Head	Perseus	Per
12	*al-Mumsik al Aᶜinnah*	He who holds the Reins	Auriga	Aur
13	*al-Ḥawwā*	the Serpent Charmer	Ophiuchus	Oph
14	*al-Ḥayyat al-Ḥawwā*	the Sepent Charmer’s Serpent Serpens	Ser	
15	*al-Sahm*	the Arrow	Sagitta	Sge
16	*al-ᶜUqāb*	the Eagle	Aquila	Aql
17	*al-Dālfīn*	the Dolphin	Delphinus	Del
18	*al-Qiṭᶜat al-Faras*	the Part of a Horse	Equuleus	Equ
19	*al-Faras Aᶜẓam*	the Larger Horse	Pegasus	Peg
20	*al-Mar’ah al-Musalsalah*	the Chained Woman	Andromeda	And

	Arabic Name	Translation	Modern Name	Abbreviation
21	*al-Muthallath*	the Triangle	Triangulum	Tri
	ZODIAC SIGNS			
22	*al-Ḥamal*	the Ram	Aries	Ari
23	*al-Thawr*	the Bull	Taurus	Tau
24	*al-Jawjzā'*	the Twins	Gemini	Gem
25	*al-Saraṭān*	the Crab	Cancer	Cnc
26	*al-Asad*	the Lion	Leo	Leo
27	*al-Sunbulah*	the Ear of Wheat	Virgo	Vir
28	*al-Mīzān*	the Balance	Libra	Lib
29	*al-ᶜAqrab*	the Scorpion	Scorpio	Sco
30	*al-Qaws*	the Archer	Sagittarius	Sgr
31	*al-Jadī*	the Goat	Capricorn	Cap
32	*al-Sākib al-Mā'*	the Water-Pourer	Aquarius	Aqr
33	*al-Ḥūt*	the Fishes	Pisces	Psc
	SOUTHERN CONSTELLATIONS			
34	*al-Qayṭus*	Cetus	Cetus	Cet
35	*al-Jabbār*	the Giant	Orion	Ori
36	*al-Nahr*	the River	Eridanus	Eri
37	*al-Arnab*	the Hare	Lepus	Lep
38	*al-Kalb al-Akbar*	the Greater Dog	Canis Major	CMa
39	*al-Kalb al-Aṣghar*	the Lesser Dog	Canis Minor	CMi

	Arabic Name	Translation	Modern Name	Abbreviation
40	*al-Safīnah*	the Ship	Argo Navis[1022]	Pup, Vel, Car
41	*al-Shujāᶜ*	the Serpent	Hydra	Hya
42	*al-Bāṭiyah*	the Jar	Crater	Crt
43	*al-Ghurāb*	the Raven	Corvus	Crv
44	*al-Qanṭūrus*	the Centaur	Centaurus	Cen
45	*al-Sabᶜ*	the Wild Beast	Lupus	Lup
46	*al-Mijmarah*	the Incense Burner	Ara	Ara
47	*al-Iklīl al-Janūbī*	the Southern Crown	Corona Australis	CrA
48	*al-Ḥūt al-Janūbī*	the Southern Fish	Piscis Austrinus	PsA

In this list, nos. 1 to 21 are the constellations of the northern hemisphere; nos. 34 to 48 are those in the southern hemisphere, and the remaining twelve from 22 to 33 are the zodiac signs situated along the ecliptic. On some globes these three groups are numbered separately.

The 48 figures can be classified as follows. Fourteen figures are anthropomorphic: 11 of these are male and 3 female. Twenty-four figures are zoomorphic: 12 animals, 4 birds, 8 reptiles. Ten represent various inanimate objects and the river Eridanus.

Human Male figures: 4 Cepheus, 5 Bootes, 7 Hercules, 11 Perseus, 12 Auriga, 13 Ophiuchus, 24 Gemini, 30 Sagittarius, 32 Aquarius, 35 Orion and 44 Centaurus.

Human Female figures: 10 Cassiopeia, 20 Andromeda and 27 Virgo.

Animal figures: 1 Ursa Minor, 2 Ursa Major, 18 Equules, 19 Pegasus, 22 Aries, 23 Taurus, 26 Leo, 31 Capricorn, 37 Lepus, 38 Canis Major, 39 Canis Minor, and 45 Lupus

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[1022] In modern times, this constellation has been divided into Puppis (Pup), Vela (Vel) and Carina (Car).

Bird figures: 9 Cygnus, 16 Aquila, 34 Cetus, and 43 Corvus.

Reptile figures: 3 Draco, 14 Serpens, 41 Hydra, 25 Cancer and 29 Scorpio.

Fish figures: 17 Delphinus, 33 Pisces and 48 Piscis Austrinus.

Inanimate Objects: 6 Corona Borealis, 8 Lyra, 15 Sagitta, 21 Triangulum, 28 Libra, 36 Eridanus, 40 Argo Navis, 42 Crater, 46 Ara and 47 Corona Australis.

The relative positions of the constellation figures can be seen in Figures F6 and F7. Besides the astronomical significance of the constellations, their figurative depiction is of interest for comparative mythology and for art history. On the basis of the iconography of the figures it is possible to situate the globe in a particular craft tradition.

Savage-Smith has given a very valuable and detailed description of the constellation figures, their forms as conceived in Greek Antiquity and in Bedouin traditions, and how these traditions coalesced in the Islamic globes and influenced the nomenclature of the constellations and the stars that constituted the constellations.[1023]

This may be illustrated with the following example. In the Greek tradition, the constellation Ursa Major is conceived as bear, and also as a cart. But the Bedouin tradition saw the four stars on the body of the bear (αβγδ) as a bier or the plank to carry the corpses on (*al-naᶜsh*), and the three stars on the tail (ε ζ η) as the three mourning daughters (*al-banāt*) of the deceased who follow the bier. Again, the twin stars in each of the four paws are imagined to be the tracks made by the cloven hoof of a deer when it is running away from the lion. Although, the constellation is represented as a bear on Islamic globes, the names of the different stars reflect these Bedouin images.[1024]

Of the three stars on the tail, the middle one ζ is accompanied by a very small star next to it (*g*, Alcor). It was not listed by Ptolemy, therefore al-Ṣūfī called it *al-Suhā* (the overlooked one) and added that this is the star by which men tested their vision.[1025]

The Sanskrit tradition sees these seven stars as the seven patriarchal sages, the most venerable of them being Vasiṣṭha, represented by ζ. The faint star next to it is imagined to be his wife Arundhatī. At marriage ceremonies, this star is shown to the

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1023 Savage-Smith 1985, ch. 5, pp. 114-212.

1024 Cf. Savage-Smith 1985, pp. 134-136, Fig. 50; see also Figure F004.2 and the related description.

1025 See Figure F027.3.

bride with the advice that she should follow the example of Arundhatī and follow the husband in all his endeavours. [1026]

Another notable example is the Bedouin tradition of a huge female form of *al-Thurayyā*: her head is situated in the region of the cluster of stars Pleiades (also called *al-Thurayyā*); her right arm passes through the constellations of Perseus and Cassiopeia, and the left hand through the head of Cetus. Therefore certain stars in these three constellations have names associated with this *al-Thurayyā*: the star on the elbow of Cassiopeia is associated with the hand of *al-Thurayyā* which is stained with henna and is therefore named *al-Kaff al-Khaḍīb,* 'the dyed hand'. The other hand is visualised on the head of Cetus and a star situated there is given the name *al-Kaff al-Jadhmā,* 'the cut-off hand', apparently because no star group connects the hand with *al-Thurayyā.* In the constellation of Perseus, several stars are associated in a like manner with *al-Thurayyā.*[1027]

A third case worth mentioning is the Bedouin conception of another giant female named *al-Jawzā'* which occupies the region of Gemini (also called *al-Jawzā'*) and of Orion. Consequently many stars in the constellation Orion carry names associated with this giant *al-Jawzā'*.[1028]

4.3. Stand

The stand consists of a horizon ring supported by three or four legs. In order to adjust the globe for the latitude of a place where it is used, a meridian ring is attached at right angles to the horizon ring. Both the rings are graduated in 1° and in 5° or 6°. In many cases, the four cardinal points are marked on the horizon ring. For adjusting the globe at the right latitude, the axis of the globe is affixed to the meridian ring and holes are bored on the meridian ring at degrees frequently used.

[1026] There are also other popular conceptions regarding these seven stars: in the US, these are known as the 'big dipper', in UK as the 'plough' and in Europe as the 'great cart'. But these conceptions did not generate and any special names for the individual stars.

[1027] Cf. Savage-Smith 1985, pp. 122-124.

[1028] Cf. Savage-Smith 1985, pp. 124-125; 190-191.

Since the stands are made separately from the globes, they get detached in course of time and are lost. Therefore, often the surviving celestial globes are without stands; even if the stands survive, they are often without the meridian rings.

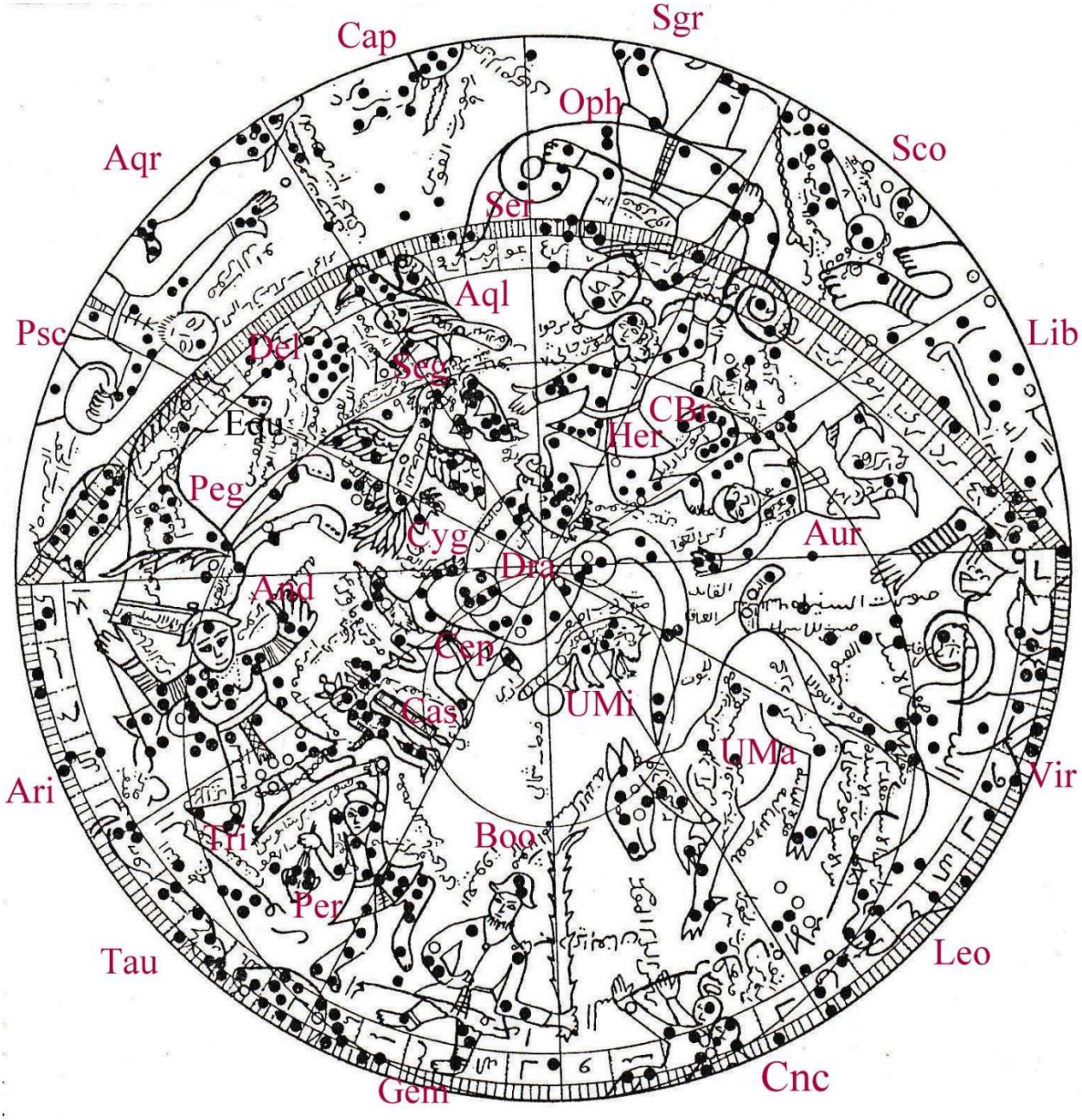


Figure F7 – Schematic Drawing of the Northern Hemisphere on globe F018.

The ecliptic forms the outer periphery and centre is the northern ecliptic pole. The northern celestial pole is at the centre of the smaller circle below the ecliptic pole. The vertical diameter joining these two centres is the solstitial colure and the horizontal diameter the equinoctial colure. The figures of the zodiac signs are partly obscured by the ecliptic scale. (from Klüber 1935, the names of the constellations have been added by us).

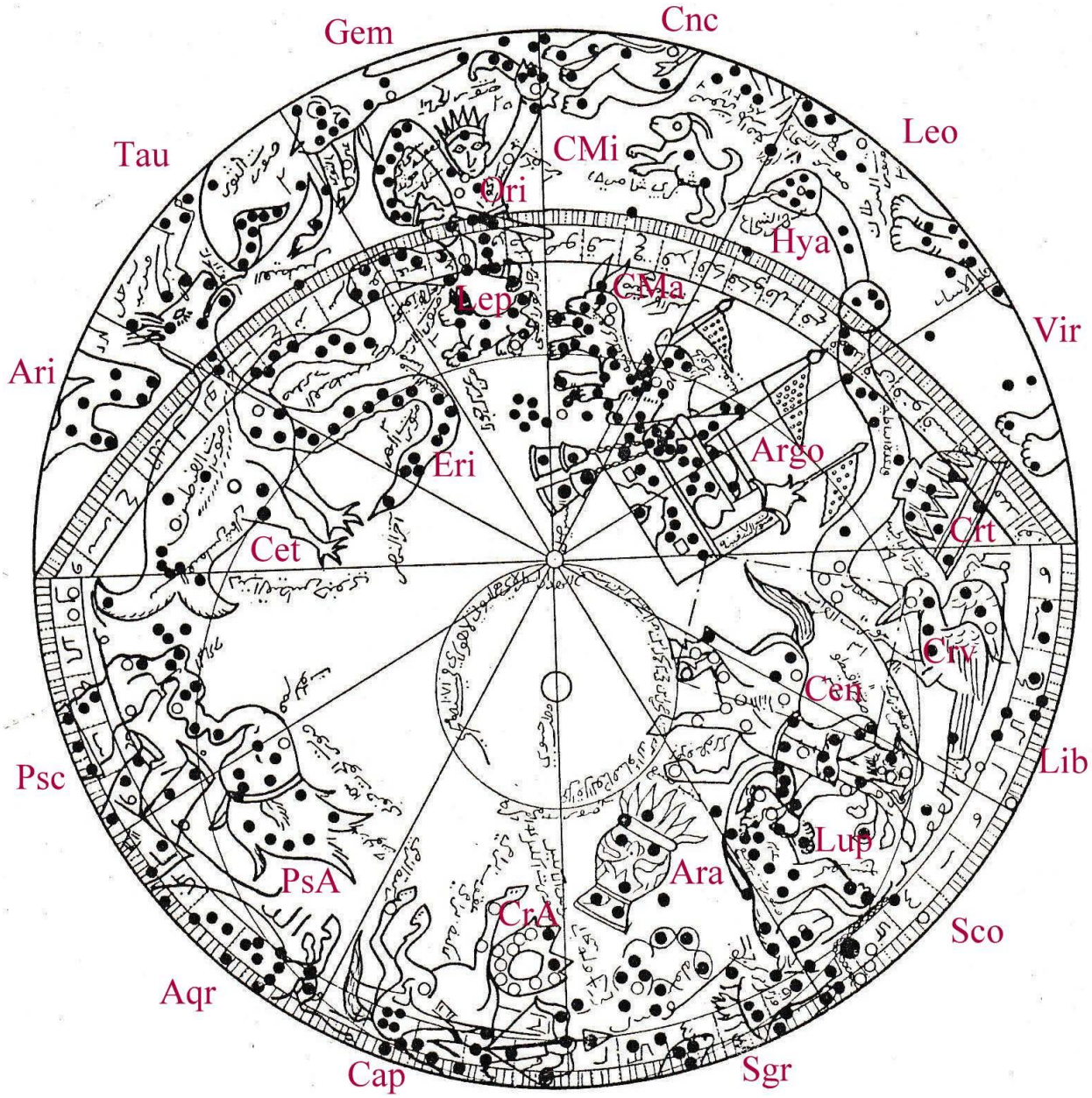


Figure F8 – Schematic Drawing of the Southern Hemisphere on globe F018.

The ecliptic forms the outer periphery and the southern ecliptic pole the centre. The southern celestial pole is at the centre of the smaller circle below the ecliptic pole. The vertical diameter joining these two centres is the solstitial colure and the horizontal diameter the equinoctial colure. The figures of the zodiac signs are partly obscured by the ecliptic scale. (from Klüber 1935, the names of the constellations have been added by us).

5. The Celestial Globe in India

It is difficult to say precisely when the celestial globe reached India. The earliest mention of the celestial globe occurs rather late in connection with the Mughal ruler

Humāyūn in the middle of the sixteenth century.[1029] Humāyūn's interest in the celestial globe is revealed in an anecdote narrated in the *Akbarnāma*:

> 'When Humāyūn reached Tabrīz during his journey in Persia, he ordered his slave Pik Muhammad Akhta Begi to search for a celestial globe – *kura* -- in that city, as he was very keen about astrolabes, globes and other observatory instruments. In Persian *kura* means a colt, so his simple slave obeyed the orders by bringing a number of colts to the royal presence. The king laughed when he saw the multitude of colts and mares before him, and bought them all the same as a good omen.'[1030]

But this does not mean that the celestial globe was completely unknown in India until the middle of the sixteenth century. Manuscript copies of al-Ṣūfī's very popular book must have reached India along with other Arabic texts on astrolabes and must have been copied.

Moreover, the Jaina monk Mahendra Sūri, who produced the first Sanskrit manual on the astrolabe in 1370 at the court of Sulṭān Fīrūz Shāh Tughluq at Delhi, gives a list of 32 astrolabe stars with their Sanskrit names. Many of the names are translated or adopted from the Arabic. But *Samudrapakṣī* (literally 'sea-bird'), the name given by Mahendra to the star ι Ceti is not a translation of the Arabic name *Dhanab al-Qayṭus Shamālī* which means 'the northerntail of Qayṭus'. Here Qayṭus is a mere transliteration of the Greek name, but it does not say anything about the nature of the figure. That it is a weird bird-like creature related to the sea could be known only from the illustrations in al-Ṣūfī's treatise or from an actual globe. Likewise, α Geminorum is known in the Arabic as *Ra's al-Taw'am al-Muqaddam* (the head of the foremost twin). Mahendra Sūri's Sanskrit name *Prathama-bāla-śīrṣa* (head of the first boy) implies the visual knowledge of the figure of Gemini as a pair of male infants on an Islamic celestial globe; in Sanskrit tradition, on the other hand, Gemini (Skt. *Mithuna*) is conceived of as an adult pair of man and woman.

1029 Sarma 1994c.

1030 Akbarnāma, 1, p. 445. Steingass, s.v. كره *kura,* a globe, a thing spherical, …; *kurra,* The colt of a horse, camel or ass (one or two years old).

Be that as it may, like the astrolabes, the first extant celestial globes in India belong to the sixteenth century.

5.1. The Lost-Wax Casting

Through her survey of all extant Islamic celestial globes, Emilie Savage-Smith made the important discovery of a significant difference between the celestial globes made in India and those made outside. Outside India, the celestial globe was made first as two hollow hemispheres and then these two were joined at the celestial equator. But in India, the globe is cast as a single hollow sphere by the *cire perdue,* or the lost wax, method.[1031]

The lost wax process of metal casting has a long history in India. The 110 mm high bronze figure, popularly known as the 'dancing girl' is considered to have been cast by the lost wax process in the Indus Valley culture at Mohenjo Daro around 3500 BC; other examples from this culture include buffalo, bull and dog, and some copper figurines. In classical period, countless metal hollow statues were produced throughout India, Nepal and Tibet for worship in temples. Several Sanskrit texts on sacral art describe the method of casting icons by the lost-wax process which is termed *madhūcchiṣṭa-vidhāna* in Sanskrit.[1032] Even today, this method is practiced in many places including Tamil Nadu in the south and Nepal in the north.[1033] Many tribal communities in central India also produce small decorative or cult objects by this method.[1034]

It is, therefore, not surprising that in India celestial globes began to be cast as single hollow spheres by this method. In this process, some holes are left in the sphere for removing the core after the casting is done. These holes are subsequently covered

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1031 On the technique of casting the celestial globes by the *cire perdue* method, see Savage-Smith 1985, pp. 90-95.

1032 Michaels 1986 translated the relevant passages from three Sanskrit texts: the *Mānasollāsa* composed by Western Chalukyan monarch Someśvara ca. 1129, the *Mānasāra* of unknown authorship and the *Śilparatna* of Kumāra (16th century) and discussed these on the basis of his practical observations of the craft as practised in Nepal.

1033 Michaels 1988.

1034 There are several anthropological and technical studies on this aspect such as Ruth Reeves, *Cire Perdue Casting in India,* New Delhi 1962.

by plugs. Often such plugs have a higher copper content and look darker than the surrounding area. After the globe is cast, its outer surface is smoothened and on this surface are engraved the circles, scales, constellation figures and the legends. Silver nails of different sizes are inlaid to indicate the positions of stars.

It is not known who began this method of producing celestial globes in India. Like the astrolabes, the first extant celestial globes belong to the sixteenth century. The earliest extant celestial globe (G001) was signed by a certain ᶜAlī Kashmīrī ibn Lūqmān in 998 AH in the thirty-fourth regnal year of Akbar (AD 1589-90).[1035] The globe is a seamless hollow sphere with four plugs. The equator and the ecliptic are indicated by single lines on which dots are made at intervals of 2°, but without any numbers. Names of zodiac signs are engraved along the ecliptic in small letters and these names do not extend to the entire length of the zodiac sign. However, we do not know where this ᶜAlī Kashmīrī worked. His *nisbāh* of 'Kashmīrī' need not necessarily mean that his workshop lay in Kashmir. No other astrolabe or celestial globe manufactured in Kashmir came to light so far.[1036]

5.2. The Lahore Family

Even though the technique of casting celestial globes as single hollow spheres by the lost-wax process may have begun earlier in India, it is to the credit of Qā'im Muḥammad of the Lahore family to have perfected this technique and to have firmly established it as the standard method for India. There are extant today some 33 celestial globes made by him, his brother Muqīm, and their respective sons Ḍiyā' al-Dīn and Ḥāmid between the years 1623 and 1691.

Only one instrument maker outside the Lahore family is known to have produced Indo-Persian celestial globes in the seventeenth century. It is Muḥammad Ṣāliḥ of

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1035 Savage-Smith 1985, no. 10, pp. 223-224, Figs. 11 (inscription) and 69 (autumnal equinox with figures Leo, Virgo, Bootes and Centaurus.

1036 Savage-Smith 1985, lists three seamless globes (no. 6, p. 220, signed by Muḥammad ibn Maḥmūd al-Ṭabarī, dated 684 AH; no. 60, pp. 247-248, made by ᶜAbd al-Raḥmān ibn Burhān al-Mawṣilī dated 718 AH; and no. 9, p. 223, by Jamāl al-Dīn Muḥammad [ibn] … al-Dīn Muḥammad al-Hāshimī al-Makkī of 981 AH) which carry dates earlier than the date of ᶜAlī Kashmīrī's globe, but concludes (p. 34) that these are very inaccurate and of poor quality and are possibly copies made at a later date.

Thatta, whose seven astrolabes have been discussed earlier (B008 - B014); five celestial globes by him are extant. But the tradition of producing celestial globes by the *cire perdue* process continued up to the middle of the nineteenth century, when Lālah Buhlomal Lāhūrī[1037] produced ten rather large-sized celestial globes, with inscriptions either in Persian, or in Sanskrit, or in English.[1038]

There are also extant several unsigned and undated globes; these are of three kinds: globes with the full set of 48 constellation figures and 1020 stars; globes with the reference circles and a limited number of stars; globes with just reference circles.[1039]

On the quality of globes produced by this process in India, Savage-Smith remarks as follows:

> 'The precision and the uniformity in the sphericity of a seamless globe cast by *cire perdue* is impressive. The workshops in the Punjāb and western Himālayas seem to have specialized in this extraordinary technique of producing celestial globes from the sixteenth through the nineteenth centuries. Only pride of craftsmanship could have justified the enormous expenditure of time and effort that went into such a technique, when simpler methods using hemispheres had long been available. The products of these Indian workshops display admirable skills on the part of the artisan in forming a nearly perfect sphere and inscribing it accurately and precisely.'[1040]

Indian celestial globes are not only accurate, they also seem to be more durable than those made in two hemispheres. Of the 58 extant celestial globes which carry constellation figures and star positions listed by Savage-Smith, as many as 35 are single hollow spheres produced in India.[1041]

1037 For his astrolabes, see B021 - B026; C029 - C030.

1038 Sarma 2015b, pp. 271-278.

1039 Indo-Persian astrolabes produced outside the Lahore family will be discussed in the next section G.

1040 Savage-Smith 1985, p. 95.

1041 Savage-Smith 1985, p. 43: 'In terms of the number of extant Islamicate celestial globes, this family is also important. Their workshop claims 21 signed globes — the largest number from a single shop. Moreover, it is very likely that not only the anonymous globe now at the Smithsonian Institution (No. 38) but also a considerable number of other Indo-Persian seamless metal globes could be attributed to this workshop, including Nos. 39-44.'

5.2.1. Qā'im Muḥammad

Besides the nine astrolabes signed by or attributable to Qā'im Muḥammad which have been described earlier (A009 - A017), there are extant today five celestial globes made by him between the years 1623 and 1637. Only two of these are with the original stand; interestingly these two stands are made in two different styles, one with straight legs resting on a lobed ring (F003) and the other with curved legs without any base (F005).[1042]

On these globes, the equator and ecliptic are drawn as two parallel bands, one band divided in 1° and the other in 5°. The equator is numbered from 5 to 360, but the ecliptic from 5 to 30, separately in each sign. There are ecliptic latitude circles, but no tropics or polar circles. Holes are bored at the celestial poles. The maker's signature and the dedication are engraved in the form of an arc around the ecliptic pole.

All the 48 constellation figures are drawn along with their names and the positions of about 1020 stars are marked with inlaid silver points. In an inscription on the globe of 1637 (F005), Qā'im Muḥammad states that he had added 3° to the star longitudes given by Mirzā Ulugh Beg so that the positions on the globe correspond to the year of manufacture. Perhaps the star positions on the other globes of his also were adjusted in this manner.

Celestial poles and some major stars are named. The names of the constellations are preceded by the term *ṣūrat* (spelt Arabic style as صورة, but in a few cases spelt in Persian or proto-Urdu style as صورت). In F005, the names of the figures of the zodiac signs are preceded by *ṣūrat burj* (figure of the zodiac sign).

However, Qā'im's celestial globes, though impeccable in construction, are highly disappointing as far as the technical and aesthetic quality of the constellation figures are concerned, especially in view of his innovations in astrolabe design and his extraordinary talent in producing them, in particular, the magnificent calligraphic rete of A013. The animal figures like the bear in Ursa Major and Ursa Minor or the lion in

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[1042] These two styles are emulated by Qā'im's son Ḍiyā' al-Dīn in his globes.

Leo, the reptiles Draco, Hydra and Serpens (sometimes with scales sometimes without), and the figure of the boat with an oversized figurehead in Argo Navis are passable.[1043]

But in drawing human figures, Qā'im Muḥammad shows absolutely no talent. These figures are drawn in careless outlines and are often anatomically inexact. The faces are drawn in full front, but neither the eyes, nor the nose, nor the mouth have any resemblance to human features. Particularly unattractive is the depiction of the nose, with three irregular holes. The mouth is indicated by a curved line which is too large for the face with a small dot below to indicate the extent of the lower lip.

Generally the human figures, whether male or female (e.g. Hercules, Sagittarius, Perseus, also Andromeda) are clothed in a stereotyped tunic with flared skirt which is held at the waist by a stereotyped belt and buckle. Sometimes the sleeves are indicated by two parallel lines on the wrists. Sometimes these are omitted with the result that the figures appear naked in the upper half.

Furthermore, when one compares the three globes F001, F004 and F005, a gradual deterioration in the quality of the constellation figures can be discerned; the figures become more rudimentary with less detail.

5.2.2. Muḥammad Muqīm

Qā'im's brother, Muḥammad Muqīm is well known for his large number of astrolabes (A018 - A058), but only two celestial globes by him are known. One is said to be in a private collection at Kuwait (F006), but no details are available about the circles or the constellation figures drawn on this globe. The other is now with the Museum of Islamic Art at Doha; it is richly engraved with very elegant constellation figures (F007).

5.2.3. Ḍiyā' al-Dīn Muḥammad

As in the case of astrolabes, so also in the production of celestial globes, Ḍiyā' al-Dīn Muḥammad is the most prolific member of this family. Besides the forty-six astrolabes described above (A059 - A104), he produced the largest number of celestial

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[1043] In fact, his highly talented son Ḍiyā' al-Dīn imitated the father's basic designs of these figures, occasionally embellishing them.

globes attributable to a single instrument maker. There are extant nineteen globes signed by him and six that can be attributed to him on stylistic grounds. Like his astrolabes, his celestial globes are also of different sizes with diameters ranging from 60 mm to 217 mm.

Chronologically the last globe made by him in 1090/1679 (F026) for the Mughal Emperor Aurangzeb is not a conventional celestial globe cast by the lost wax method, but an openwork globe made in two hemispheres and then joined together. Leaving this aside, all his other globes carry the equator and ecliptic in two bands, generally divided in 1° and 5°; the equator is numbered continuously from 5 to 360 starting from the vernal equinox onwards, while the ecliptic is numbered from 5 to 30 separately in each sign. On three small globes (F017, F023, F024), divisions are marked at 2° and 6°. There are ecliptic latitude circles, equatorial tropics and equatorial polar circles. Signature is engraved almost in a full circle inside the Antarctic circle.

In all the globes save four (F011, F017, F023 and F024), the full set of 48 constellation figures is drawn and the positions of about 1020 stars are indicated by inlaid silver points. The labels of the figures are prefixed with *ṣūrat* spelt in proto-Urdu style (صورت). The labels also contain the serial numbers of the constellations. Ḍiyā' numbers the northern constellations from 1 to 21, the zodiac signs from 1 to 12 and then the southern signs from 1 to 15. On some globes, he also numbers the stars within each constellation.

In the case of animal figures and others like Argo Navis, he follows Qā'im's basic design with some embellishments or variations. For example, in the figure of Argo Navis, variations can be seen in the design and in the number of the pennants, in the design of the pavilion at the back, in the design of the two oars, and in the figureheads. The figureheads are generally shaped like lion's heads, but on globe F009 it is formed like a parrot's heads, looking backwards.

Ḍiyā' al-Dīn makes a radical departure from his father's rendition of human figures: here he is largely influenced by his uncle Muḥammad Muqīm. There is a great stylistic affinity between Muqīm's constellation figures on globe F007 and Ḍiyā' al-Dīn's figures on several globes, in particular F009 and F029. His outlines are bold and anatomically correct; the clothing and jewellery are drawn with great detail, the faces are often in three-quarters profile, with clear depiction of the eyebrows, eyes, nose and

mouth. The eyes are almond shaped with hatched circles for pupils. In many cases, the womanhood of Virgo and Andromeda is indicated by the outlines of their breasts. Even though he is unaware of the mythological context of the figures, he infuses their postures and faces with the correct expression. Technically and aesthetically his constellation figures are comparable to the human figures in contemporary Mughal miniature paintings.

But sometimes unfamiliarity with the mythological background leads to embarrassing depictions. Following the Greek convention, the two figures of Ophiuchus and Hercules are drawn on Islamic globes with short skirt-like kilts. Sometimes, the outlines of Hercules's arms end in half-circles on his chest (e.g. on F028[1044]). Later, either Ḍiyā' al-Dīn himself or one of his assistants developed these half circles into feminine breasts on three globes (F019 at Hyderabad, F020 at Edinburgh and F027 at Rampur[1045]). It is probably such depictions which led to the designation of the figure of Hercules *Nṛtya-kālī-mūti* (figure of the dancing goddess Kālī) on the Sanskrit globe H001 and the star α Herculi as *Nṛtya-kālī-śira* (head of the dancing goddess Kālī) on the Sanskrit astrolabe D013.

But in general, Ḍiyā' al-Dīn's iconography of constellation figures is emulated in the few Sanskrit globes.

Ḍiyā' al-Dīn made an interesting innovation in the design of the meridian ring. In F008, the thickness in one half of the meridian ring is reduced so that there is recess between the ring and the globe. At the mid-point of the thinner half on the inner side is attached an arc of 90° which is graduated in single degrees. This arc can be rotated along the surface of the globe and can be used in measuring the altitudes. In the mid-ninettenth century, Lālah Bulhomal of Lahore introduced this feature, with slight variations, in five globes (G010, G011, G016, G017 and H004).

1044 See Savage-Smith 1985, Fig. 54.

1045 This is the main reason why I attributed this globe to an unknown globe-maker in my Rampur catalogue (Sarma 2003, pp. 65-72). At that time, I did not yet study the images on the globes at Hyderabad and Edinburgh.

5.2.4. Ḥāmid

Just three celestial globes by Ḥāmid are extant (F033 - F035), but none with the original stand. Again, of these three only one carries constellation figures.

On all the three globes the equator and the ecliptic are represented by double bands, but there are variations in the graduations. On F033, the two circles are divided in 1° and 5°, while on the other two globes, they are divided in 1° and 6°. The equator is not numbered continuously, but in two batches from equinox to equinox, as 5 … 180, or 6 … 180. On the ecliptic the numbering is done separately in each zodiac sign. There are ecliptic altitude circles, but no tropics or polar circles. Like Qā'im, Ḥāmid also engraves his signature in an arc around the southern ecliptic pole on F033 and F034, but around the southern celestial pole on F035.

Globes F033 and F035 are without any constellation figures. On F034, all the 48 constellation figures are drawn and the positions of about 1020 stars indicated. The human figures are depicted as contemporary men and women of distinction and not as figures of mythology. Thus Hercules and Ophiuchus, placed head to head, are draped in contemporary Mughal clothing; elaborate turbans, knee-length flared tunics with long sleeves, tight trousers and pointed boots. Most unusually, Leo is depicted as a tiger with stripes.

Star positions are indicated on all the three globes, but in a different manner on each globe. On F033 about 67 stars are marked by inlaid silver points on which are engraved dots within circles; on F034 all 1020 stars are shown in two different styles and on F035 a smaller number of stars in three different styles.

6. The Smithsonian Globe and its Attribution

The National Museum of Natural History at Washington DC, a Smithsonian institution, acquired in 1972 an unsigned and undated celestial globe engraved in Arabic. In order to understand the milieu and the context in which this globe was produced, Emilie Savage-Smith studied a vast range of Arabic texts on the celestial globe and astrolabe and surveyed all the Islamic celestial globes extant all over the world. Her study resulted in the path-breaking work *Islamicate Celestial Globes: Their History, Construction, and Use* in 1985. On the basis of her exhaustive study of the historical antecedents of the globe and on the basis of the linguistic and technical features of the globe, she came to the conclusion that the globe is attributable to Qā'im

Muḥammad of the Lahore family. The art-historian Andrea P. A. Belloli of the Los Angeles County Art Museum studied the iconography of constellation figures on the globe, compared them with the constellation figures in the two globes signed by Qā'im Muḥammad which are now with the Stonyhurst College (F001) and the Victoria and Albert Museum of London (F003), and also contemporary Mughal miniature paintings and came to the same conclusion. Her art-historical analysis is included as Chapter 4 of the above-mentioned book. But surprisingly neither scholar made an attempt to closely compare the Smithsonian globe with the globes produced by Qā'im Muḥammad's son Ḍiyā' al-Dīn. Had they done so, they would have seen that the Smithsonian globe shows greater similarity with the globes produced by Ḍiyā' al-Dīn rather than with the globes of his father Qā'im Muḥammad.

While discussing the evidence presented by these two scholars for the attribution of the Smithsonian globe to Qā'im Muḥammad, it should be borne in mind that the Lahore family produced a large body of instruments of which some 134 astrolabes and 33 celestial globes are extant today. Some of these were made for high dignitaries at the Mughal court, including the Emperors Shāh Jahān and his successor Aurangzeb. The family must have maintained a large workshop at Lahore as Savage-Smith rightly assumes.[1046] But we do not have any idea how many people were employed there and what their individual task were. The finished products bore the names of the family members but not the names of any of the assistants. In the case of the astrolabes, it was shown that occasionally there are discrepancies in the astrolabes signed by the same person, with regard to the latitudes of localities, the maximum number of the daylight hours, or even in the symbols used for zero.

Secondly, Mughal miniatures, unlike any other group of art work in India, provide much visual information about the material culture of the Mughal court, like the architecture, furniture, clothing and so on. At the same time, not every depiction can be

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[1046] Cf. Savage-Smith 1985, p. 34: 'This particular family of metalworkers from Lahore excelled in certain metallurgical techniques, in particular the production of hollow cast globes. The variety in the techniques and designs of the engraved images on the globes suggest that the family maintained a workshop of metalworkers and apprentices, in which several people would perhaps be involved in the production of an instrument which nevertheless bore only the name of the family members supervising the production.'

taken as a photographic record of the real life. In 1992, I made a study of the astronomical instruments shown in Mughal miniature paintings.[1047] My study brought to light, for the first time, the only two cases of the pictorial representation of the ubiquitous sinking bowl water clock, but rarely any image of the astrolabe which was held in high esteem in the learned circles of Muslims. There are several paintings depicting the assemblage of astronomers measuring time and preparing the horoscope of the new born royal prince; the astronomers in these paintings are depicted more often with an obscure ring dial which is hardly mentioned in literature than with the astrolabe. With this caveat, we shall now discuss the evidence for the attribution of the celestial globe to Qā'im Muḥammad.

6.1. Technical and Linguistic Evidence

Savage-Smith lists six technical and linguistic features which occur on the Smithsonian globe and on Qā'im Muḥmmad's two signed globes at the Stonyhurst College and at the Victoria and Albert Museum of London, in support of the attribution of the Smithsonian globe to Qā'im Muḥammad:

> '[i] In Ursa Major the stars on the lower front paw are labelled *tatimmat qafzah al-thālithah* (the complement of the third lap), while [ii] Pegasus the star in the northernmost hoof bears undeciphered label, *mrhlt al-faras.* Furthermore, [iii] in the constellation Perseus the star name written on the sword held overhead is written as *muʿtaṣam al-thurayyā* (the refuge of the Pleiades), which must be a misspelling of *miʿṣam al-thurayyā* (the wrist of Pleiades). These terms are not known to occur in any star catalog nor on any globes or astrolabes except the globes No. 11 and No. 13 made by Qā'im Muḥammad ibn ʿĪsā ibn Allāhdād Asṭurlābī Lāhūrī Humāyūnī made in 1032 H/AD 1622-1623 and AD 1626-1627 … [F001 and F003]. On both of these globes the identical terms are clearly inscribed. Two other globes by Qā'im Muḥammad (Nos. 12 and 14 [i.e., F004 and F005]) were not available for detailed study, and it is not known if these terms occur on them as well. […]

1047 Sarma 1992a.

> ‘[iv] The positioning of the sequence of the lunar mansions along the ecliptic as done on the Smithsonian globe is known to occur on only one other globe, that being the earliest globe made by Qā’im Muḥammad (No.11). On these two globes, the first lunar mansion is placed at 13° House of Aries with the twenty-eighth lunar mansion at the vernal equinox, in contrast to the usual arrangement, in which the first mansion is at the vernal equinox and the second about 13° House of Aries. […]
>
> ‘[v] Moreover, the maker of the Smithsonian globe has numbered the ecliptic continuously from the vernal equinox. On all other globes but one the graduations of the ecliptic are numbered in 30° intervals. This one exception is again the earliest globe by Qā’im Muḥammad (No. 11) where he labels the ecliptic continuously from the vernal equinox as well as giving it a second set of numbers which divide it into 30° intervals.
>
> ‘[vi] Finally, the star positions on the Smithsonian globe are identical to those on the globes of Qā’im Muḥammad that have been examined.’[1048]

These are undoubtedly very carefully made observations, but they cannot be treated as unique characteristics of Qā’im’s globes. That they occurred in the Smithsonian globe as well as in one or two globes signed by Qā’im is a mere coincidence and does not establish conclusively that the Smithsonian globe was made by Qā’im Muḥammad and not by his son Ḍiyā’ al-Dīn who continued the family profession obviously in the same workshop and possibly with some of the assistants who worked also with his father. Moreover, some of the features like [iv] and [v] are clearly engraving errors; these do not occur on F004 and F005 which carry the signature of Qā’im Muḥammad.

Finally, Savage-Smith offers a possible reason why this one particular globe is without signature while all other globes of this family which she had examined carry signatures and dates:[1049]

[1048] Savage-Smith 1985, p. 97.

[1049] Savage-Smith 1985, p. 98.

> ‘It is quite probable that the maker, after completing the tedious construction of the sphere and the precise placement of the stars, the drawing and graduation of the great circles, delineation of the constellation figures and labeling of the stars, began to draw the equatorial tropic circles. In the northern hemisphere of this globe a lesser circle parallel to the equator but not in the position of the Tropic of Cancer was partially drawn (see Figures 73 and 76). It would seem that having started to draw the tropics, the maker discovered that he had placed the northern circle too far from the equator. For this reason the maker may have stopped incising the circle and ceased work altogether on the globe, for such an error in engraving would be impossible to correct. This may well be the reason the globe bears no maker's signature and date, which were no doubt the last items to be added to a globe.’

There is indeed an unfinished small circle in the northern hemisphere but, if it was the northern tropic drawn at a wrong place, was that drawn as the last item of engraving?

One would have thought that the globe-maker would first draw the reference circles including the tropics and mark the star positions with silver points and only then would proceed to draw the constellation figures around the star pointers and finally engrave the labels. In any case, this is not the only instance when an instrument produced at the Lahore workshop was left unsigned. Savage-Smith has not surveyed the astrolabes produced by the family, which is done in the present catalogue. Of the 134 astrolabes produced by this family, there are several astrolabes which are signed, but not dated, and a still larger number which are neither signed nor dated. These show no defects or short-comings. Therefore, it is futile to speculate why certain astrolabes were not dated or why certain astrolabes or celestial globes carry no inscription at all.[1050]

6.2. Art-Historical Evidence

The art-historian Belloli sets out to study the ‘iconographic peculiarities of the figures [on the Smithsonian globe] and their relation to counterparts on earlier and

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[1050] This is true not only of the products of the Lahore family, but of several other instrument-makers as well, such as Bulhomal and Ṣāliḥ who also left some instruments without signatures.

contemporary globes; and the significance of contemporary factors relevant to the globe's manufacture,' the contemporary factors being Mughal miniature paintings. She describes the various constellation figures on the Smithsonian globe in great detail; she notes how the human figures are delineated and their garments are represented and how the animal figures are represented. Of the other figures, she pays special attention to the figure of the ship in Argo Navis.

Finally, she comes to the astonishing conclusion that: 'A stylistic comparison between the Smithsonian globe figures and those on the other celestial globes listed in the catalog indicates an extremely close affinity between the Smithsonian figures and those on the globes (Nos. 11 and 13) signed by Qā'im Muḥammad.'

It is difficult to see where this 'extremely close affinity' lay. As we have mentioned above, the human figures in the globes signed by Qā'im Muḥammad in 1623 and 1627 (which Belloli has seen) and also in the globes of 1629 and 1637 (which Belloli has not seen), are anatomically very inexact, which is not the case with the human figures of the Smithsonian globe. Belloli concedes that 'the faces on Qā'im Muḥammad's figures differ somewhat in their idiosyncratic rendition from those on the Smithsonian globe' but insists that 'in all other ways the figures on the three globes are almost identical'.

It is again difficult to see what these 'other ways' are. On the Smithsonian globe, the garments worn by the human figures are very carefully represented. On the four globes signed by Qā'im Muḥammad, no great effort was made in this regard. In this connection, Belloli asserts that a sash tied at the waist with one loop is the most decisive factor not only in identifying the maker of the Smithsonian globe but also in fixing the precise time of its manufacture:

> 'A survey of paintings done under Akbar and Jahāngīr shows single-looped sashes occurring in works dated or attributed to the years between AD 1583 and 1610 [fn. 53]. This suggests that such sashes were popular during Akbar's reign and that fashion died out completely shortly after Jahāngīr gained the throne.

> 'A preference for the single-looped sash worn by itself on Qā'īm Muḥammad's globes[1051] suggests that he must have begun work as a maker of celestial globes during the reign of Akbar, continuing under Jahāngīr without adjusting his mode of dressing the constellation figures to mirror changes in the contemporary male fashions. Such a theory fits quite well with the generally conservative picture we have constructed of Qā'im style, especially in comparison to that of his son. In any event, Qā'im's particular modification of outfit standards for male constellation figures on earlier globes to reflect contemporary garb justifies a dating of the Smithsonian globe to the first quarter of the seventeenth century or slightly earlier.'[1052]

Assuming that the fashion of the single-looped sashes really died out after Jahāngīr ascended the throne, and assuming further that Qā'im Muḥammad's globes reflect the sartorial fashions of the Mughal court precisely by the year, how does one then explain the fact that Ḍiyā' al-Dīn depicts Andromeda with a single-looped sash in his globes of 1663 at Hyderabad (F019) and Edinburgh (F020); also in the unsigned globe at Rampur (F027)? But the whole issue becomes irrelevant when we consider that in Mughal miniatures women are never shown with such single-looped sashes and that it is only the men, that too manual labourers, who wear single-looped sash, as for example, in the miniature showing Babur's garden at Kabul.[1053]

1051 It is not clear on which of his globes by Qā'im Muḥammad shows this preference for single-looped sashes. As it happens, just two globes signed by Qā'im Muḥammad were available to Savage-Smith and Belloli, namely the one at Stonyhurst College (no. 11 in Savage-Smith Catalogue) and the one at the Victoria and Albert Museum (no. 13). But of these two globes, no figures are published of singled-looped sashes in Savage-Smith's book. Fresh images I have obtained from the Stonyhurst college show Andromeda and Perseus with two loops, and Virgo and Bootes without any loops. The only figure with a single loop is Cassiopeia (see Figure F001.2). On Qā'im's globe at New Delhi (F004), just the figure of Perseus is shown with a single loop and no other figure; I do not find any figure with a single loop on Qā'im's globe at Patna (F005). Even on the Smithsonian globe, there are just two figures with a single loop, viz. Cassiopeia (Savage-Smith 1985, Fig. 56) and Virgo (Savage-Smith 1985, Fig. 68). All others have either two loops or no loops. Thus there is no basis for Belloli's theory of 'preference for single-looped sash worn by itself on Qā'im Muḥammad's globes.'

1052 Savage-Smith 1985, p. 113.

1053 Titley & Wood 1999, front cover illustration and pl. 31.

In a like manner, Belloli assumes that the design of the boat in Argo Navis on the various Lahore globes reflects the contemporary Mughal naval architecture, in particular the different renderings reflect contemporary styles:

> 'The representations of the Argo constellation vary from globe to globe perhaps more than any of the other diagrams; this may have been due to local or temporal differences in ship design of a kind more radical than, for example, variations in basic fashion of dresses. Not all of the boats have sails, pennants, or even masts. Thus it is all the more significant that the Argo Navis diagram on Qā'im's globe (no. 11, see Figure 46) is practically the twin of that on the Smithsonian globe.'[1054]

As stated above, Ḍiyā' al-Dīn followed his father Qā'im Muḥammad in the design of the ship; he did not make any substantial changes in the basic design, but only added embellishments. Therefore, there are many ship figures on Ḍiyā's globes which appear to be close to Qā'im's ship figures. Moreover, it is not correct to say that the differences in the rendition of the ship on the various globes reflect 'local or temporal' differences in ship design. In the vast territory of Mughal empire, there were prevalent several styles of ships. That the thirty and odd celestial globes made at Lahore carry a photographic record of the ship construction in the Mughal empire is an unwarranted assumption. The fact is that the ship designs on the Lahore globes do not even correspond to the ships depicted on Mughal miniature paintings, which themselves may not entirely reflect the contemporary reality.[1055]

The diverse renderings of the boat on the globes are not a factual record of technological changes or variations in naval architecture in the Mughal territories in the seventeenth century, but fanciful creations of the artist in the engraver who wished to add variety. In real life, no boat existed with such oversized figureheads.

In sum, it is futile to look for one-to-one correlation between the clothing engraved on the globes and the clothing in real life or to attempt to correlate the artefacts or dresses to contemporary styles in the Mughal realm of the seventeenth century. Of

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1054 Savage-Smith 1985, pp. 109-111.

1055 On the ships shown on Mughal miniatures, see Verma 1978, Pl. LXXI.

course, the instrument makers are not immune to contemporary surroundings, but imagination also plays a significant role in the design of the constellation figures. Lahore instruments makers may not know the Greek mythological background of the human figures; but they would also not try to depict male figures with unusual names like *Qīqā'ūs, Barsā'ūs,* or *al-ᶜAwwā',* or the female figures named *al-Dhāt al-Kursī* or *al-Mar'ah al-Musalsalah* precisely like contemporary men and women, but try to distance them somewhat from contemporary styles. It is only Ḥāmid, a rebel in many respects, who clothes them like contemporary men and women.

Therefore, it is not these minutiae which are decisive in the attribution of the Smithsonian globe. More decisive are how confident the outlines of the human figures are, how accurate the anatomical details are and how well-formed the faces are. These can be best discussed by juxtaposing the images of the three main figures of Andromeda, Virgo and Centaurus in the two globes signed by Qā'im Muḥammad at Delhi and Patna on the one hand with the same figures on the Smithsonian globe on the other; this will immediately show the great gulf between the globes signed by Qā'im Muḥammad and the Smithsonian globe.

Andromeda 1629 Delhi | Andromeda1637 Patna | Andromeda nd Smithsonian



(photo by S. R. Sarma)



(photo by S. R. Sarma)

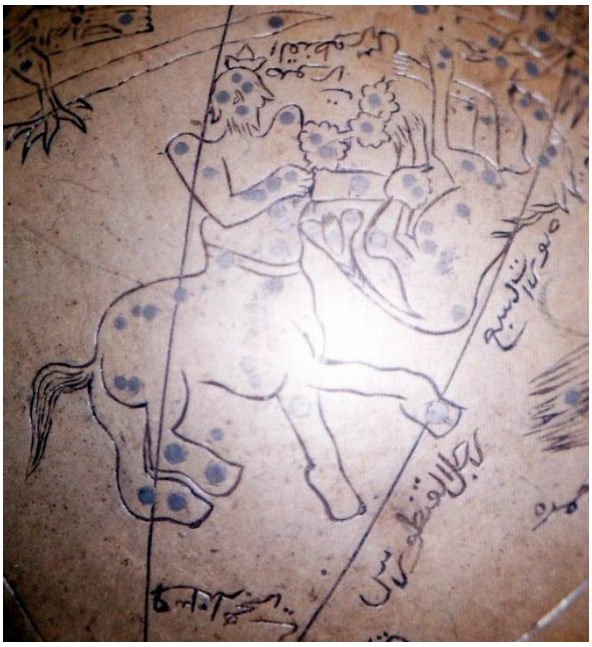


(From Savage-Smith 1985, Fig. 62)

Figure F9 – The figure Andromeda on three globes

In these three renderings of Andromeda, although the physical posture is the same, the general design of the tunic, the sash and the necklace are the same, the refinement and elegance of the Smithsonian version is unmatched in the other two.

Centarus 1629 New Delhi



(photo by S. R. Sarma)

Centaurus 1637 Patna



(photo by S. R. Sarma)

Centaurus nd Smithsonian



(from Savage-Smith 1985, Fig. 84)

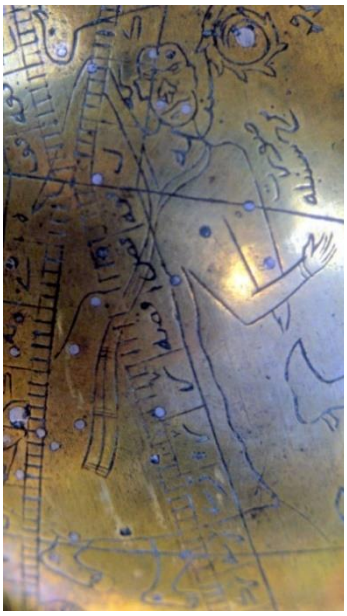
Figure F10 – The figure of Centaurus on three globes.

In the first two figures, the shoulders of Centaurus are highly exaggerated in order to include the star points, and the faces are undefined. The legs of the horse are drawn

in very crude manner. No effort is made to give a proper shape to vine leaves held by Centaurus. As against these two, the horse on the Smithsonian globe is very accurately delineated, so also the upper human half, and the vine twig.

Virgo 1629 Delhi | Virgo 1637 Patna | Virgo nd Smithsonian


(photo by S. R. Sarma)


(photo by S. R. Sarma)



(from Savage-Smith 1985, Fig. 84)

Figure F11 – The figure of Virgo on three globes.

The only common feature in these three depictions of Virgo is the outstretched hand on the right. The outlines of the first two figures are extremely clumsy; the arms and the wings are undifferentiated; the faces can hardly be regarded as human faces. It is inconceivable that the person who drew these two repulsive faces could be the same as the one who created the highly elegant figure of Virgo on the Smithsonian globe.

In sum, the physiognomy of the human figures, their facial features and garments on the first two globes are very primitive in comparison to the very fine rendition on the Smithsonian globe; the same is the case with the anatomy of the horse in the figure of Centaurus. The Smithsonian globe does not display any affinity with the globes made by Qā'im Muḥammad and cannot be attributed to Qā'im Muḥammad.

On the other hand, in all the human figures engraved on the Smithsonian globe can be seen the refined hand of Qā'im's son Ḍiyā' al-Dīn; and it is to him the globe is attributed in this catalogue under F028.

7. Conclusion

Despite this disagreement on the attribution of the Smithsonian globe, I am heavily indebted to Savage-Smith's splendid work, as the frequent references to it show. I have used her catalogue numbers for the identification of Indo-Persian globes (e.g. 'ESS 11'). In her *Islamicate Celestial Globes,* she classifies the celestial globes into three classes: (A) those carrying the figures of all the 48 constellations and some 1020 star positions, (B) those without any constellation figures, but with the positions and names of some prominent stars, and (C) those without constellation figures or star names, but with only the major circles. I have followed this classification only in the case of anonymous globes; in the case of signed globes, I put together all the globes signed by a globe maker, whether the globes carried constellation figures or not.

She also introduced a new class of 'astrologer's globes'.[1056] Whether they can be of any use to an astrologer or not, these are imperfectly made celestial globes, combing various desperate elements. More and more such globes are turning up in tourist markets in India. These are not included in this catalogue.

Two globes occupy a special place in this catalogue and in the historiography of the instruments produced by the Lahore family. It is while studying the globe F018 at Berlin that von Klüber became interested in the work of its maker Ḍiyā' al-Dīn and wrote to Sulaiman Nadvi, asking for relevant information. This query from von Klüber resulted in Nadvi's pioneering publication of 1935 where he surveyed, for the first time, eight astrolabes and four celestial globes made by various members of the Lahore family.

Globe F013 made by Ḍiyā' al-Dīn in 1653 is with the Aligarh Muslim University where I spent my entire academic career. This is the first instrument by the Lahore family which I had the opportunity to study and which, in a way, set me off on my exploration of other extant Indian astronomical instruments. It is also one of the most beautiful instruments produced by Ḍiyā' al-Dīn. In my description of this globe, I shall provide a very comprehensive photographic documentation, illustrating all the constellation figures — as my personal tribute to Aligarh Muslim University.

[1056] Maddison & Savage-Smith 1997, nos. 112, 113 and 114, pp. 160-165.

F001 CELESTIAL GLOBE BY QĀ'IM MUḤAMMAD, 18 J (AD 1623-24)

18th regnal year of Jahāngīr (AD 1623-24)

Diameter 188 mm

UK, Lancashire, Clitheroe, Stonyhurst College Library

ESS 11; Répertoire 1



Figure F001.1 – Globe with a modern stand (© The Governors of the Stonyhurst College)

This is the earliest globe produced in the Lahore family and also the earliest astronomical instrument created by Qā'im Muḥammad. It was made for a high Mughal dignitary Nawāb Iʿtiqād Khān; 'Iʿtiqād Khān' is a title conferred by the Mughal emperor Jahāngīr on Mirzā Shāpur, the brother of Nūr Jahān Begum who was the consort of Jahāngīr. At the time when the globe was made, Mirzā Shāpur held the governorship of Kashmir.[1057]

The globe is cast as a single hollow sphere; there are three plugs, including one large one near the inscription in the southern hemisphere. Holes are bored at the celestial poles.

Although this is the first of the five extant celestial globes which Qā'im Muḥammad made, the constellation figures on this globe display maximum embellishment in comparison to his subsequent productions: in particular, in the minute engravings which cover the figures of the reptiles Hydra and Serpens, the eastern fish near Andromeda, and the wings of Virgo and Corvus.

Circles

The equator and ecliptic are represented by double bands, one divided in 1° and the 5°. These divisions of 5° are numbered on the equator continuously from 5 to 360, starting from the vernal equinox. Obviously by mistake, the ecliptic was also numbered in the same way from 5 to 360 from the vernal equinox onwards; later, when the mistake was realized, the ecliptic was renumbered separately in each sign from 5 to 30; these news numbers are smaller and placed wherever there was adequate space in the cell. The names of the zodiac signs are written along the ecliptic; the names of the 28 lunar mansions are also engraved along the ecliptic, but on the other side. Ecliptic latitude circles are drawn at 30° intervals. There are no other circles.

1057 On Mughal titles, cf. Athar Ali 1985, p. xxiv and J 359, J 461, J 506: '… in official use, the title replaced the personal name; and the title earned later replaced the earlier title. For example, Nūr Jahān's father Ghiyāṣ Beg held the title Iʿtimād-ud-daula, granted to him by Jahāngīr. His son Abul Ḥasan first received the title Iʿtiqād Khān [in 1020/1611-12]; subsequently, when the title Āṣaf Khān was conferred upon him [in 1023/1614-15], he relinquished the title Iʿtiqād Khān. The latter title was granted to his brother Shāpur [in 1024/1615-16], who was then known by it.'



Figure F001.2 – Vernal Equinox (© The Governors of the Stonyhurst College)

Constellation Figures and Stars

All the 48 constellation figures are drawn along with their names, and the positions of about 1020 stars are marked with inlaid silver points. Celestial poles and some major stars are named. Since the globe maker took great trouble in engraving these constellation figures, it will be useful to study their iconography and note their stylistic affinities or stylistic changes. We begin first with the inanimate objects, then the zoomorphic figures and conclude with the anthropomorphic figures.

Inanimate Objects

From the viewpoint of iconography, the two constellation figures of Corona Borealis and Triangulum are the simplest. The former is drawn, to the right of Bootes, as a pair of lines, slightly heart-shaped, one inside the other, labelled *ṣūrat al-Fakkah* (see Figure F001.5). There are eight inlaid star pointers between the two lines. The largest of them is named *Nayyir al-Fakkah,* 'the luminous one of *al-Fakkah* (α Coronae Borealis).

The figure of Libra is drawn as a common weighing balance with a beam from which the pans are suspended by three strings each (Figure F001.3). The pans are not shallow pans, but deep vessels with thick rims to which the strings are attached. This design of Libra is generally followed in all the Lahore globes. The star in the southern pan is labelled *Kiffah Janūbī,* 'southern pan' (α Librae) and the northern counterpart *Kiffah Shamālī,* 'northern pan' (β Librae).

The constellation figure Crater (Figure F001.3) is depicted, close to Hydra and Corvus in the southern hemisphere, as a vessel with a narrow mouth and curved handles on each side; the top of the vessel is decorated with a graceful pattern. The figure is labelled *ṣūrat al-Bāṭiyah.* There is no named star.

The most prominent among the inanimate figures is the boat in the constellation Argo Navis. The large figurehead at the front is fashioned like a lion with its mane neatly combed back. At the back is a pavilion with an ornate dome surmounted by a trifoliate finial. The main mast is surmounted with a more elaborate trifoliate finial. The furled sails are tied to this main mast; a pair of chains fall from the main mast down to the figurehead. Pennants are attached to the figurehead, to the main mast and to the main deck.[1058]

[1058] See Savage-Smith 1985, Fig. 46.



Figure F001.3 – Autumnal Equinox (© The Governors of the Stonyhurst College)

Zoomorphic Figures

The zoomorphic figures can be divided in animals, birds and reptiles. We consider the animals first, beginning with the horse Pegasus. By convention only the front half of the horse is depicted on celestial globes: head, long neck with mane and wing and forelegs, and part of body cut in the middle (Figure F001.2). The rest of the horse's body is not shown because it occupies the same space as the figure of Andromeda and shares some stars with the latter. The horse's head, which is partly obscured by the scale of the equator, is accurately drawn; the mane on the neck is indicated by a series of short lines drawn very close to one another; the wing gets the greatest attention, with meticulously drawn scales and feathers on the fringe. But no such care is shown to the forelegs, which look like the chair legs, without any hoofs.

The figure is labelled *ṣūrat Faras al-Aᶜẓam,* 'figure of the larger horse' (Pegasus). Several stars in this constellation are named: *Matn al-Faras,* 'side of the horse' (α Pegasi); *Mankib al-Faras,* 'shoulder of the horse' (β Pegasi); *Janāḥ al-Faras,* 'wing of the horse' (γ Pegasi); *Surrat al-Faras,* 'navel of the horse' (δ Pegasi). These four together are known as the 'Square of Pegasus'. The last star is common to Andromeda and carries a second designation *Rās al-Mar'ah al-Musalsalah,* 'head of the chained woman' (α Andromedae). The star near the mouth is labelled as *Fam al-Faras,* 'mouth of the horse' (ε Pegasi).

There are three pairs of stars with the common designation *saᶜd,* which means roughly 'omen'. The two large stars on the neck are called *Saᶜd al-Humām,* '*saᶜd* of the hero' or '*saᶜd* of the sleet or hail' (ςξ Pegasi); the two stars on the stomach between the legs *Saᶜd Bāriᶜ,* 'an excellent *saᶜd*' (λμ Pegasi); the two stars on the lower leg *Saᶜd Maṭar,* 'a rainy *saᶜd*' (ηο Pegasi).

Two stars close together at the back of the wing are labelled *al-Kūb;* Savage-Smith states that it is an error for *al-Karab,* 'the place where the rope is attached to a bucket', which is derived from another conception of a leather bucket in this constellation.[1059]

Finally, near the hoof of the lower leg is a label *mrhlat al-Faras.* Savage-Smith remarks that '[t]his star does not bear an individual name in any of the literature or any other studied globes', with the exception of F003 and F028.[1060]

The first zodiac sign Aries is depicted as a goat with its head turned backwards (Figure F001.2 and Figure F001.7). The horns, mane, and tail are engraved with series of lines and the cloven pairs of hoofs are marked in each leg. The figure is labelled *ṣūrat al-Ḥamal.* The two stars on the horns receive the names *Muqaddam al-Sharatayn,* 'the anterior one of the two signals' (β Arietis) and *Mu'akkhir al-Sharatayn* 'the posterior one of the two signals' (γ Arietis).

As in the figure of Pegasus, only the front part of the bull is depicted also In the figure of the second zodiac sign Taurus, only the front part is depicted, as is done in the figure of Pegasus; i.e., just the head, horns, forelegs and rump. The label *ṣūrat al-Thawr*

1059 Savage-Smith 1985, p. 159.

1060 Savage-Smith 1985, p. 160.

is engraved on the body. The star near the eye is named *ʿAyn al-Thawr,* 'eye of the bull' (α Tauri).

The zodiac sign Leo is shown in full (Figure F001.3), but its body is contracted in the middle, with a high rump, rear legs tall and straight like pillars and short fore legs which are folded. The end of the tail makes a loop to accommodate a star. The face is in three-quarters profile, with eye, nose, jowls and whiskers. A series of long parallel lines on the head indicate its mane; the fur on the neck is suggested by four curls. Unlike Aries and Taurus, the figure of Leo faces west.

The title *ṣūrat al-Asad* is written near the mane of the lion. The two stars between the eyes are called respectively *Rās al-Asad Shamālī,* 'northern head of the lion' (μ Leonis) and *Rās al-Asad Janūbī,* 'the southern head of the lion' (ε Leonis). The other named stars are: *Qalb al-Asad,* 'heart of the lion' (α Leonis, Regulus); *Al-Ṣarfah,* 'change of the weather' (β Leonis); *Al-Jabhah,* 'forehead' (γ Leonis) *Ẓahr al-Asad,* 'back of the lion' (δ Lionis); *Mankhar al-Asad,* 'nose of the lion' (κ Leonis); *Mankib al-Asad,* 'shoulder of the lion'.

The constellation Raven is shown pecking at the serpent Hydra, to the right of Crater (Figure F001.3). The two upraised wings are filled with short strokes to create the impression of feathers, and long parallel lines are drawn to indicate the tail feathers. The label *ṣūrat al-Ghurāb* is engraved in the space between the two wings. There are three named stars: *Minqār al-Ghurāb,* 'beak of the raven' (α Corvi); *Janāḥ al-Ghurāb al-Ayman,* 'right wing of the raven' (γ Corvi); and *Janāḥ al-Ghurāb al-Aysar,* 'left wing of the raven' (δ Corvi).

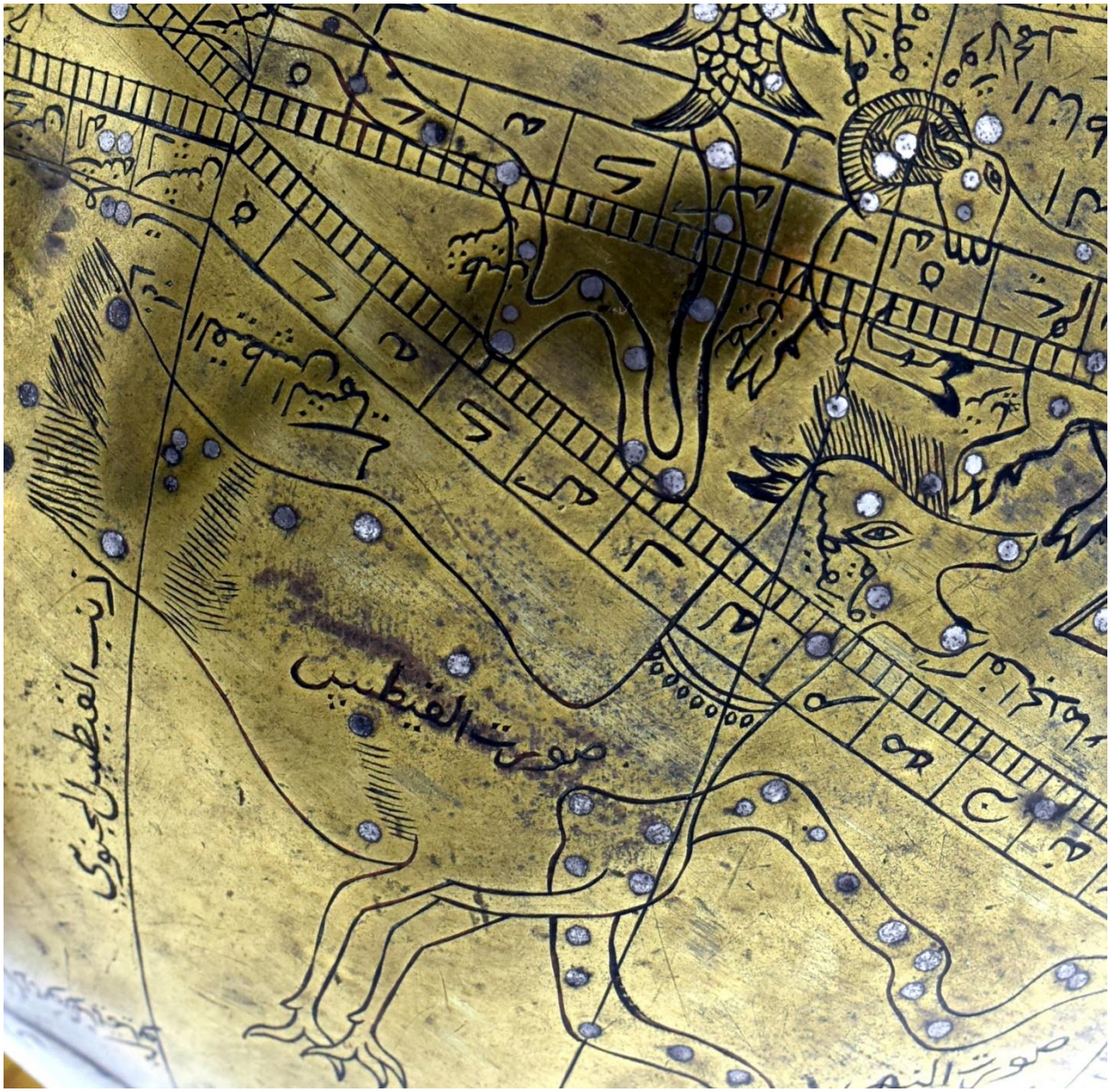


Figure F001.4 – Constellation figure Cetus (detail of Figure F001.2)

The figure of the sea-monster Cetus is a combination of whale, bird and dog. It stands on two bird legs, each with three toes; the long body is engraved with closely drawn series of parallel lines to indicate the feathers. The neck is adorned with a collar with beads; the head is shaped like a dog's head with pointed ears; on the head are drawn a series of oblique lines to indicate the fur. The label *ṣūrat al-Qayṭus* is engraved on the body. There are four named stars: *Fam al-Qayṭus,* 'mouth of Cetus' (γ Ceti); *Kaff al-Jadhmā',* 'the cut-off hand' (α Ceti). On the tail there are two stars *Dhanab al-Qayṭus Shamālī,* 'northern tail of Cetus' (ι Ceti) and *Dhanab al-Qayṭus Janūbī,* 'southern tail of Cetus' (β Ceti), but the tail is not properly bifurcated to indicate fins of the fish.

The two serpents Hydra (Figure F001.3) and Serpens and the eastern fish of the constellation Pisces are engraved with tiny scales. Hydra carries the label *ṣūrat al-Shujāᶜ,* with two named stars *Fard al-Shujāᶜ,* 'the isolated one of the serpent' (α Hydrae) and *Mankhar al- Shujāᶜ,* 'nose of the serpent' (σ Hydrae). Serpens is labelled as (*ṣūrat al-Hayyah*).

In the constellation Pisces, the eastern fish situated under the arm of Andromeda is filled with scales (Figure F001.7), while the western counterpart which is engraved on the equator scale immediately to the west of the vernal equinox is not filled with scales, probably because these would interfere with the division marks on the equator. But both are decked with scarves around their neck, the eastern one with pattern and the western one without. From the mouths of both issue long forked tongues. The label *ṣūrat al-Ḥūt* is engraved next to the scarf of the western one.

Human Figures

Qā'im appears to draw the human figures, their clothing, hair and face, according to a set formula. Bootes, for example, is clothed in a short tunic; two parallel lines indicate the sash tied around the waist; from the knot at the middle, two loose ends fall down in the form of an inverted Roman letter V and are decorated with a border and fringes. On either side of these is a kind of decoration on the tunic. The lower half of the tunic is flared, the edges are decorated with double lines. The V-neck is also emphasized with double lines. There are pairs of parallel lines at the elbows and wrists, to indicate armlets and bracelets, or the ends of the sleeves. The legs are encased in boots with spurs. But there are no lines to indicate any nether garment.

The hair on the head falls in two strands on either side of the face. One strand terminates in a trifoliate formation. The face is shown in full. The eyebrows, eyes, nose and the nostrils are all drawn together producing a grotesque appearance. A long bow-shaped line and a very short line below denote the upper and lower lips. With his left hand Bootes holds erect a sword, with a handle, wrist-guard and blade. The handle is very crooked, but is decorated with a trifoliate end.

The label reads *ṣūrat al-Baqqār wa Huā al-ᶜAwwā'* (figure of the howler, that is, the ox-driver). The star on his forehead is named *Rās al-ᶜAwwā',* 'head of the ox-driver' (β Bootis). The star below the hemline of his tunic is labelled as *Simāk Rāmiḥ,* 'the

armed *Simāk*' (α Bootis, Arcturus); and the star on the forward calf is called *Mufrid al-Rāmiḥ,* 'solitary [star] of the lancer' (η Bootis, Mufrid).



Figure F001.5 – Constellation figure Bootes (detail of Figure F001.3)

The constellation figure Perseus is drawn almost in the same style. He also wears a short tunic with a sash at the waist; the two loose ends make a loop each and then fall down together up to the hemline. The hemline, the two ends of the sash and the sleeves are decorated with pairs of parallel lines. He too wears boots with spurs. There are pair of lines near each knee suggesting breeches of some kind. His hair falls in two strands on either side of the face. The facial features consist of eyebrows, eyes, heart-shaped nostrils, lips represented by a long bow-shaped line and a very short line below it, and a long beard. The head of the ghoul which he carries is also drawn in a similar manner. His sword has a wrist guard and a curved blade.

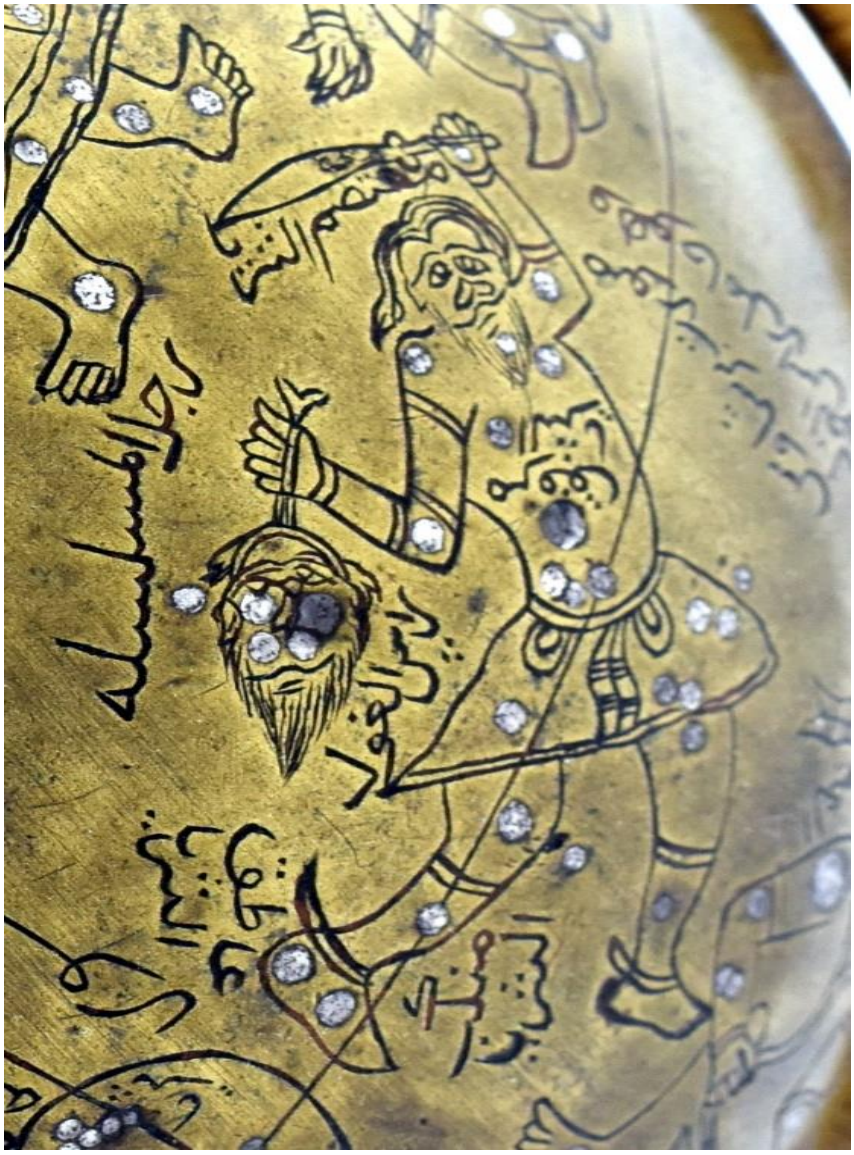


Figure F001.6 – Constellation figure Perseus (detail of Figure F001.2)

The label, engraved in two lines to the right of the figure, reads *ṣūrat Barsā'ūs wa Huma Ḥāmil Rās al-Ghūl* (figure of Perseus, that is, the bearer of the ghoul's head). The star on his stomach is named *Mirfaq al-Thurayyā,* 'elbow of *al-Thurayyā*' (α Persei); the one on his left foot *ᶜĀṭif al-Thurayyā,* a mistake for *ᶜĀtiq al-Thurayyā,* 'the shoulder-blade of *al-Thurayyā*' (ος Persei); the star on his shin-bone *Mankib al-Thurayyā,* 'the shoulder of *al-Thurayyā*' (ξ Persei); and the star on the head of the ghoul *Rās al-Ghūl,* 'head of the ghoul' (β Persei). Under the sword is written *muqṣam al-Thurayyā*;

according to Savage-Smith, it is a mistake for *Miʿṣam al-Thurayyā,* '*wrist of al-Thurayyā*' (hχ Persei).[1061]

The constellation figure of Andromeda also follows the same formula, but with an ankle-length gown. The sash at the waist is indicated by three lines; the two loose ends form two loops at the waist and then fall down together up to the hemline of the gown. The two ends of the sash, the hemline, the two sides of the skirt, the sleeves are all decorated with three or four lines. The neckline is not indicated, but there is drawn a bead necklace. Below the gown, the ankles and feet are bare. Her two arms are stretched out; the hands and fingers are clearly drawn. The hair falls in strands on either side of the face. The two eye brows are drawn as a single line. For once, the almond-shaped eyes and pupils are drawn accurately. The nostrils are drawn in the form of a heart. A very long bow-shaped line indicates the upper lip. The lower lip is bud-shaped. If only the nose were drawn somewhat better, the face would have been passable.

The label reads *ṣūrat al-Mar'ah al-Musalsalah* (the figure of the chained woman). As mentioned already, the star on the forehead is common to Andromeda and Pegasus and has two names *Rās al- Mar'ah al-Musalsalah,* 'head of the chained woman' (α Andromedae) and *Surrat al-Faras,* 'navel of the horse' (δ Pegasi). The star on her stomach is named *Batn al-Ḥūt,* 'belly of the fish' (β Andromedae); the one on her right foot carries the label *Rijl al-Musalsalah,* 'foot of the chained one' (γ Andromedae).

[1061] Savage-Smith 1985, p. 149.



Figure F001.7 – Constellation Figure Andromeda (detail of Figure F001.2)

On her lower left is the constellation figure of Cassiopeia (Figure F001.2); it is drawn more or less in the same manner. Her gown is not clearly defined; it appears to be knee-length and full-sleeved. But the sash is clear with a single loop; the two ends with pattern fall together on to her knees. Her feet are clad in shoes. She is seated on a high chair; the two back posts are very tall with trifoliate finials. The figure is labelled *ṣūrat Dhāt al-Kursī* (figure of the one with chair); a star near her left elbow is named *Kaff al-Khaḍīb,* 'dyed hand' (β Cassiopeiae, Kaff).

On the lower right of Andromeda is the figure of Triangulum. It is drawn as an isosceles triangle, the base being shorter than the two sides. The constellation is not labelled. There are four star pointers, three at the base and a larger one at the apex; the last one is named *Rās al-Muthallath,* 'head of the triangle' (α Trianguli).



Figure F001.8 – Constellation figure Virgo (detail of Figure F001.3)

The figure of Virgo also follows the same formula as Andromeda, but the long gown is without any decorative lines; the V-shaped neckline is extended up to the sash. The engraver intended to draw two lines to indicate the sash around the waist, but did not complete the lower line. The two loose ends of the sash hang down together. The hair and face are depicted in the same manner as Andromeda. The only feature where the engraver paid greater attention are the two wings, in particular, the northern wing where each tiny segment is carefully hatched with parallel lines. The figure carries the

label *ṣūrat al-Sunbulah* (figure of the ear of wheat). There is only one named star which is on her right palm, with the name *Simāk Aʿzal,* 'unarmed *Simāk*' (α Virginis, Spica).

STAND

Savage-Smith states that 'the ungraduated metal meridian ring and the wooden pedestal stand on which it is mounted are of very recent origin,'[1062] but the photo provided by the Stoneyhurst College (Figure F001.1) shows clearly that the meridian ring is divided in 1° and 5° and numbered from 5 to 90, separately in each quadrant, starting at the north and south points and reaching up to the zenith above and nadir below. The non-functional wooden stand is modern.

INSCRIPTION

The inscription is engraved in two lines along an arc around the southern ecliptic pole.

> *ṣāhib nawāb iʿtiqād khān sanah 18 julūs jahāngīrī*
> *ṣanʿat aqal al-ʿibād qā'im muḥammad ibn ʿīsā ibn allāhdād asṭurlābī lāhūrī humāyūnī.*
> 'Owner Nawāb Iʿtiqād Khān. Eighteenth regnal year of Jahāngīr.
> The Work of the least of the servants [of God] Qā'im Muḥammad, son of ʿĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn.'

The eighteenth regnal year of Jahāngīr began on 21 March 1623 (20 *Jumaida al-Awwal* 1032 AH) and lasted up to 20 March 1624.

PROVENANCE

Acquired in Lucknow in 1858.

BIBLIOGRAPHY

Savage-Smith 1985, no. 11, p. 224, figs. 12, 13, 37, 41 and 46

[1062] Savage-Smith 1985, p. 124.

F002 CELESTIAL GLOBE BY QĀ'IM MUḤAMMAD, 1035 AH (AD 1626)[1063]

21st regnal year of Jahāngīr, 1035 AH (AD 1626)

Diameter ?

Paris, PC

ESS 12; Répertoire 3

The globe is cast as a hollow sphere by the lost wax process; there is a large circular plug on the equator where the figure of Ophiuchus is engraved.

CIRCLES

The equator and the ecliptic are graduated in single degrees with every fifth numbered; the equator is numbered from 0 to 360 continuously from the vernal equinox onwards and the ecliptic from 5 to 30 separately in each zodiac sign. The names of the zodiac signs are engraved along the ecliptic ring and those of the lunar mansions are incised on the other side of the ecliptic ring. There are ecliptic latitude circles. Besides the names of zodiac signs and lunar mansions, those of the constellations, celestial poles and some prominent stars are also engraved.

CONSTELLATION FIGURES AND STARS

All the 48 constellation figures are represented and positions of some 1020 stars are marked by inlaid silver points.

STAND

The quadruped stand with ungraduated horizon ring is a modern replacement. There is no meridian ring.

INSCRIPTION

The following inscription is engraved around the ecliptic and equatorial poles in the south:

> *ṣanah aqall al-cibād qā'im muḥammad ibn cīsā ibn allāhdād asṭurlābī lāhūrī humāyūnī sanah 1035 hijrī sanah 21 julūs jahāngīrī.*

[1063] Entry based on Savage-Smith 1985, no. 12, pp. 224-225, Fig. 36.

'The work of the least of the servants [of God] Qā'im Muḥammad, son of cĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn [in] the year 1035 Hijrī, the twenty-first regnal year of Jahāngīr.'

The year 1035 Hijrī lasted from2 October 1625 to 20 September 1626; Jahangir's 21st regnal year commenced ca. 21 March 1626. Therefore, the astrolabe was made between 21 March and 20 September 1626.

PROVENANCE

Formerly in the collection of Bahari of Teheran.

BIBLIOGRAPHY

Savage-Smith 1985, no. 12, pp. 224-225, Fig. 36.

F003 ⊙ CELESTIAL GLOBE BY QĀ'IM MUḤAMMAD, 22 J (AD 1627)

22nd regnal year of Jahāngīr (AD 1627)

Diameter 134 mm

London, Victoria and Albert Museum (# M. 828-1928)[1064]

ESS 13; Répertoire 4

Cast as single hollow sphere, with one plug in the region of Piscis Austrinus.

CIRCLES

The ecliptic and equator are represented by double bands, graduated in 1° and 5°. On the equator the groups of 5° are numbered continuously from 5 to 360, starting at the vernal equinox. On the ecliptic, these are numbered from 5 to 30, separately in each zodiac sign. The names of the zodiac signs are engraved along the ecliptic. There are ecliptic latitude circles.

CONSTELLATION FIGURES AND STARS

The globe carries the full set of 48 constellation figures and 1020 stars inlaid with silver points of 3 different sizes. The constellations, the celestial poles, and several major stars are labelled. Some of the human figures are carefully delineated.

Bootes wears a knee-length tunic with half sleeves, the flap closing on his right side, with a sash around the waist, two ends of which fall down in the form of the inverted Roman letter V. Two purses are attached to the sash. He wears pointed boots. His hair in shown in two strands, but his face is not well defined.

Virgo is depicted with a skirt up to the middle of the calves; her fingers and toes are well drawn; she wears bracelets on her wrist.

Scales are engraved on Piscis Austrinus and on Virgo's wing feathers,

STAND

Stand (ht. 143) with three legs which stand on a ring with six lobes. The ring is joined by three bars; at their junction is a central leg to support the semicircular arc

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[1064] The Victoria and Albert Museum wrote to say that they do not permit publication of private photography of their objects. Therefore, this entry is regretfully without my photos.

which holds the meridian ring in position. A semicircular arc is attached to the horizon ring below at east and west points. At right angles to this is a quarter circle in which there are 11 holes.

The horizon ring is divided into three bands; the inner band is graduated in 1°, the middle one is numbered from 5 to 90, separately in each quadrant, starting at the east and west points and reaching up to the north and south points. The outer band is engraved with the names of the four compass directions and the four intermediate directions.

The meridian ring is graduated in 5° and labelled in the upper half.

INSCRIPTION

The inscription is engraved in an arc around the southern ecliptic pole:

> *sanᶜat aqall al-ᶜibād qā'im muḥammad ibn ᶜīsā ibn allāhdād asṭurālbī humāyūnī lāhūrī; sanah 22 julūs jahāngīrī*
>
> 'The work of the least of the servants [of God], Qā'im Muḥammad, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor Humāyūn] in the regnal year 22 of Jahāngīr.'

Jahāngīr's twenty-second regnal year commenced ca. 21 March 1627 and he died on 8 November 1627. The celestial globe was completed between these two dates.

BIBLIOGRAPHY

Savage-Smith 1985, no. 13, p. 225, Figs. 38 and 42.

F004 ⊙ CELESTIAL GLOBE BY QĀ'IM MUḤAMMAD, 1039 AH (AD 1629-30)

Diameter 136 mm

New Delhi, National Museum (#80.705)



Figure F004.1 – Inscription on the globe (courtesy National Museum, New Delhi)

This globe was made for Ibn Nūr al-Dīn Ḥussayn Abū Tālib Tabātabāī Yazd, whose name is embossed in large letters in an arc around the southern ecliptic pole.[1065] It is cast as a single hollow sphere by the *cire perdue* process. There is a neat circular plug of about 21 mm diameter at the North Pole. Holes are made at the two celestial poles. There is silvery sheen on the globe. The original stand is not extant.

CIRCLES

The equator and the ecliptic are represented by double bands, the inner one divided in 1° and the outer band in 5°. The outer band of the equator is numbered in 5s from 5

[1065] It is not known who this patron was. He does not seem to have held any rank at the Mughal court; his name is not listed in Athar Ali 1985.

to 360, starting from the vernal equinox. The outer band of the ecliptic is numbered from 5 to 30, separately for each of the 12 signs. The names of the signs are engraved in long flowing style either below or above the ecliptic circle. There are ecliptic latitude circles, but no tropics or polar circles.

Constellation Figures and Stars

All the 48 classical constellation figures are depicted together with their names which are preceded by the term *ṣūrat* (صورت). The positions of about 1020 fixed stars are marked with inlaid silver points; some of the important stars are named. The northern and the southern celestial poles are named respectively as *al-quṭb al-shamālī* and *al-quṭb al-janūbī.* Some silver nails near the North Pole became detached and are lost.

The quality of the constellation figures on this globe is generally inferior to the quality of the figures on the globe of 1623 (F001). On this globe there are no minute engravings of the scales on the bodies of serpents and of the fishes, or of feathers in the wings of Virgo, Corvus and other birds, as is done in globe F001.

A few of the constellations figures drawn on this globe will be described below, starting with the constellation Ursa Major. The name of the figure is engraved in front of its head as *ṣūrat Dubb Akbar.* The bear in this constellation hardly resembles a bear; it looks more like a donkey. Moreover, the two legs on its right are anatomically incorrect. But the names of the stars in this constellations are of great interest, because they reflect a complex mixture the original Greek notions and the later Bedouin conceptions regarding this constellation.[1066] While the Greeks saw it as a bear (also as a cart), the Bedouin tradition saw a bier in the four stars forming a square; in the present figure, they form rather a rhombus. Their collective name *al-naʿsh,* 'the bier' (αβγδ Ursae Majoris) is written on the rump of the bear. The individual names of the four stars are also written. The first one on the left at the top is named *Ẓahr al-Dubb,* 'back of the bear' (α Ursae Majoris), the second one at the top carries the name *Maghriz al-Dubb,* 'base of the bear' (δ Ursae Majoris); the one immediately below it is called *Fakhdh al-*

[1066] On this nomenclature, see Savage-Smith 1985, pp. 134-136.

Dubb, ‘thigh of the bear’ (γ Ursae Majoris) and the star at the base of the neck has the designation *Mirāt al-Dubb,* ‘loin of the bear’ (β Ursae Majoris).



Figure F004.2 – Ursa Major (photo by S. R. Sarma). Notice the large circular plug.

In the Bedouin tradition, three stars on the tail are conceived as the three mourning daughters who follow the bier; their collective designation *al-banāt,* ‘the daughters’, is written below the tail. The first one is named *al-Jawn,* ‘the black horse’ (ε Ursae Majoris), the second *al-ᶜAnāq,* ‘the goat’ (ζ Ursae Majoris) and the last *al-Qā’id,* ‘the leader’ (η Ursae Majoris).

The nomenclature of the twin stars in each of the four paws follows another tradition. Each pair is imagined to be the track of a deer’s cloven hoof when the deer is running away from the lion. Thus, the twin stars in the rear paw are named *al-Qafzah al-Ulā,* ‘the first leap’ (νξ Ursae Majoris), those in the middle paw *al-Qafzah al-Thānī,* ‘the second leap’ (λμ Ursae Majoris), and those on the upper front paw *al-Qafzah al-Thālithah,* ‘the third leap’ (ικ Ursae Majoris). Furthermore, the two stars in the lower

front paw are given the label *Tatimmat Qafzah al-Thālithah,* 'the complement of the third leap'.[1067]



Figure F004.3 – Argo Navis with Canis Major (photo by S. R. Sarma)

Qā'im Muḥammad's basic design of the constellation figure Argo Navis consists of a flat-bottomed boat with a high prow surmounted by a huge leonine figurehead, a cabin or pavilion at the stern covered by an ornate dome, a main mast to which the furled sails are tied, an open gallery incorporating an unidentifiable vase-like form, and two ornate oars one of which carries the star Canopus. Qā'im Muḥammad's son Ḍiyā' al-Dīn employs the same basic design on his globes with additional embellishments.

On this globe, the leonine figurehead is drawn very perfunctorily; it would require much imagination to see the lion's mane in the parallel series of strokes above the figurehead. At the rear is a domed pavilion with an ornate finial. At the top of the main mast also is a more elaborate finial. There are three pennants. The rolled-up sails are

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[1067] According to Savage-Smith 1985, p. 136, this name occurs only in the globes at Stonyhurst (F001), Victoria & Albert Museum (0) and at the Smithsonian (F028) and is otherwise 'unknown in astronomical literature'. But it also occurs on 0 and 0; as far as I know, Savage-Smith has not seen these two globes.

tied to the top of the main mast; the two ropes to release the sails are tied to the figurehead. There are two fiddle-shaped oars on either side at front. The second one carries the star named *Suhayl* (α Carinae, Canopus). The name of the constellation is engraved above the figure on the right *ṣūrat al-Safīnah.* In front of the ship is the clumsy figure of Canis Major, with poorly drawn legs; it is labelled *ṣūrat Kalb al-Akbar.*



Figure F004.4 – Virgo on the left; Andromeda, Cassiopeia and Perseus on the right (photos by S. R. Sarma)

The human figures are the least attractive features on this globe. In the figures of Virgo, Andromeda, Cassiopeia and Perseus, their shoulders and arms are not correctly depicted. The eyes and mouths of all these figures are drawn in such a manner that they all look downwards with sullen expressions on their faces.

Virgo is drawn without any hair, her arms and wings are not clearly separated. The right, or rather the southern arm is not shown at all. In the northern arm, the palm should be facing the viewer and not the other way. The nose looks like a trifoliate leaf. Her gown is also very incompletely drawn. Her label is engraved to the right of her face *sūrat al-Sunbulah.* On her right palm is situated the bright star *Simāk Aʿzal* (α Virginis). In the figures of Andromeda, Cassiopeia and Perseus the labels are the same as on globe F001, but the rendition is rather inferior.



Figure F004.5 – Sagittarius (left) and Centaurus (right) (photos by S. R. Sarma)

Qā'im Muḥammad's utter inability to draw the legs of horses becomes manifest in the composite figures of Sagittarius and Centaurus. In both figures the tails of the horses are drawn with great care, but the legs are very crude. In Sagittarius, the human half has no torso; the neck of the horse is extended into the human head. In Centaurus, the three olive branches look like three toothed wheels of a machine. Both wear caps; Sagittarius a conical cap with a trifoliate finial; the flowing headband, which accommodates several stars, is attached not to the cap but to his face.



Figure F004.6 – Inscriptions (detail from Figure F004.1)

INSCRIPTION

The name of the dignitary for whom the globe was made is embossed in large letters in an arc around the southern ecliptic pole, starting from the southern equatorial pole:

ṣāḥibuhu ibn nūr al-dīn ḥussayn abū tālib tabātabā'ī yazd

'The owner [is] Ibn Nūr al-Dīn Ḥussayn Abū Tālib Tabātabā'ī of Yazd.'

Below this is engraved the globe maker's signature in much smaller and plainer letters; but it could not be completed in one continuous line, because the end of the constellation figure Eridanus and the label of the star *Ākhir al-Nahr* stood in the way. Therefore, the date was engraved in two instalments at two different places: *sanah 1039 hijrī* is written below the foot of Centaurus at the top right and *sanah 2 julūs shāh jahān* next to the name of the owner. The signature omits the word *asṭurlābī,* without which the word *humāyūnī* does not make much sense:

ṣanᶜat aqall al-ᶜibād qā'im muḥammad ibn ᶜīsā ibn allāhdād humāyūnī lāhūrī sanah 1039 hijrī sanah 2 julūs shāh jahān.

'Made by the least of the servants [of God], Qā'im Muḥammad, son of ʿĪsā, son of Allāhdād of Lahore, [the astrolabe maker to the Emperor] Humāyūn [in] the year 1039 Hijrī, the second regnal year of Shāh Jahān.'

F005 ⊙ CELESTIAL GLOBE BY QĀ'IM MUḤAMMAD, 1047 AH (AD 1637-38)

Diameter 173 mm

Patna, Khuda Bakhsh Oriental Public Library

ESS 14; Répertoire 7 = 8[1068]



Figure F005.1 – Globe with stand (photo by S. R. Sarma)

This globe is cast as a single hollow sphere; there are two plugs: a heart-shaped one (length 70, width 57) near the south pole and a circular one (d. 23) near the north pole. Holes are bored at the equatorial poles.

CIRCLES

The equator and ecliptic are represented by double bands; the inner band is divided in 1° and outer one in 5°. The equator is numbered from 5 to 360, starting at the vernal equinox, while the ecliptic circle is divided into 12 signs and each sign is in 5° and numbered from 5 to 30. The names of the signs are engraved along the ecliptic circle,

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[1068] Répertoire lists it twice, one under 'Patna (Bihar, Inde): Khudā Baksh Oriental Public Library (1127)' and another time under 'Bankipore (Bihar, Inde): Bibliothèque Orientale'. Bankipore is the suburb of Patna where Khuda Bakhsh Oriental Public Library is situated. The Répertoire states that Nadvi gave two different locations, which is not the case. Nadvi merely mentions Bankipore Library.

but not the names of the lunar mansions. Six ecliptic latitude circles divide the ecliptic at right angles, creating 12 houses of the zodiac. There are no tropics, nor polar circles.

Constellation Figures and Stars

The full set of 48 constellation figures are drawn and labelled with their names preceded by the term *ṣūrat* (صورة, occasionally also صورت). For the first time, the word *burz* was added to the labels of the figures of the zodiac signs, e.g., *ṣūrat burj sunbulah* (figure of the zodiac sign Virgo). The positions of 1022 stars are indicated by inlaid silver points and the names of some of these stars are engraved. In a long inscription, Qā'im Muḥammad explains that he had added 3° to the star longitudes given by Mirzā Ulugh Beg so that the positions on the globe correspond to the year 1047 Hijrī.

However, the quality of the constellation figures, whether they are human figures or others, engraved on this globe is much inferior to that of the earlier globes by Qā'im. For example, the figure of Centaurus is almost like the same in F001 with the legs of the horse drawn very crudely, but here the human arms are also depicted in the same crude manner as the horse-legs. Centaurus is labelled as *ṣūrat al-Qantūrus,* Lepus *ṣūrat al-Sabaᶜ* and the star on the foreleg of the horse *Rijl al-Qantūrus,* 'foot of Centaurus' (α Centauri).

In the case of human figures, the outlines very often do not correspond to human anatomy and the faces are drawn with stump-like noses, eyes without expression and mouths represented by crooked lines. Minimal attention is paid to their clothing. The tunics are indicated mainly by the hemline at the bottom. Sometimes a girdle with a buckle is added at the waist; often the neckline or the ends of sleeves are not indicated and figure appears to be naked in the upper half.



Figure F005.2 – Centaurus and Lepus (photo by S. R. Sarma)

Perhaps the most successful human figures on this globe are those of Hercules and Serpentarius. The figures are anatomically correct and the faces with locks of hairs on either side are not unattractive. Hercules is labelled as *ṣūrat al-Jāthī* (figure of the kneeling man) and the star on his forehead *Rās al-Jāthī,* 'head of the kneeling man' (α Herculi). The label of Ophiuchus reads *ṣūrat al-Ḥawwā* (figure of the snake charmer) and the star on his forehead *Rās al-Ḥawwā,* 'head of the snake charmer' (α Ophiuchi, Rasalhague).



Figure F005.3 – Hercules (left) and Serpentarius (photo by S. R. Sarma)

Andromeda is rendered in a like manner, with outstretched hands. The face is rendered clumsily with a stump nose, wide mouth, ugly ears, life-less eyes. Two strands of hair fall on either side of the face; the left strand looks more like the bud of a bell-flower rather than the strand of hair. The tunic is closed in the front, the ends of the sash fall vertically down with a loop. Six small circles across neck suggest a necklace.

The name of the constellation is engraved above her left shoulder: *ṣūrat al-Mar'ah al-Musalsalah* (figure of the chained woman). The star on her forehead is designated as *Rās al-Mar'ah al-Musalsalah,* 'head the chained woman' (α Andromedae); it also carries a second name *Surrat al-Faras,* 'navel of the horse' (δ Pegasi). The star above Andromeda's right hand is called *Janāḥ al-Faras,* 'wing of the horse' (γ Pegasi).



Figure F005.4 – Andromeda with Cassiopeia on the lower right (photo by S. R. Sarma)

On the lower right is Triangulum with the label *ṣūrat al-Muthallath* (figure of the tringle) and the star at the apex is named *Rās al-Muthallath,* 'head of the triangle' (α Trianguli). The star on Andromeda's right foot carries the name *Rijl al-Musalsalah,* 'head of the chained[woman]' (γ Andromedae). Her rescuer Perseus is depicted just below her figure. It is amusing that his upraised sword (which is supposed to protect her from the sea-monster Cetus) looks as if it is piercing her foot!

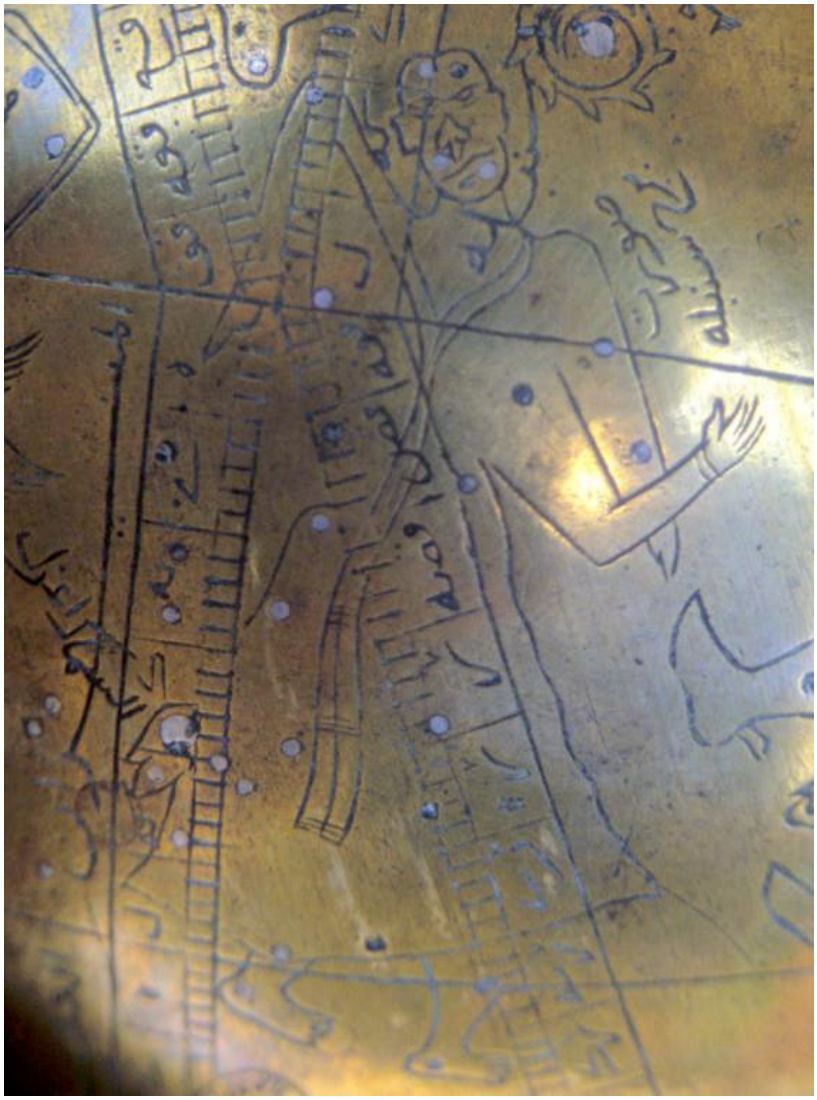


Figure F005.5 – The figure of Virgo (photo by S. R. Sarma)

The figure of Virgo on this globe is the most repulsive female human figure even drawn by Qā'im Muḥammad. She is without any hair. Her shoulders, wings and arms are placed in anatomically impossible positions. Her name is engraved as *ṣūrat burj Sunbulah* (the figure of the zodiac sign Virgo). The star on her southern palm is named *al-Simāk Aʿzal,* ‘’ (α Virginis).

The figure Aquarius is also very ungainly. The outlines of his figure do not even match human anatomy even roughly. In drawing the face, Qā'im mixes up elements of profile and full front. The label reads *ṣūrat burj Dalw* (the figure of the zodiac sign Aquarius).



Figure F005.6 – Aquarius (photo by S. R. Sarma)

While all these figures are without any headgear, Cepheus the king of Egypt, is endowed with a highly complex crown. His face is drawn in profile; the tunic is fastened by a belt with a buckle in the middle. His label reads *ṣūrat Qīqā'ūs.* In Figure F005.7 can be seen some other constellation figures also. On the lower right is the figure of Draco, depicted in outline only without any scales. The label reads *ṣūrat al-Tinnīn* (figure of the dragon); the star on its head is named *Rās al-Tinnīn,* 'head of the dragon' (γ Draconis).

The largest figure in the middle is Cygnus with outstretched wings. Its legs folded in motion are drawn as crudely as the horse's legs in Centaurus. The label is engraved above its neck: *ṣūrat al-Dajājah* (figure of the fowl). The large star on its beak bears the designation *Minqār al-Dajājah,* 'beak of the fowl' (β Cygni); the star on its tail is called

Dhanab al-Dajājah Huwā al-Ridf, 'tail of the fowl, that is to say, the follower' (α Cygni). The second name *al-Radf* is derived from the Bedouin tradition.[1069]



Figure F005.7 – Cepheus (photo by S. R. Sarma)

Below the figure of Cygnus is the figure of Lyra; it is represented here as a crown and labelled as *ṣūrat al-Shulyaq.* The star in this constellation is named *Nasr Wāqiʿ*, 'falling eagle' (α Lyrae, Vega). On the extreme right is the constellation Sagitta, represented by an arrow with a trifoliate arrow-head and the label *ṣūrat al-Sahm* (figure of the arrow). Above the arrow is the lower part of the figure Delphinus, entitled *ṣūrat al-dulfīn* (figure of the dolphin) and the star on its tail named *Dhanab al-Dulfīn,* 'tail of the dolphin' (ε Delphini). To the right of the arrow is the lower part of Aquila; the star on its tail is labelled as *Dhanab al-ʿUqāb,* 'tail of the eagle' (ς Aquilae).

[1069] Cf. Savage-Smith 1985, p. 146.

STAND

The stand consists of a horizon ring supported by three *S*-shaped legs with octagonal feet. It has a height of 160 mm. The horizon ring (width 18 mm, thickness 6 mm) is graduated in 1° in the inner band and in 6°in outer band, but not numbered.

The meridian ring (width 8 mm, thickness 6 mm) is graduated in 1° in the inner edge; groups of 6° are marked, but not numbered. There is semi-circular arc attached to the underside of the horizon ring at the east and west points to support the meridian ring.

The axis of the globe is fixed permanently to the meridian ring. But the meridian ring can slide through the notches in the horizon ring and the supporting half circle, so that the globe can be adjusted to the desired terrestrial latitude.

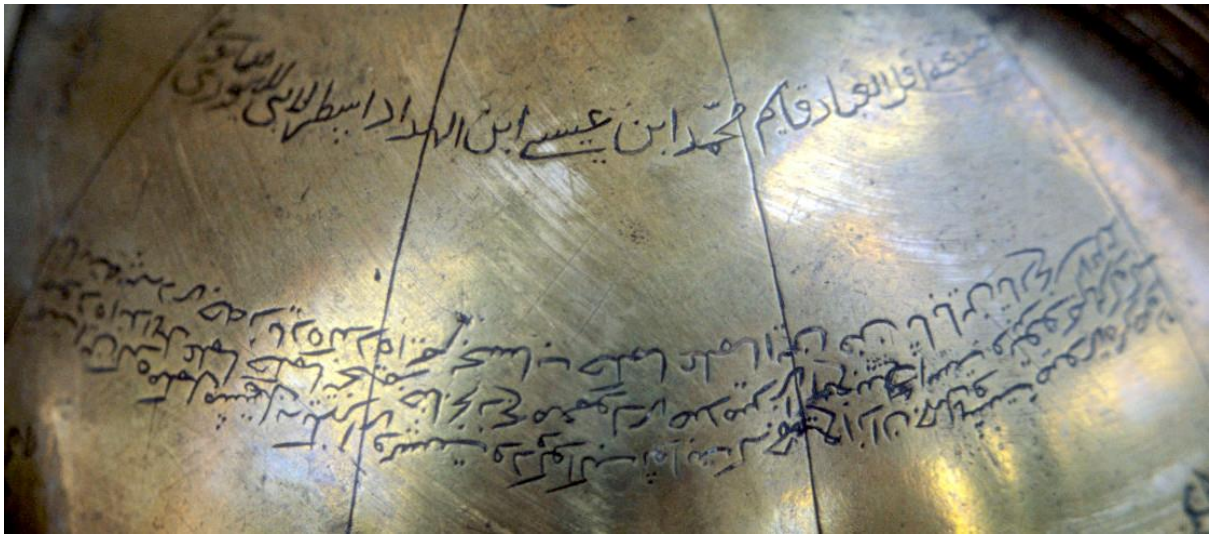


Figure F005.8 – Inscriptions on the globe (photo by S. R. Sarma)

INSCRIPTION

The signature of the globe maker is engraved in an arc around the southern ecliptic pole across the segments of Capricorn, Aquarius and Pisces; the date is added a little further away on the left, under Scorpio:

> *ṣanᶜat aqall al-ᶜibād qā'im muḥammad ibn ᶜīsā ibn allāhdād asṭurlābī lāhūrī humāyūnī sanah 1047 hijrī sanah 11 julūs shāh jahān.*
>
> 'The work of the least of the servants [of God] Qā'im Muḥammad, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, [in] the year 1047 Hijrī, the eleventh regnal year of Shāh Jahān.'

There is one more inscription in three lines further down (engraved in reverse direction) which states:

> 'The whole of the complete globe contains 1022 stars, all of which scholars and astronomers have observed to be 48 constellations, just as has been observed also in the observatory of Mirzā Ulug Beg, and we have added 3 degrees to the position (*tawīm*) of each fixed star, according to calculations of the scholars and wise men of this science, up to this date, the year 1047 H.'[1070]

Between Ulugh Beg's star catalogue of 1427 and the present celestial globe, there is an interval of 200 years. The precision of 3° in 200 years works to be 1° in 66 years and 8 month. Mahendra Sūri also mentions the same rate of precision in his manual of 1370.[1071]

BIBLIOGRAPHY

Savage-Smith 1985, no. 14, p. 225.

[1070] Translation by Savage-Smith 1985, p. 225.

[1071] Mahendra Sūri, 1.40.

F006 CELESTIAL GLOBE BY MUḤAMMAD MUQĪM, 1049 AH (AD 1639-40)[1072]

Diameter ?

Kuwait, PC

ESS 15; Répertoire 12

Cast as a single hollow sphere with a rectangular plug near the southern ecliptic pole. Probably with the original stand. Engraved with ecliptic latitude circles.

CONSTELLATION FIGURES AND STARS

The globe carries the full set of 48 constellation figures; positions of about 1020 stars are marked with inlaid silver points; stars are numbered within each constellation.

INSCRIPTION

The inscription at the end of the constellation of Eridanus reads thus:

> *ṣanᶜat aḍaf al-ᶜibād muḥammad muqīm ibn ᶜīsā ibn allāhdād asṭurlābī humāyūnī lāhūrī fī sanah 1049 hijrī.*

'The work of the weakest of the servants [of God], Muḥammad Muqīm, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn in the year 1049 Hijrī [= AD 1039-40].'

[1072] Entry based on Savage-Smith 1985, no. 15, pp. 225-226.

F007 CELESTIAL GLOBE BY MUḤAMMAD MUQĪM, 1039 AH (AD1639-40)[1073]

Diameter 135 mm

Qatar, Doha, The Museum of Islamic Art (# MW.146)



Figure F007.1 – Globe with the stand (© The Museum of Islamic Art, Doha)

On this elegantly crafted globe, the website of the Museum of Islamic Art, Doha, offers the following particulars: ‘MW.146.1999. Brass Celestial Globe (modern stand), India (Lahore), 1049 AH (1639-1640 CE), made by Muhammad ibn 'Isa ibn al-Hadad

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[1073] Entry based on the three photos kindly provided by Marc Pelletreau, Head of Multimedia, The Museum of Islamic Art, Doha.

Asturlabi ibn Humayuni ... .' The name of globe maker is not complete: it should read either 'Muḥammad Muqīm ibn ᶜĪsā ibn Allāhdād Asṭurlābī Humāyūnī Lāhūrī' or 'Ḍiyā' al-Dīn Muḥammad ibn Qā'im Muḥammad ibn ᶜĪsā ibn Allāhdād Asṭurlābī Humāyūnī Lāhūrī'. I requested the museum for an image of the signature, but they did not send the image.

Stylistically, constellation figures on the present globe match very well with those on the globes by Ḍiyā' al-Dīn Muḥammad. Therefore, I had assumed him to be the maker of this globe. But in a recent paper, Savage-Smith confirms that the globe is by 'Muḥammad Muqīm Asṭurlābī Humāyūnī Lāhūrī' and reproduces the same image as Figure F007.1.[1074] If so, it is not known whether it is identical with the globe F006 which too was produced by Muqīm in the same year or whether it is a different one.

The globe appears to have been cast as a single hollow sphere by the *cire perdue* method. An oblong plug is visible on the equinoctial colure a little above the constellation figure of Andromeda. Holes are bored at the equatorial poles and the axis passes through them.

Circles

The equator and ecliptic are divided in 1° and 5°; the equator is numbered continuously from 5 to 360, starting from the vernal equinox; the ecliptic is numbered from 5° to 30°, separately in each of the twelve signs. The names of the signs are engraved along the ecliptic. There are ecliptic latitude circles, but no tropics or arctic circles.

Constellation Figures & Stars

The outlines of all the 48 classical constellation figures are drawn with great skill and imagination. The names of the figures are written with the prefix *ṣūrat* (figure) as in all the Lahore globes. The positions of about 1020 fixed stars are marked with inlaid silver points. The names of some major stars are also engraved next to the silver points. Moreover, in each constellation, the stars constituting the constellation are numbered serially.

[1074] Savage-Smith 2017, p. 4.



Figure F007.2 – Globe (detail of Figure F007.1; © The Museum of Islamic Art, Doha)

Interestingly, the figures of the zodiac signs are drawn with dotted lines, as can be seen in the figures of Aries, Taurus, Gemini and Cancer in Figure F007.2 and in the figures of Sagittarius, Capricorn and Aquarius in Figure F007.3.[1075]

The male figures of Perseus, Cepheus, Auriga and Orion wear short tunics, tied at the waist by a plain slash, the loose ends hanging down in the form of an inverted V. The two females Andromeda and Cassiopeia wear ankle-length gowns, so does the male figure Aquarius. A variation in Aquarius's gown is that the upper flap is tied under left

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[1075] Muqīm's nephew Ḍiyā' al-Dīn emulates this feature in his globes F029, F030 and F031.

armpit. Auriga and Orion wear elaborately wound turbans, while Cepheus dons a long conical cap and Cassiopeia a turban with gold lace.[1076] In many globes by Ḍiyā' al-Dīn, trousers are suggested by lines drawn on the ankles indicating the extent of the trousers. No such lines are drawn on this globe and consequently all the figures appear naked beneath the tunics.

In Figure F007.2, the graduated scale in two bands running from the left to the right in the lower half is the ecliptic circle. The lower band is divided in 1°; the upper band is divided in 6° and numbered from 6 to 30 separately in each zodiac sign. Above this band, the names of the zodiac signs *al-Ḥamal* (Aries), *al-Thawr* (Taurus), *al-Jawzā'* (Gemini) and *al-Saraṭān* (Cancer) are engraved in long flowing style to cover the entire length of the sign. The figures of these four signs, viz. the ram, bull, twins and crab are drawn in dotted outlines on the ecliptic belt. The front part of the ram's body is towards the west, but its head is turned backwards and looks to the east. The name of the figure is engraved near the head as *ṣūrat al-Ḥamal,* 'figure of the ram'. Several stars are marked by inlaid silver points, but only one star, the large star on the top of the head, is named *al-Nāṭiḥ 4,* 'that which butts or gores' (α Arietis).

This is followed by the figure of Taurus, represented by the front half of the bull facing east, with the head, two long pointed horns, the high hump, and the two forelegs folded backwards. On the body is engraved the name of the figure *ṣūrat al-Thawr,* 'figure of the bull'. The very large star on the head is labelled as *ᶜAyn al-Thawr 14,* 'eye of the bull' (α Tauri, Aldebaran).

Next comes Gemini, represented by twin infants with the label *ṣūrat al-Jawzā',* 'figure of the twins'. The large star on the forehead of the first infant is named *Rās al-Taw'am al-Muqaddam,* 'head of the foremost twin' (α Geminorum, Castor) and that on the forehead of the second infant *Rās al-Taw'am al-Mu'akkhar,* 'head of the rear twin' (β Geminorum, Pollux). The fourth sign Cancer is depicted as a crab facing west with the label *al-Saraṭān.*

[1076] On the different styles of turbans depicted in Mughal miniatures, see Verma 1978, Pl. XXXII.

In the upper register can be seen, from left to right, the constellation figures of Andromeda, Cassiopeia, Perseus, Auriga and Ursa Major. Below the ecliptic belt are the figures of Orion and Canis Minor. We may consider the male figures first.

Perseus is clothed in a short tunic which stops above his knees; the two parallel lines on the left wrist suggest full sleeves; however, these are missing on the right wrist. A sash is wound around his waist; two loose ends dangle in the form of the inverted letter V. His legs are bare. His face as well as the face of the ogre in his right hand are facing the front; the hair and beard on both faces are indicated by series of parallel lines. Under his left arm is engraved the name of the constellation figure *ṣūrat Barsā'ūs,* 'figure of Perseus'. There are many numbered stars in this constellation, three of which are named.

The star on his chest carries two names according to the Hellenistic and Bedouin traditions: *Janb Barsā'ūs 4,* 'side of Perseus' (α Persei, Algenib) and *Mirfaq al-Thurayyā 4,* 'elbow of Thurayyā' (α Persei, Mirfaq). In the Hellenistic tradition, the figure is conceived as that of Perseus who rescues Andromeda from the sea-monster Cetus. The Bedouin tradition sees a huge female figure by name *Thurayyā* in the region of Taurus, Perseus, Cassiopeia and Cetus. The star on the forehead of the ghoul's head is called *Rās al-Ghūl 6,* 'head of the ghoul' (β Persei, Algol). Next to the upraised lower left arm which wields the sword is written *Muᶜtaṣam al-Thurayyā* (the refuge of the Pleiades), which Savage-Smith regards as a misspelling of *Miᶜṣam al-Thurayyā* (the nebulous wrist of Pleiades).[1077] There is no number after this name because this star is not listed in any catalogue of stars.

Auriga is also dressed in a short tunic with a deep neckline, but there is no sash around his waist. His legs are also bare. The most remarkable feature is the elaborately wound turban on his head. The title of the figure is engraved above his right shoulder and reads *ṣūrat Mumsik al-Aᶜinnah,* 'figure of the one who holds the reins'. Although the title indicates that he holds the reins, the pictorial representation shows him with a whip in his left hand and this weapon is depicted in diverse ways on different globes. The bright star on his right shoulder is named *ᶜAyyūq 4* (α Aurigae, Capella). The star

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[1077] Savage-Smith 1985, p. 97.

on his left shoulder is designated as *Mankib Dhī al-ʿInān 5,* ‘the shoulder having the reins’ (β Aurigae, Menkalinan). A star on his left ankle is common to one of the horns of Taurus; it is labelled as *Kiʿāb Dhī al-ʿInān 11,* ‘ankle or heel having the reins’ (γ Aurigae = β Tauri).



Figure F007.3 – Aquarius and other figures (© The Museum of Islamic Art, Doha)

The figure of **Orion** is devoid of any lines indicative of clothing, except the large turban, which is wound in a manner slightly different from that in the figure of Auriga. The label engraved under his upraised left arm reads *ṣūrat al-Jabbār,* 'figure of the giant'. The star on his right shoulder is named *Mankib al-Jawzā' 3,* 'shoulder of *al-Jawzā''* (α Orionis) and the star on the right foot *Rijl al-Jawzā' [al-Yusrā] '[left] foot of al-Jawzā''* (β Orionis).

In contrast to these figures, the figure of Aquarius, drawn in dotted outlines, is clothed in an ankle-length tunic; a sash is wound around the waist, its two loose ends falling down in the form of an inverted V. The upper part of the tunic is closed under the left armpit in the 'Hindu fashion'.[1078] The sparse hair at the back of the head is combed down. The label reads *ṣūrat al-Dalw,* 'figure of the bucket'.

To the left of Aquarius is the figure of the zodiac sign Capricorn, drawn in dotted outlines. Its forepart is that of a goat and hind part that of a fish. The label reads *ṣūrat al-Jadī,* 'figure of the goat'. Just one star is named *Dhanab al-Jadī,* 'tail of the goat' (δ Capricorni).

The upper register in Figure F007.3 is filled with several figures, two birds, two horses, a dolphin and two inanimate objects, all neatly drawn. On the very left is the figure of Aquila, its upper part engraved on the equator scale. Its name is written below the equator scale as *ṣūrat al-ᶜUqāb,* 'figure of the Eagle'. Two named stars in this constellation are *Nasr Ṭā'ir,* 'flying eagle' (α Aquilae, Altair) and *Dhanab al-ᶜUqāb,* 'tail of the eagle' (ζ Aquilae). Next to it is the constellation Sagitta with the label *ṣūrat al-Sahm,* 'figure of the arrow'. This is followed by Delphinus, depicted with the face of a grinning cat and the body of a fish; the label reads *ṣūrat Dulfīn,* 'figure of Dolphin'; a star on its tail carries the name *dhanab al-dulfīn,* 'tail of the dolphin' (ε Delphini). Next comes Equulus, with the label *ṣūrat Qitᶜat al-Faras,* 'figure of the part of the horse'. At

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[1078] The Mughal emperor Akbar is said to have decreed that Muslims should fasten the upper flaps of their *jāmas* on the right-hand side and the Hindus on the left-hand side. This convention is followed in the court scenes depicted in the miniature paintings of this period; cf. Sarma 2008a, p. 101 and Fig. 4.3 (unfortunately in p. 101, n. 74, there are two errors in the references; '*Akbarnāma* (III, p. 342)' should read '*Āᶜīn-i Akbarī* (III, p 342)' and '*Āᶜīn-i Akbarī,* I, p. 94' should be '*Āᶜīn-i Akbarī,* I, p. 84'.
In the present globe, the globe maker is not attempting to portray Aquarius as a Hindu personage; he was merely introducing a variation in the clothing; see also globe F031 for similar rendition of Aquarius.

the end of the row is the large figure of Pegasus, with the label *ṣūrat Faras Aᶜẓam,* 'figure of the greater horse'. Three stars can be seen in this photo: *Mankib al-Faras,* 'shoulder of the horse' (β Pegasi), *Janāḥ al-Faras,* 'wing of the horse' (γ Pegasi) and *Fam al-Faras,* 'mouth of the horse' (ε Pegasi).

In the uppermost row are Lyra and Cygnus. The label of the former is not visible in the photo. The figure of Cygnus is drawn with both wings fully stretched out and the legs folded forward. The label is engraved below the long neck as *ṣūrat Dajājah,* 'figure of the fowl'. There are two named stars: *Dhanab al-Dajājah,* 'tail of the fowl' (α Cygni) and *Minqār al-Dajājah,* 'beak of the fowl' (β Cygni).



Figure F007.4 – Andromeda (© The Museum of Islamic Art, Doha)

Of the female figures, Andromeda is clothed in an ankle-length tunic with long sleeves. No neckline of the tunic is drawn. As in the figures of Perseus, Orion and Aquarius, the two loose ends of the sash hang down in the form of the inverted letter V. Her legs are bare. Her hair falls in symmetrical strands on either side of the face. The label of the figure is missing, but the names of three stars of this constellation are engraved. The star on the forehead is named *Rās al-Musalsalah,* 'head of the chained [woman]' (α Andromedae); a star on the right side of the waist is designated as *Janb al-Musalsalah 12,* 'side of the chained [woman]' (β Andromedae); a star on right foot *Rijl*

al-Musalsalah, ‘foot of the chained [woman]’ (γ Andromedae). The dress and the posture of this figure closely resemble the same on the Smithsonian globe F027.

Above her head is the figure of Pegasus with which she shares the stars α Andromedae. This figure has already been discussed.



Figure F007.5 – Cassiopeia and Cepheus
(detail of Figure F007.1; © The Museum of Islamic Art, Doha)

To the left of Andromeda is the figure of **Cassiopeia,** also dressed in an ankle-length tunic with a sash at the waist. She wears a turban which is adorned with gold lace that goes all around and from front to the back. The chair on which she is seated is the most remarkable feature of this globe. The two back legs on the left which continue to

form the back posts, together with the three cross-pieces, look like a ladder. The front legs are shorter and have no cross-piece. All the four legs are topped with trifoliate finials with sharp tips. But strangely, there is no seat connecting the back legs and with the front legs; consequently Cassiopeia, the lady with the chair, is sitting on empty space. What is still more strange is that the feet of all the four legs of the chair are shaped line human feet and resemble the dangling feet of Cassiopeia.[1079] The label reads *ṣūrat Dhāt al-Kursī,* 'figure of the one with the chair'. The star on her left elbow carries the name *Kaff al-Khaḍīb,* 'dyed hand' (β Cassiopeia).

Next to her is the kneeling figure of **Cepheus** wearing a short tunic like Perseus and other men with similar sash and bare legs. He differs from the other men in his headgear which is a long conical cap. The label reads *ṣūrat Qīqā'ūs,* 'figure of *Qīqā'ūs*'. A star between his legs carries the name *Rāᶜī,* 'shephard' (γ Cephei).

STAND

The globe is mounted horizontally on a four-legged stand, with a well-polished horizontal ring which does not carry a degree scale. No provision has been made for a meridian ring. The stand is clearly a modern substitute for the lost original.

[1079] The same bizarre chair can be seen also in globe F029 by Ḍiyā'; Cassiopeia wears the same type of turban there also.

F008 CELESTIAL GLOBE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1055 AH (AD 1645-46)[1080]

Diameter 170 mm

New York, Columbia University, Butler Library, David Eugene Smith Collection (#27-198)

ESS 18; Répertoire 1



Figure F008.1 – Globe with stand (courtesy, Butler Library, Columbia University)

[1080] Entry based on Savage-Smith 1985, no. 18, pp. 226-227.

Globe

Cast as a single hollow sphere with many plugs; one large oval plug spreads from Piscis Austrinus to the southern equatorial pole; another circular plug is in the northern hemisphere.

Circles

The equator and the ecliptic are graduated in 1° and 5° and the divisions of 5° are marked by dotted lines as is done on many astrolabes. On the equator, the groups of 5° are numbered from 5 to 360, starting from the vernal equinox and on the ecliptic separately for each zodiac sign from 5 to 30. The names of the zodiac signs are engraved along the ecliptic. The equatorial poles, the constellation figures and many stars are named. The northern constellations, the zodiac signs and the southern constellation are numbered separately; individual stars within many northern constellations are also numbered.

Constellation Figures

All the constellation figures are drawn; about 1020 stars are indicated by inlaid silver nails.

Stand

The stand, which appears to be original, is rather complex. Here the horizon ring is supported by three legs curved in shape of the letter *S*. The horizon ring is graduated in 1° and 5°. The groups of 5° are numbered 5 to 90, separately in each quadrant, starting from the east and west points and ending at the north and south points.

A semi-circular arc is attached below the horizon ring at the east and west points to support the meridian ring. Another semi-circular arc is affixed above the horizon ring also at the east and west points; it is hinged at one point and held with a pin at another point so that, when necessary, it can be lifted and the globe removed. This arc serves to mark the zenith and the prime vertical. A small ring is attached at the top of this arc as a handle.

The outer edge of the meridian ring is graduated in 1° and 5° and numbered from 5 to 90, four times. The inner edges are divided in 1°.

One half of the meridian ring is twice as thick as the other half. At the midpoint of the thinner half is attached underneath an arc of 90° which is graduated in single degrees.

On the meridian ring, two opposite quadrants have holes at every 5°; and the other opposite quadrant, there are holes approximately at 18°, 23°, 27°, 32° and 37°, so that the globe can be set for use at these five latitudes.

INSCRIPTION

The globe-maker’s signature is engraved near the end of Eridanus and reads thus:

> *ʿayn ṣanʿat ḍiyā’ al-dīn muḥammad ibn qā’im muḥammad ibn ʿīsā ibn allāhdād asṭurlābī humāyūnī lahūri fī sanaḥ 1055.*
>
> ‘This is the work of Ḍiyā’ al-Dīn Muḥammad, son of Qā’im Muḥammad, son of ʿĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the year 1055.’

BIBLIOGRAPHY

Savage-Smith 1985, no. 18, pp. 226-227, Fig. 15.

F009 CELESTIAL GLOBE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1057 AH (AD 1647-48)[1081]

Diameter 137 mm

St. Petersburg, The State Hermitage Museum (IS-1473)

ESS 19; Répertoire 5



Figure F009.1 – Globe with a modern stand (© The State Hermitage Museum)

[1081] Entry based on detailed photos generously provided by Zhanna Etsina, Manager, Rights and Reproductions Office, The State Hermitage Museum, St. Petersburg.

This is one of the most beautiful globes crafted by Ḍiyā' al-Dīn Muḥammad, with a fine rendition of the constellation figures and excellent calligraphy. It has a diameter of 137 mm and the area of its surface measures 58,988 mm^2 which is less than the area of an A4 sheet of paper, viz., 62,370 mm^2. This small area of the globe is filled with the reference circles, the 48 classical constellation figures along with their labels and serial numbers, about 1020 silver star pointers, their serial numbers and, in some cases, their long names. With so much engraving, the globe looks rather cluttered.

The globe is cast as single hollow sphere. There are two large circular plugs, one covers the heads of Hercules and Ophiuchus and the other Onion's feet and the figure of Lepus. The second plug is blank; the engraving was not extended upon it. It is probable that the original engraved plug is lost and this new one was added at a later point. A third plug, rectangular and copper-coloured, can be seen at Gemini. The globe appears to have been gilded, but the gilding is fading at places. The silver points, however, have retained their lustre. The original stand is lost; the globe is now mounted on a modern stand, which is imaginatively designed but is non-functional.

Circles

The equator and the ecliptic are divided in 1° and 5°. The intervals are marked by dotted lines. On the equator, these intervals are numbered in *Abjad* notation continuously from the vernal equinox onwards from 5 to 360; on the ecliptic they are numbered from 5 to 30 separately in each zodiac sign. The names of the zodiac signs are engraved along the ecliptic. Ecliptic latitude circles are traced at intervals of 30°. The equinoctial colure is drawn as a dotted circle. Another dotted circle was traced parallel to the equator in the south between the Tropic of Cancer and the polar circle; it can be seen in Figure F009.10, Figure F009.12 and Figure F009.13, but its function is not clear; no such circle was drawn in the north.[1082] The celestial poles are named *quṭb shamālī* (north pole) and *quṭb janūbī* (south pole) respectively.

[1082] In globe F029, an attempt was made to draw a similar circle faintly, but was not completed.

Constellation Figures and Stars

On the globe the full set of 48 constellation figures is drawn and the positions of about 1020 stars are marked with silver points. The names of the constellation figures are engraved in large graceful letters; these are followed, for the first time, by serial numbers, separately for the northern constellations, southern constellations and zodiac signs. But the numbering is not done consistently; some titles are not followed by serial numbers. The stars in each constellation are numbered serially in common Arabic/Persian numerals and the names of several prominent stars are inscribed.



Figure F009.2 – Constellation Figures around the northern poles (© The State Hermitage Museum)

Figure F009.2 shows the constellation figures around the two northern poles. The six ecliptic latitude circles converge at the ecliptic pole at the centre of the image, which is not labelled. To its right is the northern celestial pole with the axis; its label reads *quṭb shamālī,* 'north pole'. The figure of the dragon in the constellation **Draco** coils around the ecliptic pole. It is drawn with double outlines patterned like ropes. The two other serpents, Serpens and Hydra, are also drawn with similar outlines. Draco is labelled as *ṣūrat Tinnīn 3.* The star on its head is named *Rās al-Tinnīn,* 'head of the dragon' (γ Draconis, Eltanin) and that on its tongue has the name *al-rāqiṣ,* 'the ambling [camel]' (μ Draconis).

Under the dragon's tail is the figure of **Ursa Minor** entitled *ṣūrat Dubb al-Aṣghar,* 'figure of the small bear'. The star on its tail, close to the north pole, carries the name

al-Jadī, 'the goat' (α Ursae Minoris, Polaris). The two stars on the upper part of its front leg are named respectively as *Anwar al-Farqadayn,* 'brighter of the two calves' (β Ursae Minoris, Kochab) and *Akhfa al-Farqadayn,* 'more obscure of the two calves' (γ Ursae Minoris).

In the lower left is the large figure of **Cygnus** with outstretched wings and long tail feathers. It is entitled *ṣūrat Dajājah 9,* 'figure of the fowl'. The star on its tail is named *Dhanab al-Dajājah,* 'tail of the fowl' (α Cygni, Deneb) and that on the beak *Minqār al-Dajājah,* 'beak of the fowl' (β Cygni, Albireo). Above this figure is **Lyra,** depicted as a large vessel with a base and a lid with a handle at the top. Its title is engraved as *ṣūrat al-Shulyāq,* 'figure of the tortoise'. A star on it is named *Nasr Wāqiᶜ,* 'falling eagle' (α Lyrae, Vega). Other constellations in this image will be described later.

Figure F009.3 shows the two major animal figures, Ursa Major and Leo, both occupying the zodiac house Leo to a great extent. Although these two figures are in the same style as on the globes by Qā'im Muḥammad, there is more refinement in the rendition here. In **Ursa Major**, the outlines are reinforced by oblique strokes to suggest the hairy limbs; similarly on its neck a series of long strokes are made to indicate the hair on the neck. The name of figure is engraved above its head as *ṣūrat Dubb al-Akbar,* 'figure of the Great Bear'. Many stars on the body are named. The star on its back carries the name *Ẓahr al-Dubb al-Akbar,* 'back of the great bear' (α Ursae Majoris, Dubhe); a star further down has the name *Mirāq Dubb al-Akbar,* 'loin of the great bear' (β Ursae Majoris, Merak); the one at the base of the tail is called *Maghriẓ Dubb al-Akbar,* 'base of the grear bear' (δ Ursae Majoris) and the one immediately below *Fakhdh Dubb al-Akbar,* 'thigh of the great bear' (γ Ursae Majoris). In the Bedouin tradition, the rectangle formed by these four stars was seen as a bier to carry a dead person and the three stars on the tail as the three mourning daughters of the deceased who follow the bier. Accordingly, the label *al-Naᶜsh,* 'the bier' (αβγδ Ursae Majoris), which is the joint name for the four stars, was also engraved on the body and the label *al-Banāt,* 'the daughters', the joint name for the three stars on the tail, is engraved above the tail. The individual names of the three stars are written below the tail: *Jawn,* 'black horse' (ε Ursae Majoris); *ᶜAnāq,* 'goat' (ζ Ursae Majoris, Mizar); and *Qā'id,* 'leader' (η Ursae Majoris, Alkaid).



Figure F009.3 – Ursa Major and Leo (© The State Hermitage Museum)

Three pairs of stars on the three feet of the bear are conceived as three leaps of a deer which was chased by the dogs of Bootes; accordingly they are named, starting from the right, as *Qafzah al-Ulā,* 'first leap' (νξ Ursae Majoris); *Qafzah al-Thānī,* 'second leap' (λμ Ursae Majoris) and (*Qafzah al-Thālith,* 'third leap' (ικ Ursae Majoris).

The figure of Leo is drawn directly below the bear, upon the ecliptic, with its forelegs crouched, its rump raised high and its tail coiled to make a full circle. The title of the constellation is engraved above the back of the lion as *ṣūrat al-Asad 5,* 'figure of the lion'. The star on the lower part of the body is called *Qalb al-Asad,* 'heart of the lion' (α Leonis, Regulus); a star on its face *Rās al-Asad Janūbī,* 'southern head of the lion' (ε Leonis). The star on its rump is given the name *Ẓahr al-Asad,* 'back of the lion' (δ Leonis, Zosma) and the star on its tail *al-Ṣarfa*, 'change of the weather' (β Leonis, Denebola).

Greater sophistication is exhibited in the depiction of the male and female figures, in their expressive faces, in their dress and postures. The male figures are generally clothed in short tunics which terminate just above the knees. The sleeves are long, indicated by two parallel lines on the wrists, but the collars vary, some with round neck and others with a V-neck. In some cases, the upper flaps close on the right, in some others on the left and yet in others in the middle. It is said that Akbar decreed that Muslims should close their tunics on their right side and Hindus on their left side; in many miniature paintings of this period the two groups are distinguished in this manner.[1083] However, the intention of the globe maker is not to portray certain figures (Auriga, Aquarius) as Muslims and certain others as Hindus (Bootes, Centaurus), but only to introduce variety in dressing styles. Likewise there is variety in the style of the sashes tied around the waist. Trousers are indicated by two lines on the ankles as in the figure of Bootes, but often these lines are omitted. Cepheus wears knee-length breeches and pointed shoes; others are barefoot.

Greater variety is introduced in the head-gear as well. Perseus, Hercules and Ophiuchus wear tight-fitting boat-like caps with a small round pom-pom on the top. Aquarius and Centaurus too wear similar caps, but the pom-poms have different shapes. Cepheus dons a very tall hat with a long feather and Sagittarius a crown. But the most striking head-hear on this globe are the elaborate turbans worn by Auriga, Bootes and Orion; the first being the most flamboyant.

[1083] Sarma 1992a.

With the exception of Auriga and Orion, all other male figures wear ear-rings, consisting of two pearls or beads; these can be seen clearly in the figures of Sagittarius (Figure F009.10), Aquarius (Figure F009.11) and Centaurus (Figure F009.12), where the faces are shown in full profile.

The female figures are clothed in long ankle-length gowns, tight trousers and patterned sashes. They are bare-headed and barefoot, but wear several armlets and bracelets. Only Cassiopeia is shown with a long necklace.



Figure F009.4 – Andromeda, Cassiopeia and Cepheus (© The State Hermitage Museum)

Figure F009.4 shows Andromeda and her parents Cassiopeia and Cepheus. **Andromeda** is in the centre, with her feet in chains and her arms outstretched, crying for rescue from the sea-monster Cetus. She is dressed in a long gown that reaches up to her ankles; and a wide sash around her waist. The gown has a round neck and is closed in the front with a series of clasps. Her upper arms and wrists are filled with several parallel lines indicating a series of armlets and bracelets. Her eyes, nose and mouth are drawn well. Above her left shoulder is engraved the title of the constellation *ṣūrat*

Mar'ah al-Musalasalah, 'figure of the chained woman'. The star on her forehead is common to the figure of Pegasus depicted just above her. Accordingly, the two names of the star are engraved one below the other: *Rās al- Mar'ah al-Musalasalah,* 'head of the chained woman' (α Andromedae) and *Janāḥ al-Faras,* 'wing of the horse' (γ Pegasi, Algenib). A star on the right side of her waist is common to the figure of the fish and carries two names related to both figures; but here only the name related to Andromeda is engraved as *Janb al-Musalsalah,* 'side of the chained [woman]' (β Andromedae). Finally a star on her right foot is named *Rijl al-Musalsalah,* 'foot of the chained one' (γ Andromedae, Almach).

To her lower left is the figure of **Cassiopeia,** seated on an intricately carved chair. Like her daughter, she too wears a long ankle-length gown and a pair of tightly fitting trousers, the folds of which are indicated by the series of parallel lines on her ankles; moreover, the ankles are adorned with anklets. The sash cannot be seen around the waist, but the two loose ends, nicely patterned, are drawn from the waist down to the end of her gown. Like Andromeda, she too is adorned with many armlets and bracelets, and a long necklace.

She is seated on a high chair with her feet dangling. The chair contains elaborately carved legs and tall back-posts with ornate finials. But in drawing the two back-posts, the engraver did not observe the perspective correctly, with the result there appear to be more than two back posts. The title was engraved along Andromeda's gown, but it was not completed because it was interrupted by Andromeda's left arm; one sees only *ṣūrat Dhāt* and not remaining *al-Kursī* . But the name of the star on her hand, *Kaff al-Khaḍīb al-Kursī,* 'the dyed hand [of the lady with] the chair' (β Cassiopeiae, Caph) is written twice; once along outline of the chair, and the second time going upwards above the chair.

Behind Cassiopeia's chair is the kneeling figure of **Cepheus,** with a short tunic, knee-length breaches, pointed shoes, a tall conical hat with a long feather. Interestingly his tunic is closed in the front by two horizontal clasps, a feature which is not seen otherwise on Indo-Persian globes. A sash is tied around his waist; the two loose ends fall in the form of the inverted letter V. He wears ear-rings and a long pointed beard. The figure is entitled *ṣūrat Qīqā'ūs 4,* 'figure of Cepheus'. The star on his left ankle is given the name *al-Rā'ī,* 'the shephard' (γ Cephei).

To the lower right of Andromeda is the figure of Triangulum, entitled *ṣūrat al-Muthallath,* 'figure of the triangle' and the star at its apex is named *Rās al-Muthallath,* 'head of the triangle' (α Trianguli). On the left-hand side of the image can be seen the graduated and numbered scale of the ecliptic and the names of the first two signs of the zodiac *al-Ḥamal* (Aries) and *al-Thawr* (Taurus) in long flowing letters.



Figure F009.5 – Perseus and Auriga (© The State Hermitage Museum)

Immediately beneath Andromeda's feet is the long curved sword wielded by her rescuer **Perseus.** Like Cepheus, he too is dressed in a short tunic with a sash, knee-length breaches, but the engraver forgot to add the shoes. With sunken cheeks and thin beard, he looks like a very old man and not like the heroic rescuer of Andromeda. The ghoul's head is drawn with a similar thin beard. The title is engraved *ṣūrat Barshā'ūs 11,* 'figure of Perseus'. A star on the hilt of the sword is named *Miʿṣam al-Thurayyā,* 'wrist of *al-Thurayyā*' (hχ Persei). The name of the star on the ghoul's head is engraved twice on either side of the face, but both times not very clearly: *Rās al-Ghūl,* 'head of the ghoul' (β Persei, Algol).

Auriga is drawn in the corner formed by the ecliptic and the ecliptic latitude circle which intersects the former at the end of the sign Taurus. He too is clothed in a short tunic with a V-neck and a thick sash around the waist; the folds in the sash and the knot in the front are drawn in detail. With his left hand, he holds a long stick, with a circular hook at the bottom and two whip-lashes at the top. The most impressive feature in this figure is the extravagant turban, its loose end fluttering in the front. The figure is entitled *ṣūrat Mumsik al-Aᶜinnah,* ‘he who holds the reins’. The star on his right shoulder is named *ᶜAyyūq* (α Aurigae, Capella) and that on the left shoulder *Mankib Dhī al-ᶜInān,* ‘the shoulder having the reins’ (β Aurigae, Menkalinan).

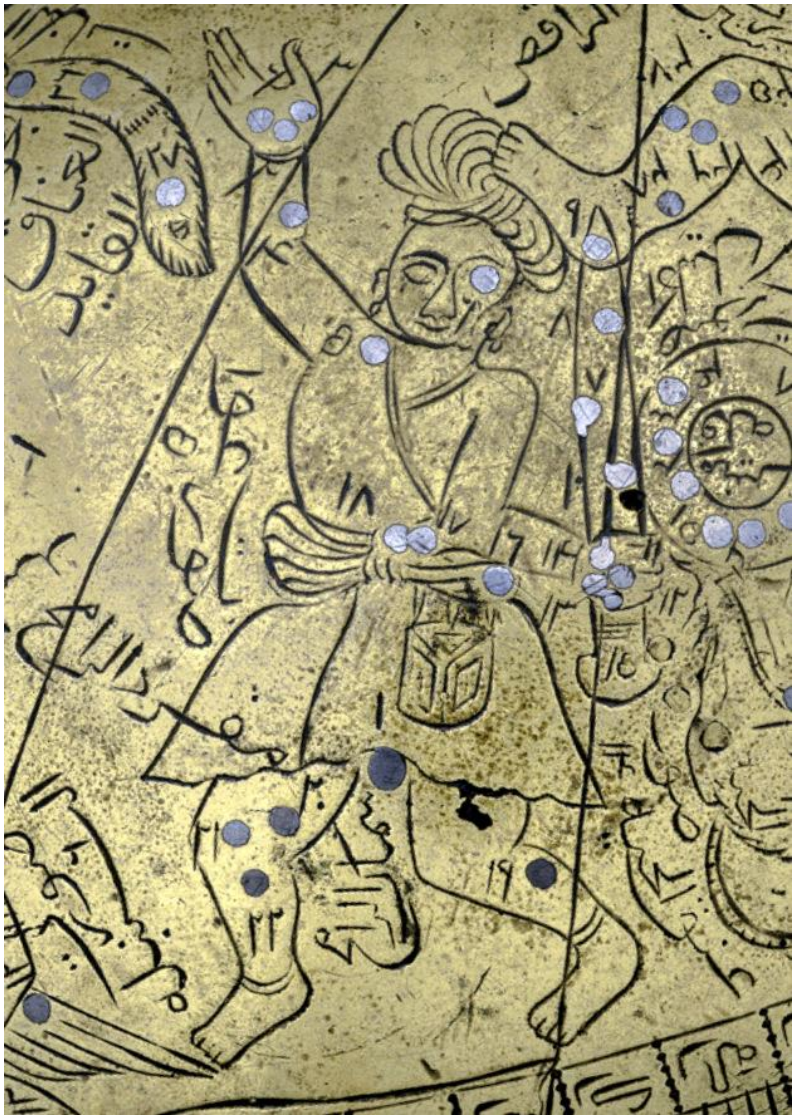


Figure F009.6 – Bootes (© The State Hermitage Museum)

Bootes is also similarly dressed in a short tunic, thick sash and an elaborate turban. On his ankles are drawn two parallel lines to indicate the bottom of the trouser legs. On the left side of the tunic, below the sash, there is a pocket. The upper flap of the tunic

closes on his left. He holds a thick sword. The title of the figure reads *ṣūrat al-ʿAwwā 5,* 'the howler'.

The star between his legs is named *Simāk al-Rāmiḥ,* 'the armed *Simāk*' (α Bootis, Arcturus); that on his right knee has the name *Mufrid al-Rāmiḥ,* 'solitary [star] of the lancer' (η Bootis, Mufrid).



Figure F009.7 – Hercules (© The State Hermitage Museum)

After casting the globe, a large circular plug, of slightly darker shade, was added precisely at the place where the heads of Hercules and Ophiuchus are situated. The plug is well integrated with the rest of the sphere and the engraving continued upon it. Like the other male figures, **Hercules** is clothed in a short skirt with a round neck, a sash with two loose ends forming the inverted letter V, a tight-fitting cap with a pom-pom on the

top. Strangely upon his chest, which is covered with his tunic, are drawn short strokes in the form of the letter W, to indicate his hairy chest. He hold a curved sickle in his left hand. His right foot rests on the fierce head of the dragon Hydra; his left foot on the turbaned head of Bootes. Next to the left elbow is the fierce head of the coiled serpent which is carried by Ophiuchus. And next to his right hand are the tail feathers of the eagle Aquila. The title of the constellation reads *ṣūrat Jāthīᶜalā Rukbatah,* 'figure of the one resting on his knees', instead of the usual shorter form *Jāthī.* The star on his forehead is named *Rās al-Jāthī,* 'head of the kneeling man' (α Herculis, Rasalgethi).

Adjacent to his head on the right is the head of Ophiuchus, placed in the reverse direction. The two heads look like the reflections of one another.



Figure F009.8 – Orion (© The State Hermitage Museum)

Between the zodiac figures Taurus and Gemini is the constellation figure of **Orion** at slightly lower level, striding the graduated scale of the equator. The lower half of his body and the full figure of the hare Lepus below his feet are covered by a large circular

plug which is blank. It appears that the original plug with the engraving was lost and the gap was filled with a blank plug at a later point. This is not joined well with the globe as in the case of other plugs. Orion's head is covered with an elaborate turban, like the one worn by Auriga and Bootes. The figure is entitled *ṣūrat al-Jabbār,* 'figure of the giant' and followed by the wrong serial number 4 instead of the correct number is 2. Two star names are visible: *Mankib al-Jawzā',* 'shoulder of *al-Jawzā''* (α Orionis) and *Yad al-Jawzā',* 'hand of *al-Jawzā''* (γ Orionis).

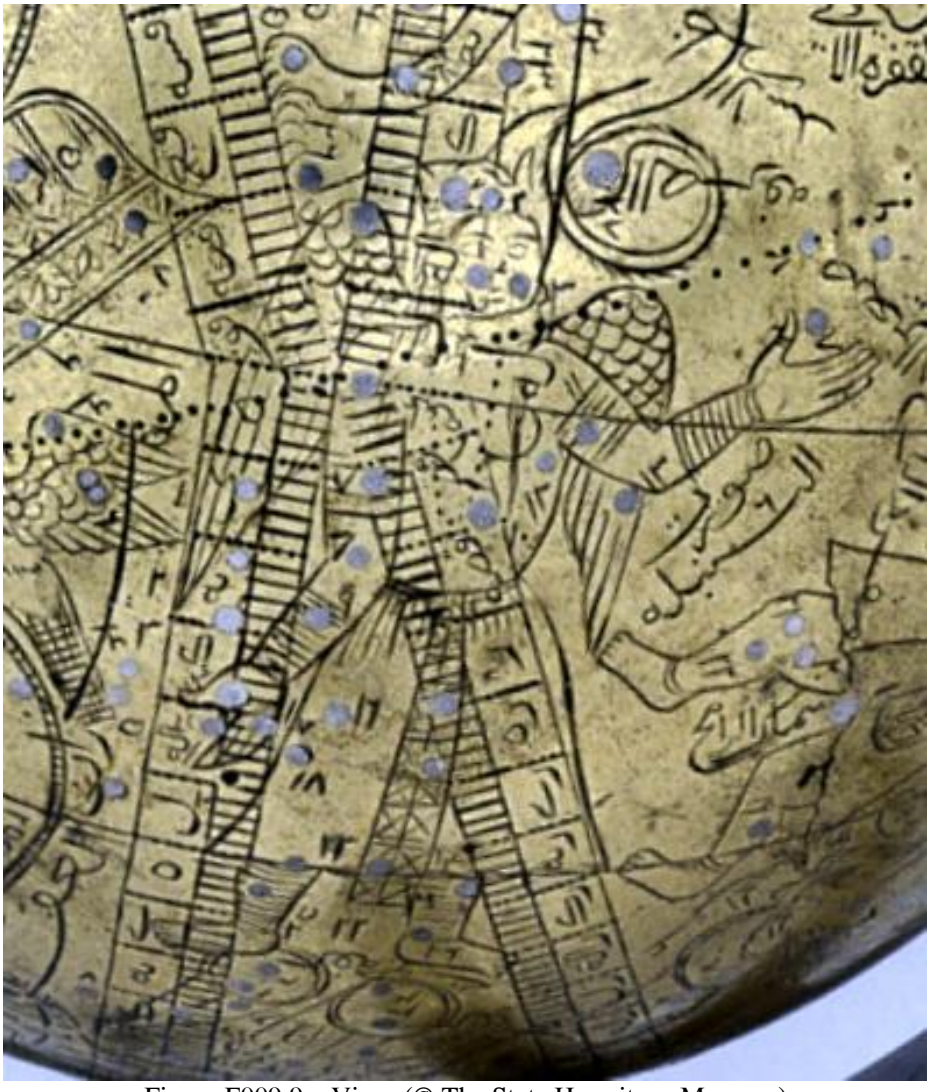


Figure F009.9 – Virgo (© The State Hermitage Museum)

The figure of the sixth zodiac sign **Virgo** is engraved upon the graduated scales of equator and ecliptic near their intersection at the autumnal equinox. She is dressed in a long ankle-length gown and tight trousers, the folds of which can be seen below the hemline of the gown. The two loose ends of the sash, decorated with geometrical patterns, hang down vertically in the front up to the hemline of her gown. Her two wings

are drawn with great detail. Her right arm hangs down parallel to the body and the left arm is pointed northwards. On other globes, both her feet are turned northwards, but here they point to different directions. The title of the figure is engraved under her left arm: *ṣūrat Sunbulah 6,* 'figure of the ear of wheat'. On the right palm is the bright star Spica, it is marked with a inlaid silver point, but not labelled.



Figure F009.10 – Sagittarius (© The State Hermitage Museum)

The ninth zodiac sign **Sagittarius** is depicted with a human torso and a horse's body; both halves are deftly delineated, in particular the two arms with which the bow and bow-string are drawn. There is a sash around the waist, one loose end, with geometrical patterns, flutters eastwards. He wears a crown, to which is attached a head-band which includes several star positions. The horse's right foreleg is raised high. The title of the figure *ṣūrat al-Qaws 9,* 'figure of the archer', is engraved above the crown. On the left foreleg, there are two stars: the upper one near the knee is named as *Rukbat*

al-Rāmī, ‘archer’s knee’ (α Sagittarii, Alrami); the one on the tendon *Urqūb al-Rāmī,* ‘archer’s tendon’ ($\beta^{1,2}$ Sagittarii).

Below the upraised foreleg is the constellation figure of **Corona Australis**, drawn as an oval ring and its lower end is given a trifoliate shape. It is entitled *ṣūrat Iklīl 14,* ‘figure of the crown’, but the direction *janūbī* (southern) is not added.



Figure F009.11 – Capricorn and Aquarius (© The State Hermitage Museum)

Figure F009.11 shows the next two zodiac signs Capricorn and Aquarius. In the figure of **Capricorn**, the front consists of a goat’s body with the head, two curved horns, and the forelegs folded backwards; the hind part consisting of a fish tail is not well developed; instead of two fins spreading in different directions, the hind part tapers to a sharp point. The title *ṣūrat al-Jadī,* ‘figure of the goat’ is incised along the horns.

Aquarius, his right arm stretched westwards above the figure of Capricorn, turns a decorated vessel upside down with his left hand and pours out the water in it; the water flows in a stream southwards up to the mouth of the southern fish. Aquarius is dressed in a long tunic, with a V-neck and flared lower half. The upper flap of the tunic is tied on the right side. A sash is tied around the waist; the loose ends fall down together

vertically. He wears a tight-fitting cap with a curved pom-pom. The title *ṣūrat al-Dalw 11,* 'figure of the bucket' is engraved next to his head.

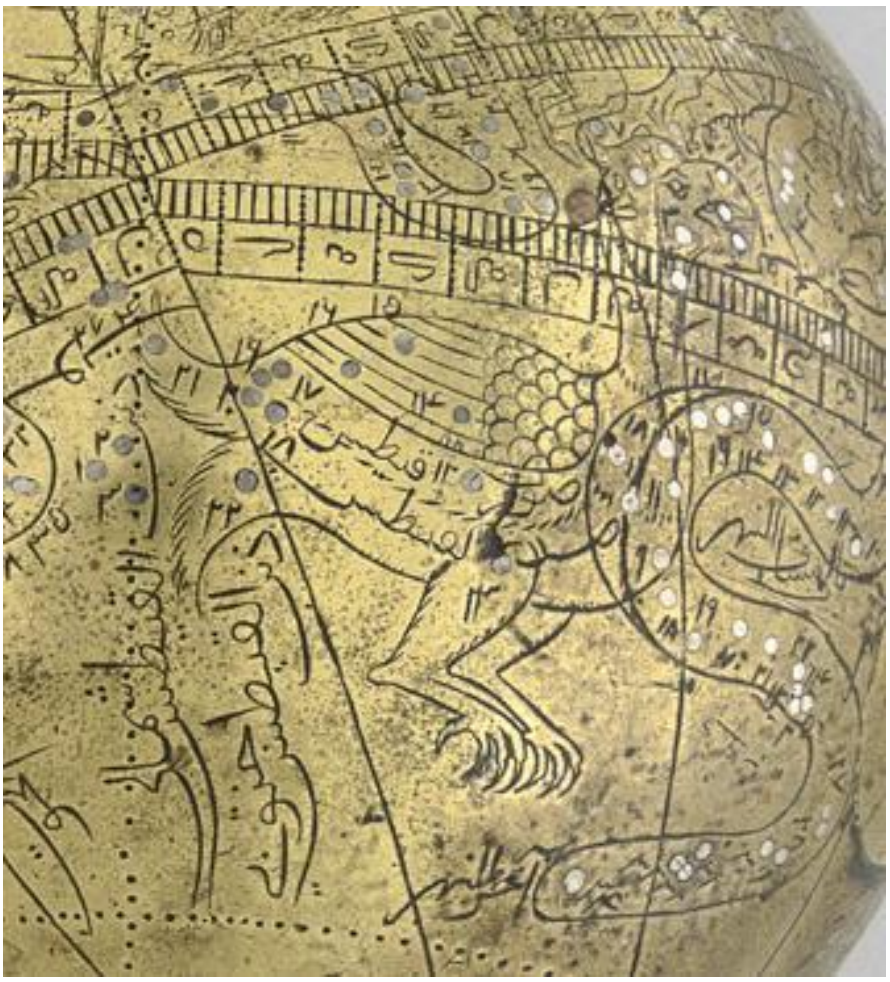


Figure F009.12 – Cetus and Eridanus (© The State Hermitage Museum)

The southern hemisphere is dominated by the three large figures of Cetus, Centaurus and Argo Navis. Of the sea-monster **Cetus,** the body is in the southern hemisphere, but the head rises above the equator and reaches up to the hooves of Aries. It is generally depicted with a bird's body, fish's tail and dog's head. Here the fish tail and bird's body are drawn well; in particular, the large wing on the bird's body is drawn with great detail, in the same manner as the two wings of Virgo are depicted. But in drawing the head, the engraver mixes up the dog's head and bird's head. The front of the head is like that of a bird with the large beak open; but the back of the head is rather strange; it looks more like a cap with a curved pom-pom.

The title of the figure, *ṣūrat Qayṭus,* 'figure of Cetus' is engraved on the body. The star on the beak is named *Kaff al-Jadhmā'*, 'the cut-off hand' (α Ceti); the star on the mouth has the name *Fam al-Qayṭus,* 'mouth of Cetus' (γ Ceti); that on the breast is

called *Ṣadr al-Qayṭus,* 'breast of Cetus', (π Ceti). The star on the northern tip of the fish tail is named *Dhanab al-Qayṭus Shamālī,* '*northern tail of Cetus*' (ι Ceti) and that on the southern tip *Dhanab al-Qayṭus al-Janūbī,* '*southern tail of Cetus*' (β Ceti, Diphda).

The winding river Eridanus makes a curve and touches the breast of Cetus, takes another curve and ends below the feet of Cetus. The star at the end is called *Ākhir al-Nahr,* 'the end of the river' (θ Eridani, Achernar); the star in the first curve is called *Tālī Masāfat al-Nahr,* 'follower of the length of the river' (γ Eridani, Zaurak).

The figure of **Centaurus** on this globe is one of the most accomplished figures engraved by Ḍiyā' al-Dīn; both the horse and the human torso are well-proportioned and drawn with extreme precision. The human figure, face in full profile, wears a tight-fitting circular helmet with a slightly trifoliate pommel. The body is clothed in a long-sleeved tunic. A sash is tied around the waist; its loose end, nicely patterned, flutters backwards suggesting the forward motion of the horse. The tunic is closed on the left side. The equine half, with the fore-legs raised high, is delineated in a powerful manner. The title of the figure is engraved in two lines and in large flowing letters in the space between the figures of Hydra and Centaurus; thus it serves also as a decorative device: *ṣūrat Qanṭūrus,* 'figure of Centaurus'. The star on the foreleg of the horse is named *Rijl al-Qanṭūrus*, 'foot of Centaurus' (α Centauri, Rigil Kentaurus).



Figure F009.13 – Centaurus and Lupus (© The State Hermitage Museum)

Centaurus holds with his right hand an olive twig and with the left hand the wild beast Lupus. The olive twig is depicted like a stylized bouquet with three large leaves. The head of the wild beast is drawn like the head of a lion with its mane.

Above the figure of Centaurus can be seen the curved tail of the serpent Hydra, its outline having a rope-like pattern. The raven Corvus is alighting on the body of Hydra. Its wings and tail feathers are drawn very vividly. The label reads *ṣūrat Ghurāb 10,* ‘figure of the raven’.



Figure F009.14 – Argo Navis (© The State Hermitage Museum)

The third large figure, that of **Argo Navis** on this globe is also the most ornate of all the Lahore globes. The main mast looks like a high tower; it is decorated with patterns of lines: a large sail is tied to it. There are three other masts; on each of them there are pairs of pennants with series of dots and with wavy outlines. These three masts and the main mast are topped by trifoliate finials. The figurehead here is not the usual lion's head; instead it is the head of a parrot with a large curved beak, looking into the body of the boat. There are three domed pavilions with finials on the top, one more ornate than the other. The body of the ship and the domes of the three pavilions are filled with diverse ornate patterns. Beneath the ship is the label *ṣūrat Safīnah 7,* 'figure of the ship'. The large star on the oar to the right is named *Suhayl.*



Figure F009.15 – Globe-maker’s signature (© The State Hermitage Museum)

INSCRIPTION

The signature of the globe-maker is engraved in four lines in the vicinity of the two southern poles:

īn ṣanᶜat ḍiyā’ al-dīn muḥammad
ibn qā’im muḥammad ibn ᶜīsā ibn allāhdād
asṭurlābī humāyūnī lāhūrī
fī sanah 1057 hijrī
‘This is the work of Ḍiyā’ al-Dīn Muḥammad,
son of Qā’im Muḥammad, son of ᶜĪsā, son of Allāhdād
of Lahore, the astrolabe-maker to [the Emperor] Humāyūn
in the year 1057 Hijrī [= AD 1647-48].’

BIBLIOGRAPHY

Savage-Smith 1985, no. 19, p. 227.

F010 CELESTIAL GLOBE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1057 AH (AD 1647-48)

Diameter ?

PLU

This finely engraved celestial globe came up for sale in December 2014 and I received these three photos of low resolution. Since then there has been no news about it. It is not known where it is now. Apparently, the globe is without a stand.

The equator and ecliptic are divided in 1° and 5° and numbered in the usual manner, the former continuously and the latter separately in each sign. There are ecliptic latitude circles. The globe appears to have been engraved with all the 48 constellation figures and marked with the positions of about 1020 stars with inlaid silver points.



Figure F010.1 – Three views of the globe

F011 CELESTIAL GLOBE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1058 AH (AD 1648-49)

Diameter ?

PLU; ex-Patna, PC0

ESS 66; Répertoire 6

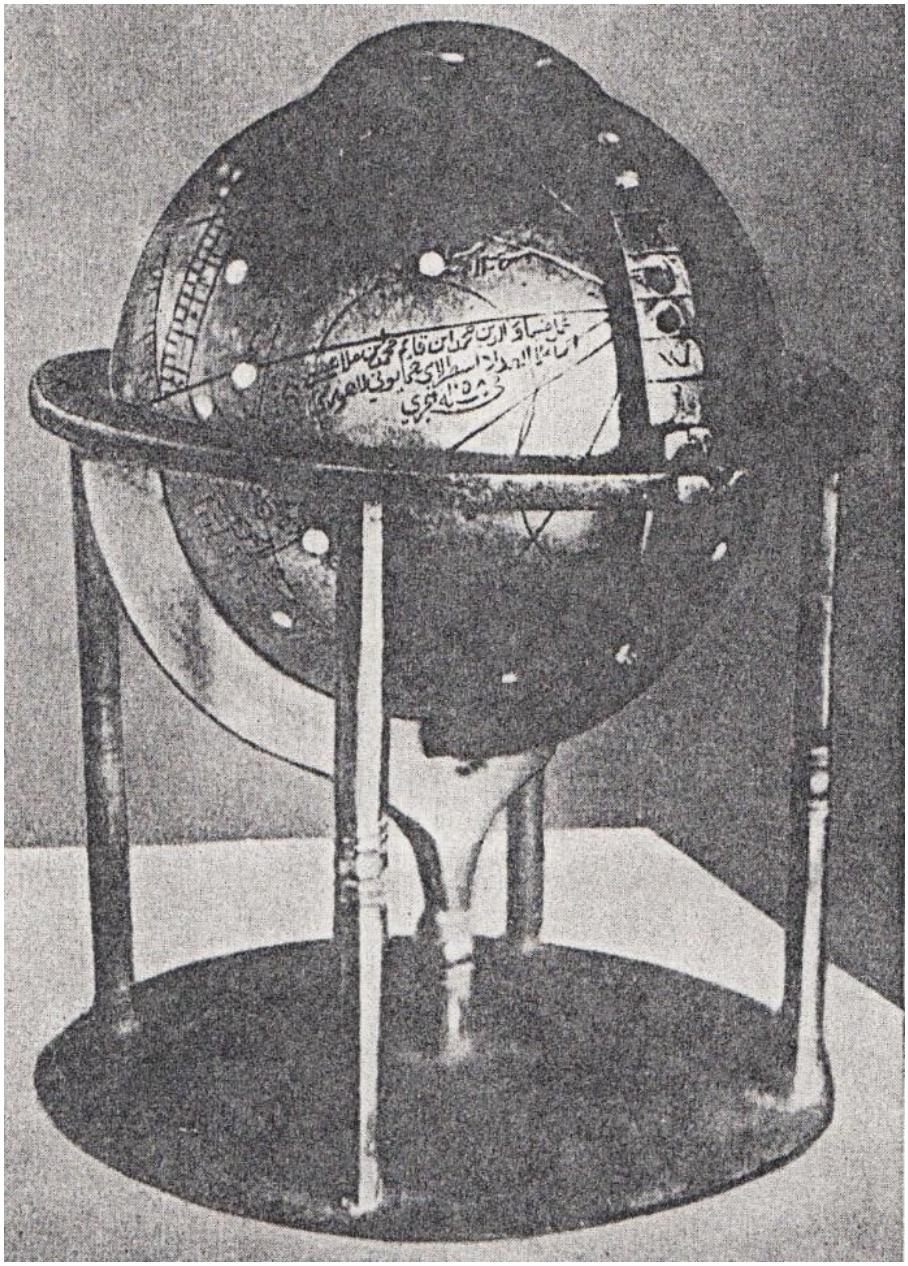


Figure F011.1 – Globe with stand (from Klüber 1935)

Syed Sulaiman Nadvi, in the very first account of the Lahore family, reported that this celestial globe was with the family of Maulvi Yusuf Sahib of Phulwari District since 1238 / 1822-23, that it weighed 1 ¼ lbs., and that it carried the following inscription:[1084]

> *ᶜamal ḍiyā' al-dīn muḥammad ibn qā'im muḥammad ibn mullā ᶜīsā ibn mullā allāhdād asṭurlābī humāyūnī lāhūrī fī sanah 1058 h[ijrī]*
>
> 'The work of Ḍiyā' al-Dīn Muḥammad, son of Qā'im Muḥammad, son of Mullā ᶜĪsā, son of Mullā Allāhdād of Lahore, the astrolabe-maker to [the Emperor] Humāyūn, in the year 1058 Hijrī [= AD 1648-49].'

Nadvi did not mention the diameter. There is no trace of this globe since then. Nadvi apparently obtained a photo of this globe and sent it to Klüber who published it in his study of the Berlin Globe (F018) without naming the source. The globe is cast as a single hollow sphere with a large plug near the signature.

Circles

The equator and the ecliptic circles are divided in 1° and 6° and numbered in 6°. There are equatorial tropics and polar circles, and ecliptic latitude circles. The names of the zodiac signs are engraved along the ecliptic circle.

Constellation Figures and Stars

There are no constellation figures; the positions of about 20 stars are indicated by large inlaid silver points.

Stand

The globe is mounted on a quadruped stand with a circular base. It is not known whether the horizon ring is graduated. The upper surface of the meridian ring is divided in 6° and numbered accordingly. There are holes in the meridian ring so that the globe can be adjusted to different terrestrial latitudes. A heavy semi-circular support for the meridian ring is attached to the underside of the horizon ring. It tapers in the middle to a pillar-like shape and joins the circular base.

[1084] Nadvi 1935, p. 628. Phulwari 'district' seems to be an error; Phulwari is actually a suburb of Patna and is generally referred to as 'Phulwari Sharif' because of a Sufi shrine situated there.

BIBLIOGRAPHY

Nadvi 1935

Klüber 1935, pp. 2, 5, 6; figure 3.

Savage-Smith 1985, no. 66, p. 251.

F012 ⊙ CELESTIAL GLOBE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1060 AH (AD 1650)

Diameter 113 mm

London, Victoria and Albert Museum (#507-1888)[1085]

ESS; Répertoire 9

The globe is cast as a single hollow sphere with two circular plugs of 31 mm and 34 mm diameter respectively. These two plugs are not well fused with the sphere and one of these seems to be coming loose.

CIRCLES

The equator and the ecliptic are divided in 1° and 5°. The divisions of 5° are marked with dotted lines on both scales. On the equator these groups are numbered from 5 to 360, from the vernal equinox onwards; on the ecliptic, they are numbered from 5 to 30, separately for zodiac signs. The names of the zodiac signs are engraved along the ecliptic circle. There are ecliptic latitude circles, but no tropics or arctic circles. The holes at the equatorial poles are now blocked by brass pins.

CONSTELLATION FIGURES AND STARS

The globe is engraved with all the 48 constellation figures; the positions of about 1020 stars are marked with inlaid silver points. I was told that the globe was once chemically cleaned with the result the silver tarnish has spread in the surround area. The constellations are labelled and also numbered in the following manner; the northern constellations from 1 to 21, the zodiac signs from 1 to 12 and the southern constellations from 1 to 15. The engravings are not very sharp and the globe is not well executed.

STAND

The globe is placed on a modern stand which is 167 high, with a horizon ring supported by four legs which are joined below by a circular ring. The horizon ring is ungraduated; the legs are joined by bolts and nuts. There is no meridian ring.

[1085] The Victoria and Albert Museum wrote to say that they do not permit publication of private photography of their objects. Therefore, this entry is regretfully without my photos.

INSCRIPTION

Usually Ḍiyā’s al-Dīn engraves his signature around the southern equatorial pole. But on this globe, the signature is engraved in three lines between two two ecliptic latitude circles in the zodiac sign Pisces:

> *ᶜamal aqall al-ᶜibād ḍiyā’ al-dīn muḥammad ibn qā’im muḥammad*
> *ibn mullā ᶜīsā ibn shaykh allāhdād asṭurlābī humāyūnī*
> *lāhūrī sanah 1060 hijrī.*
>
> ‘The work of the least of the servants [of God], Ḍiyā’ al-Dīn Muḥammad, son of Qā’im Muḥammad, son of Mullā ᶜĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, [in] the year 1060 Hijrī.’

BIBLIOGRAPHY

Savage-Smith 1985, no. 20, pp. 227-228.

F013 ⊙ CELESTIAL GLOBE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1064 AH (AD 1653-54)

Diameter 120 mm

Aligarh, Aligarh Muslim University, Ajmal Khan Tibbiya College

ESS 21; Répertoire 13



Figure F013.1 – Globe with stand (photo by S. R. Sarma)

This is indisputably the finest celestial globe fashioned by Ḍiyā' al-Dīn Muḥammad where astronomy, iconography and calligraphy perfectly match with one

another.[1086] We have seen that globe F009 has a diameter of 137 mm and the area of its surface measures 58,988 mm^2 which is less than the area of an A4 sheet of paper, viz., 62,370 mm^2.

The present globe is still smaller with its diameter of 120 mm and with the surface area of 45239 mm^2 . Here also are engraved diverse kinds of circular scales, about 1020 star pointers and 48 outline drawings of men, women, animals, birds, reptiles and inanimate objects, together with their names and the names of some 101 prominent stars. Yet this globe does not look cluttered like F009, because here the individual stars in each constellation are not numbered serially and the bodies of snakes and fishes are not filled in with minutes scales as in F009, so that the focus remains on the human figures.

The globe is cast as a single hollow sphere by the lost wax process. A circular plug with a diameter of 41 mm is in the southern hemisphere, covering Centaurus, Lupus and Ara. Another circular plug with a diameter of 30 mm covers the torso of Perseus and the arm of Auriga in the northern hemisphere. The metal content of both the plugs matches exactly with that of the sphere. Around the larger plug in the south, there is some dark substance used for joining.

Two small holes were bored at the two poles of the equator for the axis to pass through, but the axis is now missing and the globe is held above the horizontal ring by means of an iron wire.

Circles

On the globe, the equator and the ecliptic are divided in 1° and 5°; the intervals of 5° are marked on both the circles by dotted lines. The equator is numbered, from the vernal equinox onwards, from 5 to 360. On the ecliptic, each zodiac sign is numbered separately from 5 to 30. The ecliptic latitude circles, equatorial tropics and equatorial polar circles are drawn as single lines. The names of the zodiac signs are engraved along the ecliptic.

[1086] I am grateful to the authorities of the Ajmal Khan Tibbiya College for allowing me to study and photograph the globe and to Ghulam Mujtaba for taking the fine and detailed photographs.

Constellation Figures and Stars

All the 48 constellation figures are drawn and the positions of about 1020 stars are marked with inlaid silver nails. The names of the constellation figures are engraved with the prefix *ṣūrat* and followed by their serial numbers, in three distinct groups. Those in the northern hemisphere are numbered from 1 to 21. The twelve zodiac signs are numbered separately as 1 to 12. Then again the figures in the southern hemisphere are numbered from 1 to 15. Moreover, the names of some 101 prominent stars are engraved. The names are inscribed with different sizes of letters and in different directions to fit in the available spaces and to avoid monotony. Moreover, often these star names are engraved in such a manner that they serve as decorative elements of the constellation figures.

As mentioned in the introduction to this section, the 48 figures can be classified as follows: 10 figures represent various inanimate objects and the river Eridanus; 24 figures are zoomorphic, consisting of 12 animals, 4 birds, and 8 reptiles; 14 figures are anthropomorphic with 11 male and 3 female figures. In the following pages, these figures will described in this order.

But first the arrangement of these constellation figures will be explained through five full views of the globe.



Figure F013.2 – Northern Hemisphere (photo by Ghulam Mujtaba)

Figure F013.2 shows the northern hemisphere with the the northern ecliptic pole at the centre, where the ecliptic latitude circles converge. The figure of the constellation Draco encircles the pole. The northern celestial pole is at the centre of the large hole, labelled as *quṭb shamālī.* The constellation figures of Ursa Minor, Ursa Major, Cassiopeia, Cepheus, Cygnus, Lyra and Hercules are arrayed here in a clockwise formation.



Figure F013.3 – Vernal equinox (photo by Ghulam Mujtaba)

At the centre of Figure F013.3 is the point of vernal equinox where the equator and the ecliptic intersect. Both are divided in 1° in the inner band and intervals of 5° are numbered in *Abjad* notation in the outer band. The constellation figures of Pegasus and Andromeda can be seen in the upper register; Aquarius, Piscis Austrinus and Cetus are in the lower half.



Figure F013.4 – Summer solstice (photo by Ghulam Mujtaba)

In Figure F013.4, the lower circle is the equator and the upper one the ecliptic. The point on the ecliptic between the signs of Gemini and Cancer is the summer solstice, when the ecliptic is at its greatest distance or maximum declination from the equator. The vertical line in the middle of the figure is the ecliptic latitude circle passing through the point of the vernal equinox.

The constellation figure of Auriga is above the ecliptic; Taurus, Gemini, Cancer are the ecliptic; Orion, Canis Minor and the head of Hydra can be seen between the ecliptic and equator. Eridanus, Lepus, Canis Major and Argo Navis are to the south of the equator.



Figure F013.5 – Autumnal equinox (photo by Ghulam Mujtaba)

Figure F013.5 shows the point of autumnal equinox where equator and ecliptic intersect at the junction of Virgo and Libra. The constellation figures of Ursa Major and Bootes are in the northern hemisphere. Leo and Virgo are on the ecliptic; Argo Navis, the body of Hydra, Crater and Corvus are to the south of the equator.

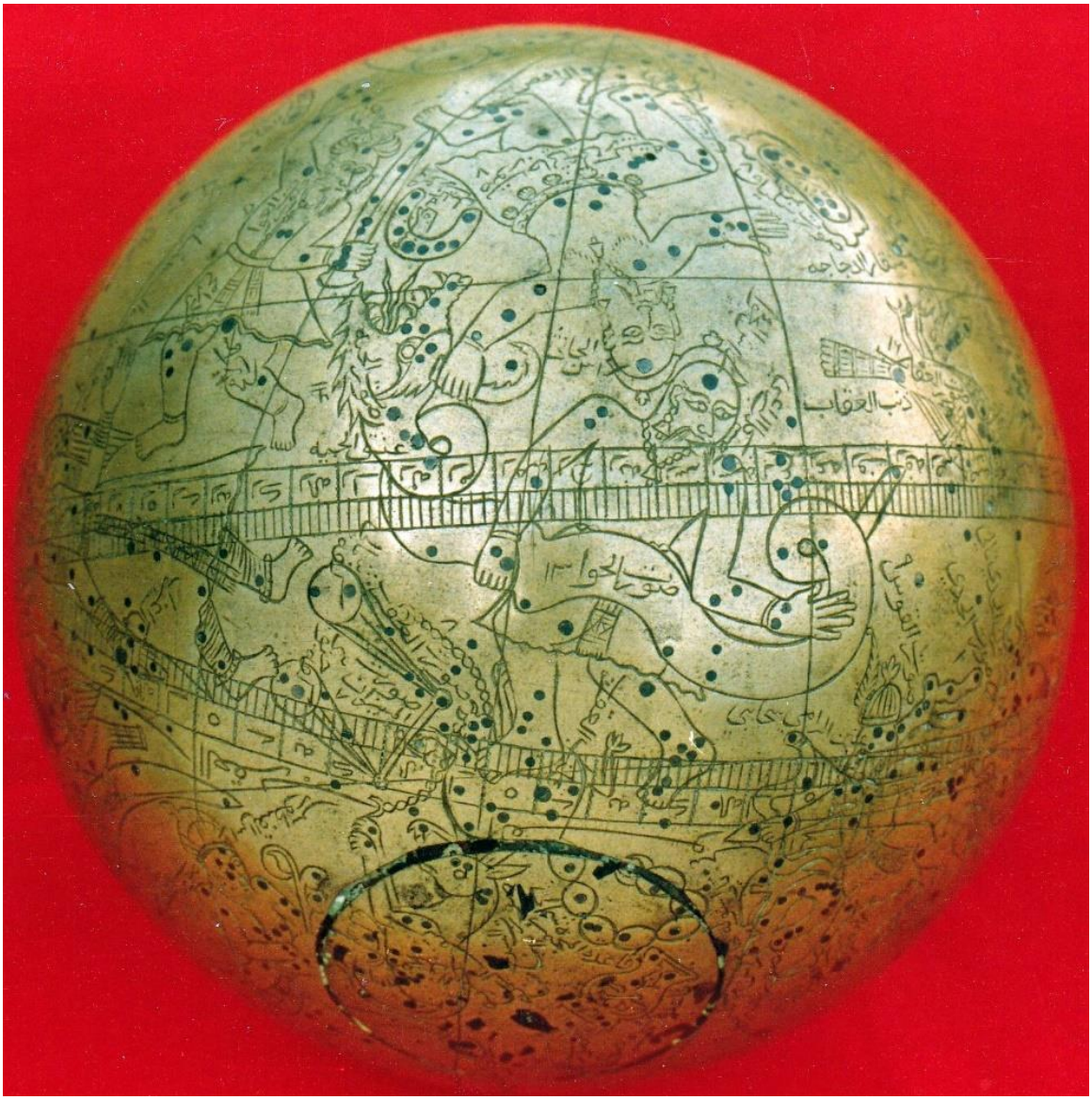


Figure F013.6 – Winter equinox (photo by Ghulam Mujtaba)

Figure F013.6 the equator is above and the ecliptic is below. The point on the ecliptic between the signs Sagittarius and Capricorn is the winter equinox when the ecliptic is once again at its greatest distance or maximum declination from the equator. This point is on the lower right in this figure; the ecliptic latitude circle passing through this point passes to the right of the figures Ophiuchus and Hercules. In the upper register are the figures of Bootes and Hercules (upside down) and Ophiuchus. On the ecliptic are the figures of Libra, Scorpio and Sagittarius. A large circular plug is at the bottom, inside which can be seen figures of Lupus and Ara.

1. INANIMATE OBJECTS

A pair of crowns, wreaths or garlands, one in the northern hemisphere and the other in the southern hemisphere are visualised by the Greeks, but their mythological background is somewhat vague. In Arabic they are called *al-Iklīl al-Shamālī* (the northern crown) and *al-Iklīl al-Janūbī* (the southern crown) respectively, but the northern crown is more commonly referred to as *al-Fakkah,* a term of uncertain connotation.[1087] On Indo-Persian celestial globes the terms *al-Fakkah* and *al-Iklīl al-Janūbī* are generally employed for the northern and southern crowns.

Corona Borealis is usually drawn as two concentric circles between the two figures of Hercules and Bootes. But on the present globe (and also on F018, see Figure F018.3) it is drawn in the form of a horse shoe (see Figure F013.31). The label reads *ṣūrat Iklīl 6,* 'figure of crown,' without the attribute *shamālī*; one of the seven stars which is situated on the curve of the horse shoe carries the label *Nayyir Fakkah,* 'luminous one of *al-Fakkah*' (α Corona Borealis).

The southern counterpart, **Corona Australis**, is drawn between the front legs of Sagittarius in the form of an oval ring with a trifoliate end. The label reads *ṣūrat al-Iklīl 14,* 'figure of the crown,' again without the attribute *Janūbī.* The star at the apex is named *Rās al-Iklīl,* 'head of the crown' (α Coronae Australis, Alphekka Meridiana) (see Figure F013.34). This is perhaps the only Indo-Persian globe on which this star is named.

The constellation **Lyra** is called in Arabic *Shulyāq*; the word may have been derived from the word denoting tortoise, since the musical instrument Lyra was constructed by stretching seven strings on a tortoise shell. But in the Arabic context, the sense of the musical instrument was soon forgotten and the constellation is never depicted as a lyre on Islamic celestial globes.[1088] On Indo-Persian globes, it is generally depicted as a crown with a trifoliate finial (see Figure F013.16). On the present globe, the label reads *ṣūrat Shulyāq 8,* 'figure of tortoise'. The largest of the ten marked stars

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1087 Cf. Savage-Smith 1985, pp. 142 and 209, Figs. 54 and 86.

1088 Cf. Savage-Smith 1985, pp. 144-146, Fig. 55.

is given the name *Nasr Wāqiᶜ,* ' falling eagle' (α Lyrae, Vega). Its is the fifth brightest star. The common name Vega is derived from the Arabic *Wāqiᶜ*.

Hercules is said to have killed with an arrow the eagle that was gnawing at the liver of Prometheus and thus the arrow is elevated to the heavens as the constellation **Sagitta**[1089] (see Figure F013.17). The label reads *ṣūrat al-Sahm 15,* 'figure of the arrow'.

Hermes is said to have placed the **Triangulum** above the head of Aries so that its brightness would mark the dimness of Aries.[1090] On the globes, it is drawn to the lower left of Andromeda (see Figure F013.37). On the present globe, the label reads *ṣūrat al-Muthallath 21,* 'figure of the triangle' and the star at its apex is named *Rās al-Muthallath,* 'head of the triangle' (α Trianguli).

Libra is the eighth sign of the zodiac.[1091] The constellation figure is depicted as a weighing balance, two pans being suspended from the beam by four strings each. At the middle of the beam is a piece of rope for holding the balance (see Figure F013.23). The label reads *ṣūrat al-Mīzān 8.* The stars situated in each of the pans are labelled as *Kiffah Shamālī,* 'the northern pan' (β Librae) and *Kiffah Janūbī,* 'the southern pan' (α Librae).

Crater[1092] is depicted as a large wine cup, or jar, placed on the back of Hydra (see Figure F013.18). Its label reads *ṣūrat al-Bāṭiyah 9,* 'figure of the bowl'. A star on its stem carries the name *Qāᶜidat al-Bāṭiyah,* 'the base of the bowl' (α Crateris).

The constellation **Ara**,[1093] situated below the tail of Scorpio and next to Lupus, is conceived as a censor in which incense is burnt. On the present globe it is depicted as a vase decorated with symmetrical patterns, with the fumes of incense rising from its mouth like the tongues of fire. It is upside down, the fumes going towards the southwest. Its label reads *ṣūrat al-Mijmarah 13,* 'figure of the incense burner'. Two stars marked on the base are labelled respectively as *Qāᶜīdat al-Mijamarah Shamālī*, 'northern base of the incense burner' (σ Arae) and *Qāᶜīdat al-Mijamarah Janūbī,* 'southern base of the

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1089 Cf. Savage-Smith 1985, p. 155, Fig. 60.

1090 Cf. Savage-Smith 1985, p. 162, Fig. 62.

1091 Cf. Savage-Smith 1985, pp. 175-176, Figs. 69 and 70.

1092 Cf. Savage-Smith 1985, p. 203, Fig. 83.

1093 Cf. Savage-Smith 1985, p. 207-209, Fig. 86.

incense burner' (θ Arae) (see Figure F013.16, inside the circular plug, below the tail of the scorpion).

Eridanus[1094] is a winding river in the southern hemisphere; rising at the foot of Orion, it winds its way up to Cetus, then reversing the course, it flows up to Lepus, then turns back again and ends near the feet of Cetus (see , lower left). The star situated at its end is appropriately named as *Ākhir al-Nahr,* 'the end of the river' (θ Eridani, Acamar). The name of the constellation is engraved on its last bend as *ṣūrat al-Nahr 3,* 'figure of the river'.

Argo Navis and Centaurus are the two most prominent constellations depicted in the southern hemisphere of the celestial globes. According to legend, Argo is the ship on which Jason sailed in search of the Golden Fleece; after his voyage, Athena placed the ship in the heavens.[1095]

The figure of the ship in the constellation Argo Navis is rather simple, but elegant. It is a rectangular structure with a single mast, topped by a finial shaped like a pomegranate fruit. To the mast is attached a rather large and stiff banner on which is engraved the title of the constellation *ṣūrat al-Safīnah 5,* 'figure of the ship'. The figurehead on the prow is meant to be a lion's head with the ears standing out, but looks more like a human face with a flimsy beard. On the back, there is a high pavilion on the upper deck, with a canopy and finial matching the finial on the mast. Below it is a cabin with a large window. The galleries are decorated with wicker-work and cartouches. A star on the figurehead is named *Ṭarfat al-Safīnah,* 'side of the ship' (ρ Puppis). The two oars are drawn like ornate bells. The large star on the right anchor is named *Suhayl* (α Carinae, Canopus); it is the second brightest star.

1094 Cf. Savage-Smith 1985, pp. 192-194, Fig. 77.

1095 Cf. Savage-Smith 1985, pp. 199-201, Fig. 81.

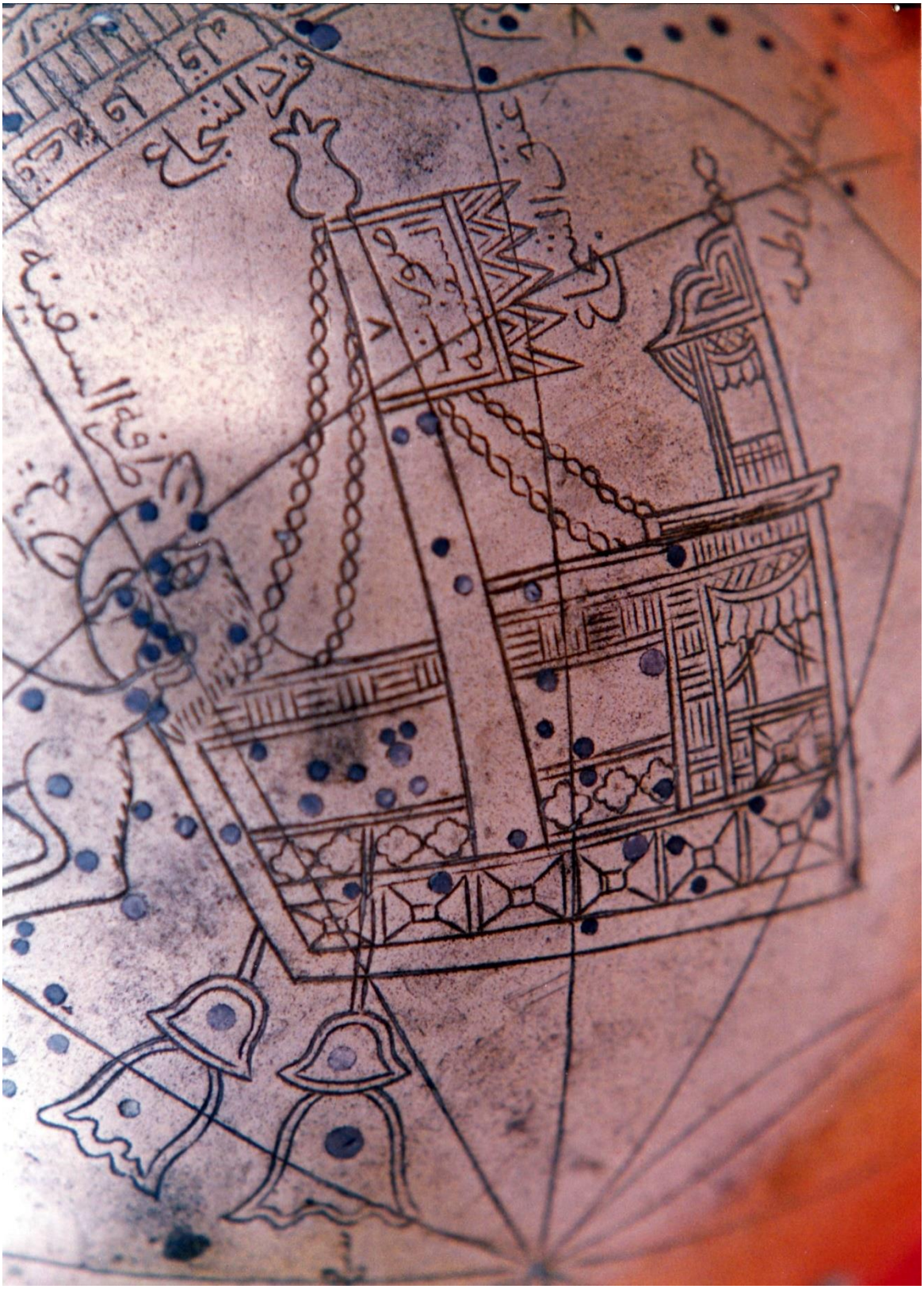


Figure F013.7 – Argo Navis (photo by Ghulam Mujtaba)

2. ZOOMORPHIC FIGURES

2.1 Animals



Figure F013.8 – Ursa Major (photo by Ghulam Mujtaba)

In the constellation **Ursa Major,**[1096] the figure of the bear is depicted in a conventional manner, with a few oblique strokes along the outline to suggest the hairy nature of the body. A large number of stars in this constellation are named. As mentioned in the introduction to this section, the nomenclature here is based on the various traditions regarding the form of this constellation as a bear, as a bier, and as a fleeing deer.

The title of the constellation and its serial number are engraved to the left of the head at the top: *ṣūrat Dubb al-Akbar 2,* 'figure of the great bear'. The large star on the back of the bear is designated as *Ẓahr al-Dubb al-Akbar,* 'back of the great bear' (α Ursae Majoris, Dubhe); the star a little below has the name *Mirāq al-Dubb al-Akbar,* 'loin of the great bear' (β Ursae Majoris, Merak); a star to the east of this one is

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[1096] Cf. Savage-Smith 1985, pp. 34-136, Fig 50.

named *Fakhdh Dubb al-Akbar,* 'thigh of the great bear' (γ Ursae Majoris) and the star at the base of the tail is given the name *Maghriz Dubb al-Akbar,* 'base of the great bear' (δ Ursae Majoris). These four stars form a rectangle that was seen as the bier to carry the deceased and was given the collective name *al-Naᶜsh,* 'the bier'; this name is also engraved just below the outline of the back.

The three stars on the tail were regarded as the three daughters who follow the bier. The collective designation *al-Banāt,* 'the daughters' is engraved on the tail between the star pointers. The individual names of these three stars are engraved below the tail: *Jawn,* 'black horse' (ε Ursae Majoris); *ᶜAnāq,* 'goat' (ζ Ursae Majoris, Mizar); and *Qā'id,* 'leader' (η Ursae Majoris, Alkaid).

Leaving aside the right foreleg, in the paws of the remaining three legs, there are each a pair of star pointers. These were regarded as the marks of the cloven hooves of a deer chased by the dogs of Bootes and were named accordingly. Starting from the east, these names are *Qafzah al-Ulā,* 'first leap' (νξ Ursae Majoris); *Qafzah al-Thānī,* 'second leap' (λμ Ursae Majoris); and *Qafzah al-Thālith,* 'third leap' (ικ Ursae Majoris).

The first constellation **Ursa Minor**[1097] is represented by a small bear drawn in the large bend made by the dragon **Draco**; the outline of the head, back and the tail of the bear are curved in the manner as the bend of the dragon. The title of the figure is engraved below its head: *ṣūrat Dubb al-Aṣghar 1,* 'figure of the small bear'. There are three named stars. The star at the end of the tail which is close to the celestial pole is called *al-Jadī,* 'the goat' (α Ursae Majoris, the Pole Star); the star at the top of its right foreleg is named *Anwar al-Farqadayn,* 'the brighter of the two calves' (β Ursae Minoris) and that on the back *Akhfā al-Farqadayn,* 'the most obscure of the two calves' (γ Ursae Minoris).

[1097] Savage-Smith 1985, pp. 132-134, Fig. 49.



Figure F013.9 – Ursa Minor (photo by Ghulam Mujtaba)

The mythical winged horse **Pegasus**[1098] which carried Perseus when he slew Medusa and rescued Andromeda is not shown in full on celestial globes, but only the forepart consisting of the head, the neck with long mane, wings, and the two forelegs is depicted and the hind part is reduced to a rectangular stump. Ḍiyā' al-Dīn's equine figures are always well-drawn, although the head of Pegasus is somewhat obscured by the overlapping band of the celestial equator. Because of the small size of the globe, the wing is given a simple form, avoiding the details of feathers as on larger globes. Its title *ṣūrat Faras Aᶜzam 19,* 'figure of the larger horse' is engraved on the front of the body.

There are five named stars: *Matn al-Faras,* 'side of the horse' (α Pegasi, Markab); *Mankib al-Faras,* 'shoulder of the horse' (β Pegasi, Scheat); *Janāḥ al-Faras,* 'wing of the horse' (γ Pegasi, Algenib); *Fam al-Faras,* 'mouth of the horse' (ε Pegasi, Enif); *Surrat al-Faras,* 'navel of the horse' (δ Pegasi). The last one is common to the figure of Andromeda and carries a name related to that figure as well; this second name is engraved diagonally across the rectangle as *Rās al-Mar'ah al-Musalsalah,* 'head of the chained woman' (α Andromedae).

[1098] Cf. Savage-Smith 1985, pp. 157-160, Fig. 61.

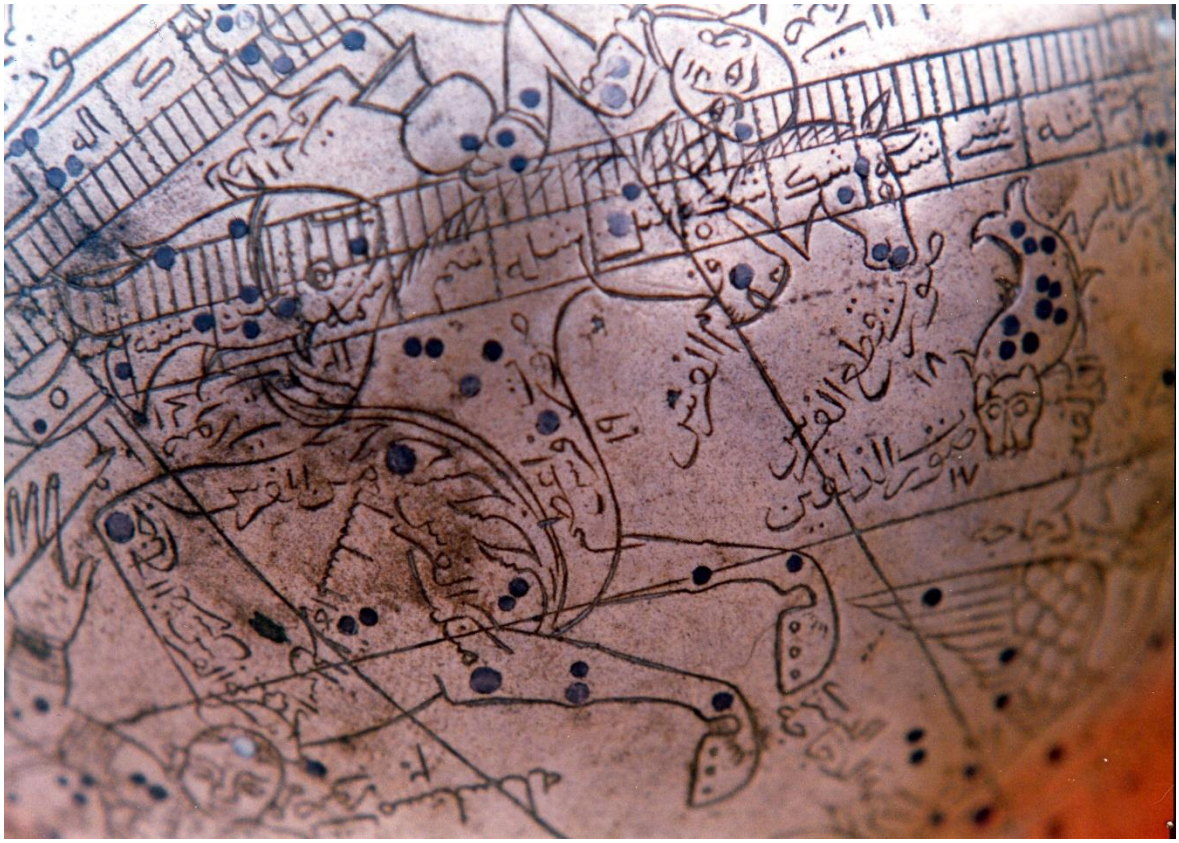


Figure F013.10 – Pegasus, Equuleus and Dolphin (photo by Ghulam Mujtaba)

To the east of the head of Pegasus is the small figure of Equuleus, represented just by the horse’s head drawn on the scale of the equator, with the label *ṣūrat al-Qiṭ*ᶜ*at al-Faras,* ‘the part of a horse’.

Further east is the figure of the dolphin. Above the wing of Pegasus can be seen the western fish of the constellation Pisces drawn precisely on the ecliptic. Above the heads of Pegasus and Equuleus can be seen the head of Aquarius and his vessel of water.

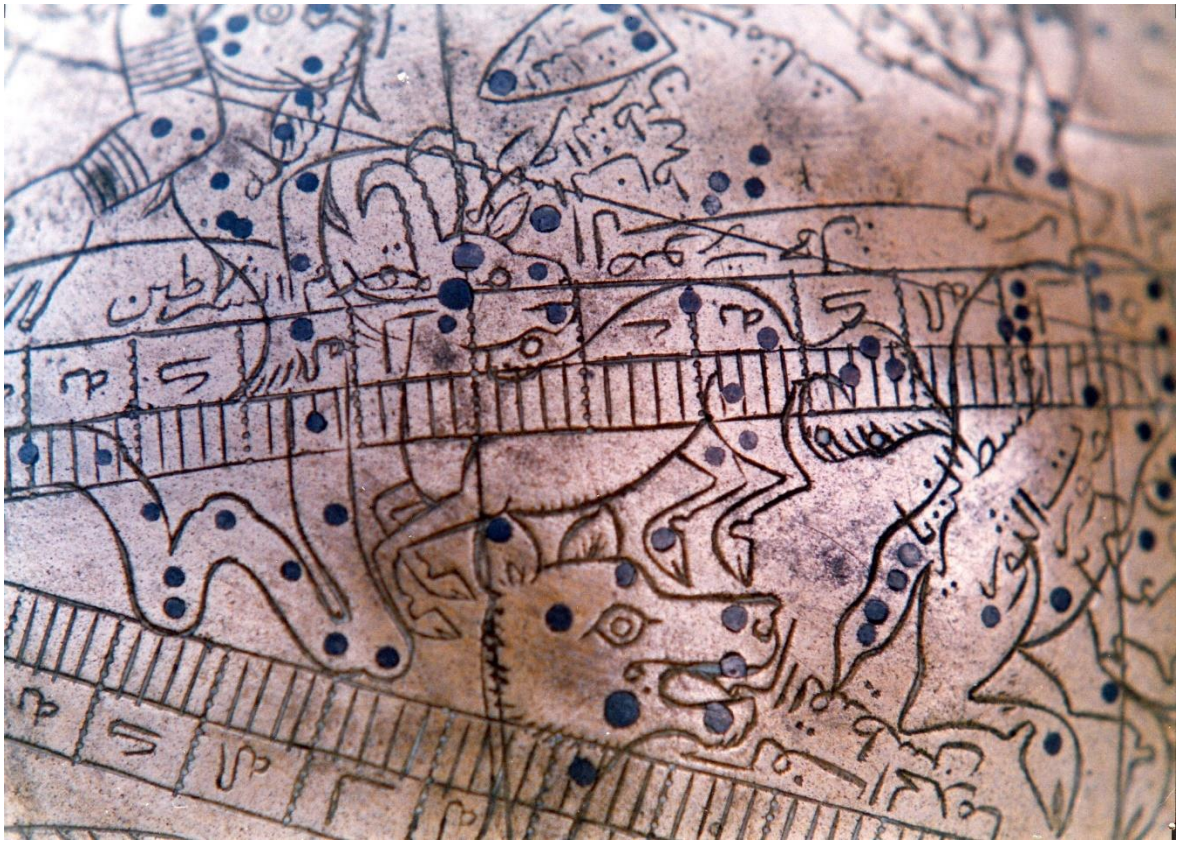


Figure F013.11 – Zodiac Sign Aries (photo by Ghulam Mujtaba)

The first zodiac sign **Aries**[1099] is represented by the figure of a ram seated with its four legs bent, its body towards west and the head bent back towards the east. It curved horns are drawn with wavy lines; its tail is depicted in the form of a large fig leaf.

The title of the figure is engraved along the ecliptic as *ṣūrat Ḥamal 1,* 'figure of the ram'. The star next to its left ear carries the name *al-Nāṭiḥ,* 'that which butts or gores' (α Arietis); it is also the first lunar mansion. The two stars on its head are called respectively *Muqaddam al-Sharaṭayn,* 'the anterior of the two signals' (β Arietis) and *Mu'akkhir al-Sharaṭayn,* 'the posterior of the two signals' (γ Arietis).

[1099] Cf. Savage-Smith 1985, pp. 162-164, Fig. 63.



Figure F013.12 – Taurus and Orion (photo by Ghulam Mujtaba)

The second zodiac sign **Taurus**[1100] is usually represented on the globes by the fore part of a bull consisting of the head, horns, hump and the two forelegs. But here, most unusually, Ḍiyā’ al-Dīn telescoped the body in a clumsy manner to show all the four legs and the tail,

The title of the figure is engraved on the body as *ṣūrat al-Thawr 2,* ‘figure of the bull’. The star near the eye is named *ᶜAyn al-Thawr,* ‘the eye of the bull’ (α Tauri). On the shoulder are four stars representing the Pleiades; one of these is given the name of *Misṭ* or *Qisṭ* (?) *al-Thurayyā*.

[1100] Cf. Savage-Smith 1985, pp. 164-166, Fig. 64.



Figure F013.13 – Zodiac Sign Leo (photo by Ghulam Mujtaba)

In the zodiac sign **Leo**,[1101] Ḍiyā' al-Dīn drew the lion very realistically, with the head in profile. It is more like a lion cub, with its mane indicated with a few short strokes. The uplifted tail, the snarling teeth and the crouching forelegs suggest that the cub is about to pounce on its prey. The name of the zodiac house, *al-Asad,* is engraved in long strokes across the lion's head. The name of the pictorial representation, *ṣūrat al-Asad 4,* 'figure of the lion' is inscribed above its eye in a vertical line. The two stars on its head are designated respectively as *Rās al-Asad Shamālī,* 'northern head of the lion' (μ Leonis) and *Rās al-Asad Janūbī,* 'southern head of the lion' (ε Leonis). The star on its upraised rump is given the name *Ẓahr al-Asad,* 'back of the lion' (δ Leonis, Zosma, Duhr) and that on the tip of the tail

Al-Ṣarfa, 'change of weather' (β Leonis, Denebola). The very large star on the upper part of the left foreleg is named *Qalb al-Asad,* 'the heart of the lion' (α Leonis, Regulus).

[1101] Cf. Savage-Smith 1985, pp. 170-172, Fig. 62.



Figure F013.14 – Zodiac Sign Capricorn (photo by Ghulam Mujtaba)

The zodiac sign **Capricorn**[1102] is represented by a composite image of a goat with the tail of a fish. On this globe, however, the figure does not have a fish tail, but just a stump. The forepart of the goat facing west is done well with two horns with many curves and the two fore-legs with slender hooves, which are bent backwards. The hind part is reduced to an oval form without the hind legs.

The title of the figure is engraved above the head: *ṣūrat al-Jadī 10,* 'figure of the goat'. The star on the horn is named *Qarn al-Jadī Thānī,* 'second horn of the goat' (α Capricorni) and the one on the tail *Dhanab al-Jadī,* 'tail of the goat' (δ Capricorni). The star on the hind part is given the name *Saᶜd nāsirah,* 'omen of fertility' (γ Capricorni).

[1102] Cf. Savage-Smith 1985, pp. 181-813, Fig. 72.

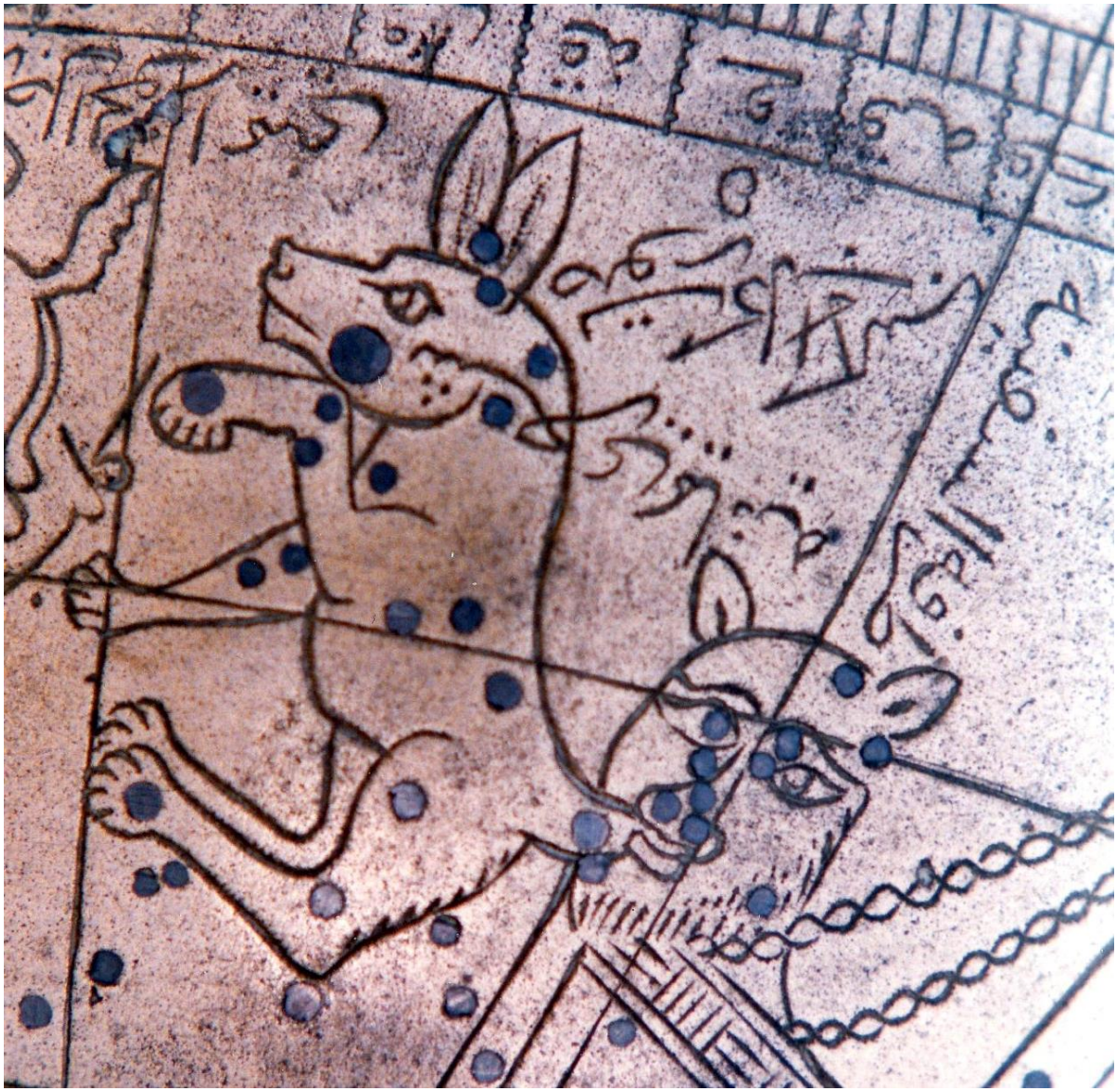


Figure F013.15 – Canis Major (photo by Ghulam Mujtaba)

Among the animal population on the celestial globe, there are also two dogs, which are considered to be the hunting companions of the giant Orion. The larger dog in **Canis Major**[1103] is situated to the west of the Argo Navis. Here it is drawn with two large ears, like those of a rabbit, and its tail overlaps the figure-head of Argo Navis. It is entitled *ṣūrat Kalb al-Akbar 5,* 'figure of the large dog'. The star on its head is named *Shiʿrā Yamānī,* 'southern *Shiʿrā*' (α Canis Majoris, Sirius). It is the brightest star on the firmament.

1103 Cf. Savage-Smith 1985, pp. 194-197, Fig. 79.

The smaller dog **Canis Minor**[1104] is situated to the south of Gemini (Figure F013.25). It is drawn nicely with the tail raised high and with drooping ears, with the title *ṣūrat Kalb al-Aṣghar 6,* 'figure of the small dog'. The star *Shiᶜrā Shāmī,* 'northern *Shiᶜrā*' (α Canis Minoris, Procyon) is the eighth brightest star. Sirius and Procyon were considered sisters.

The constellation **Lepus**[1105] is situated to the south of Orion and to the west of Canis Major (Figure F013.31). This hare is said to be chased by Orion with his two dogs. The title reads *ṣūrat al-Arnab 37,* 'figure of the hare'. There are no named stars.

The constellation **Lupus**[1106] is represented as an unidentifiable wild animal (Figure F013.35) which is held by Centaurus by its two hind legs. It is usually drawn with a tapering snout like a fox. The title reads *ṣūrat al-Sabᶜ,* 'figure of the wild beast'. Three stars carry names: *Fakhudh al-Sabᶜ,* 'thigh of the wild beast' (α Lupi), *Dhanab al-Sabᶜ,* 'tail of the wild beast' (χ Lupi) and *Kutuf al-Sabᶜ,* 'shoulder of the wild beast' (γ or δ Lupi).[1107]

1104 Cf. Savage-Smith 1985, pp. 197-199, Fig. 80.

1105 Cf. Savage-Smith 1985, p. 194, Fig. 78.

1106 Cf. Savage-Smith 1985, pp. 207-209, Figs. 84, 85.

1107 Cf. Klüber 1935, p. 20.



Figure F013.16 – Cygnus and Lyra (photo by Ghulam Mujtaba)

2.2 Birds

In the Greek conception, the constellation **Cygnus**[1108] is assumed to be a flying swan, but the Arabic name *al-Dajājah* connotes chiefly domestic fowl, hen and cock. Ḍiyā' al-Dīn, however, depicts it as a special kind of swan, flying with both wings spread out (compare the wing feathers with those of Virgo and Corvus); the tail feathers are elegantly curved like a palmette ; there is an ornate plume on the head, and wattles under the chin.

The figure is entitled *ṣūrat Dajājah 9,* 'figure of the fowl'. The star at the top of the tail feathers is labelled as *Dhanab al-Dajājah,* 'the tail of the fowl' (α Cygni, Deneb) and the star at the tip of its beak *Minqār al-Dajājah,* 'the beak of the fowl' (β Cygni).

[1108] Cf. Savage-Smith 1985, 146-147, Fig. 55.

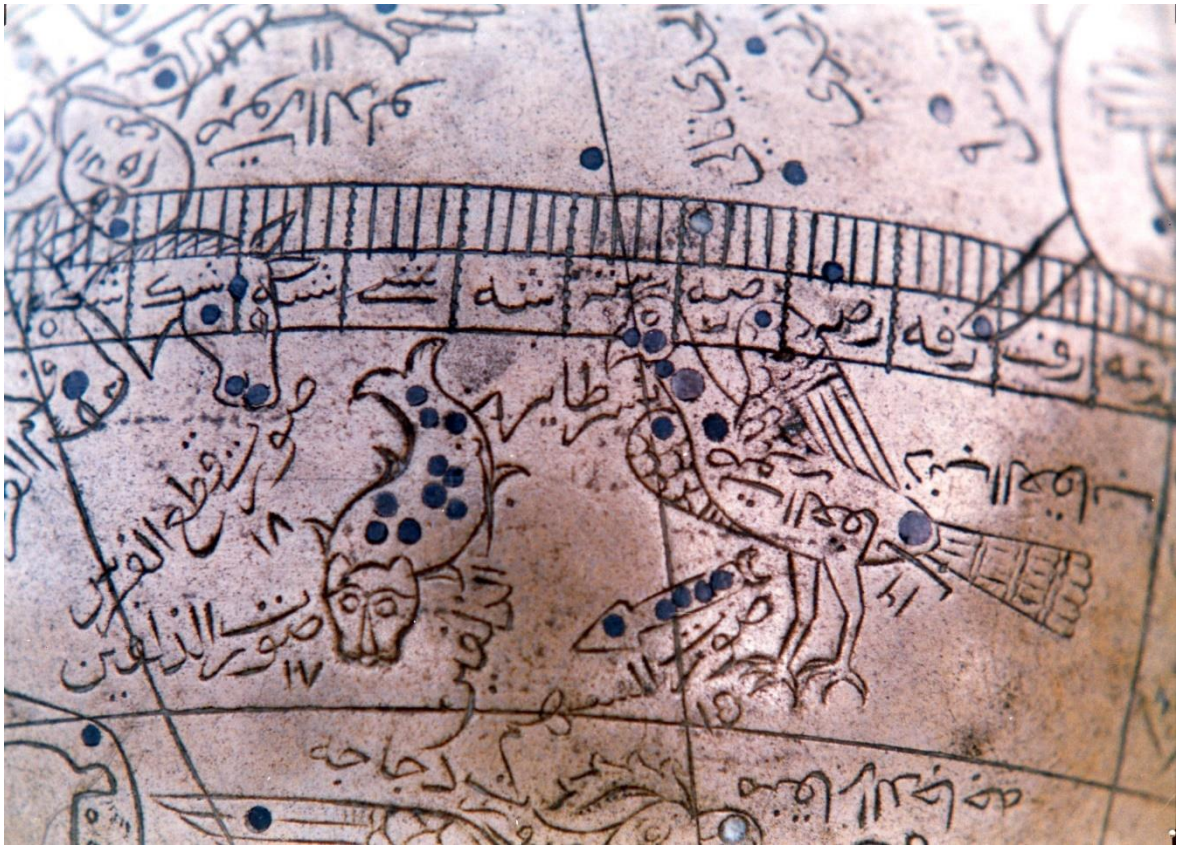


Figure F013.17 – Equuleus, Delphinus, Sagitta and Aquila (photo by Ghulam Mujtaba)

Aquila,[1109] the eagle, is said to be the one killed by Hercules with the arrow or the one Zeus employed to carry Ganymade to Olympus. It is depicted as seated with the wings slightly raised. It is labelled as *ṣūrat al-ᶜUqāb 16,* ‘figure of the eagle’. The star on its neck is named *Nasr Ṭā’ir,* ‘the flying eagle’ (α Aquilae, Altair) and the star at beginning of the tail feathers *Dhanab al-ᶜUqāb,* ‘the tail of the eagle’ (ζ Aquilae).

[1109] Cf. Savage-Smith 1985, 155-157, Fig. 60.



Figure F013.18 – Crater and Corvus (photo by Ghulam Mujtaba)

Corvus,[1110] the raven, is said to be pecking at the serpent Hydra. On this globe, it is shown next to Crater, with its wings raised as if it has just alighted on Hydra. Its label is engraved across the body of Hydra as *ṣūrat al-Ghurāb 10,* 'figure of the raven'. The star on its beak is named *Minqār al-Ghurāb,* 'the beak of the raven' (α Corvi). The star on its wing closer to the Crater is labelled as *Janāḥ al-Ghurāb,* 'the wing of the raven' (γ Corvi).

[1110] Cf. Savage-Smith 1985, pp. 203-204, Fig. 83.



Figure F013.19 – Sea monster Cetus (photo by Ghulam Mujtaba)

The sea monster **Cetus**[1111] is not actually a bird; while the Greeks imagined it as a huge whale, on Islamic celestial globes it has a weird composite form: a snarling dog's head with a collar around the neck, bird's feet, and a feathered fishtail. Perseus rescues Andromeda from this sea-monster.

In this rendering, the wing of Cetus is drawn in minute detail, in the same style as the wings of Cygnus, Aquila, Corvus and Virgo. The collar on the neck is indicated by a series of short lines. The label of the figure is engraved on the body *ṣūrat al-Qayṭus 1,* 'figure of Cetus'. The large star on its jaw is named *Fam al-Qayṭus,* 'mouth of Cetus' (γ Ceti), the star on the neck *Kaff al-Jadhmā,* 'the cut-off head [of *al-Thurayyā*]' (α Ceti). The star on the breast is called *Ṣadr al-Qayṭus,* 'the breast of Cetus' (π Ceti); that on the northern tip of the tail *Dhanab al-Qayṭus Shamālī,* 'the northern tail of Cetus' (ι Ceti) and the one on the southern tip of the tail *Dhanab al-Qayṭus Janūbī,* 'the southern tail of Cetus' (β Ceti).

[1111] Cf. Savage-Smith 1985, pp. 187-189, Fig. 73.

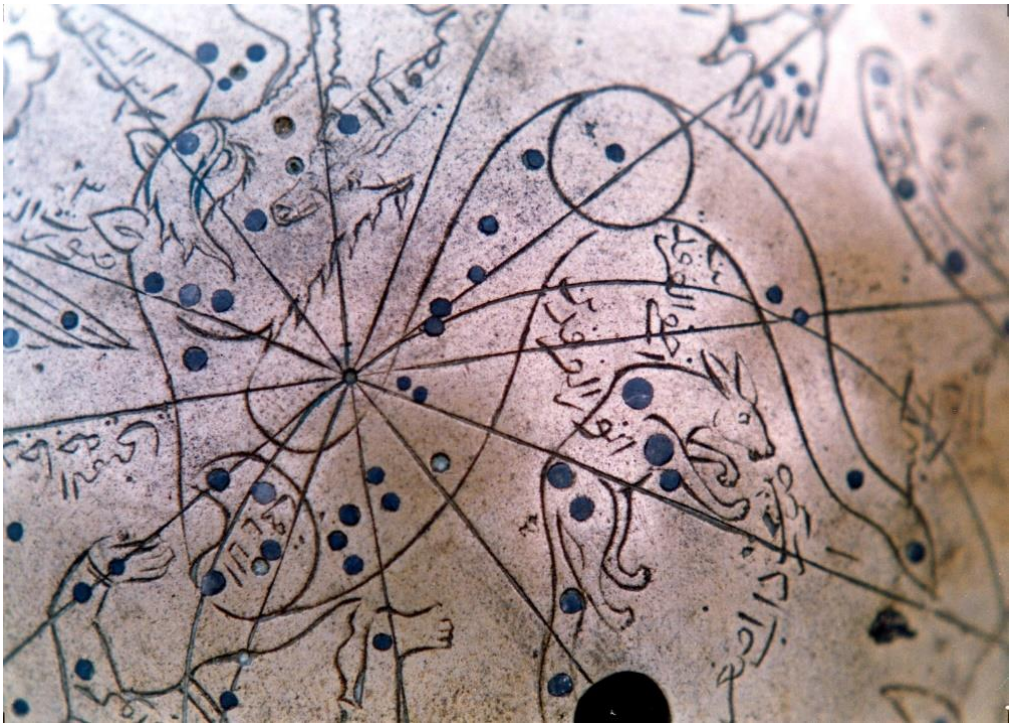


Figure F013.20 – Draco and Ursa Minor (photo by Ghulam Mujtaba)

2.3 Reptiles

Like his father Qā'im Muḥammad, Ḍiyā' al-Dīn generally takes great pains to fill the bodies of the three serpents Draco, Serpens and Hydra minutes scales. But on this globe, these are drawn with simple outlines, probably because the globe is too small for such minute engravings. The coils in the body of the serpents are shown by simple circles. **Draco**[1112] dominates the northern polar regions with large bends. Its head is rather huge; there are spikes on the underside; the mouth is wide open; the forked tongue appears to have been erased by the name of the star engraved there. It has two small ears; over the eyes are two enormous lids. The name of the constellation figure is engraved below the lower ear: *ṣūrat al-Tinnīn 3,* 'figure of the dragon'. The star on its head has the label *Rās al-Tinnīn,* 'head of the dragon' (γ Draconis) and that on its tongue is named *al-Rāfid,* 'the wandering [camel]' (μ Draconis).

Serpens[1113] is also drawn in simple outlines without the complex scales on the body (see Figure F013.32 and Figure F013.33). The head with the long eyelids is drawn as in Draco, but the two coils are drawn more realistically. The title is engraved on the

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1112 Cf. Savage-Smith 1985, pp. 136-138, Fig. 51.

1113 Cf. Savage-Smith 1985, pp. 153-155, Fig. 59.

lower part of the head *ṣūrat al-Ḥayyah 14,* 'figure of the serpent'. The star on the neck is named *ᶜUnuq al-Ḥayyah* (α Serpentis).

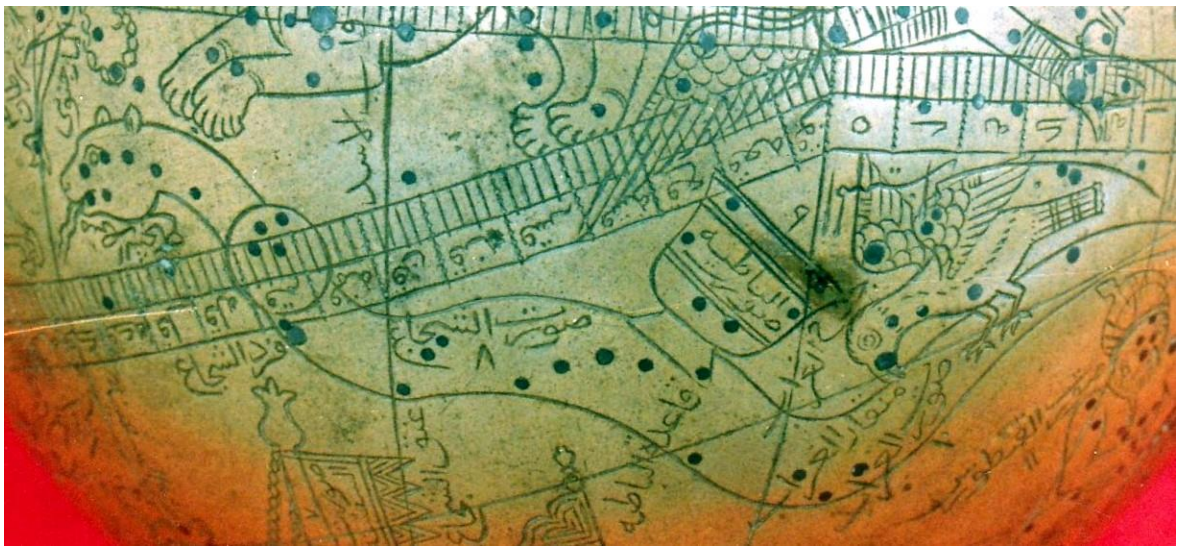


Figure F013.21 – Hydra, Crater, Corvus (photo by Ghulam Mujtaba)

Hydra[1114] occupies a long stretch, extending from the house of Scorpio to the house of Capricorn. This snake is also drawn in simple outlines as the other snakes and the coil on the equator is shown as a mere circle. Its title *ṣūrat al-Shujāᶜ 8,* 'figure of the serpent', is engraved on the body below the coil. Immediately under the coil is the star *Fard al-Shuāᶜ,* 'the isolated one of the serpents' (α Hydra, Alphard).

[1114] Cf. Savage-Smith 1985, pp. 201-203, Fig. 82.



Figure F013.22 – Zodiac Sign Cancer (photo by Ghulam Mujtaba)

The figure of **Cancer**[1115] occupies a narrow space between Gemini and Leo. It is drawn with one of its front claws and one of its back legs stretching to the north of the ecliptic and the other claw and leg stretching south of the ecliptic. The legs end in feet with three toes. It is entitled *ṣūrat Saraṭān 4,* 'figure of the crab'. The star on its northern leg is named *Ikmār Shamālī* (ι Cancri) and the star on its southern leg *Ikmār Janūbī* (α Cancri); these names are unusual. Usually these two stars are named *Zubānā Shamālī,* 'northern claw' and *Zubānā Janūbī,* 'southern claw'.

[1115] Cf. Savage-Smith 1985, pp. 168-170, Fig. 66.



Figure F013.23 – Zodiac Signs Libra and Scorpio (photo by Ghulam Mujtaba)

The figure of **Scorpio**[1116] is drawn facing the west; its two claws in the front stretch on either side of the figure of Libra; its two legs with three-toed feet stretch to the north and south of the ecliptic; its long tail spreads westwards beyond Lepus and bends backwards and is partly engraved on the large plug. Ophiuchus appears to be stamping his eastern foot on its belly. Its label is written between its northern claw and the northern pan of Libra: *ṣūrat al-ᶜAqrab,* 'figure of the scorpion'. The name of the star on its belly is written northward up to the leg of Ophiuchis: *qalb al-ᶜAqrab,* 'the heart of the scorpion' (α Scorpii, Antares).

[1116] Cf. Savage-Smith 1985, pp. 177-179, Fig. 70.

2.4 Fishes

Delphinus,[1117] the dolphin, is depicted with the face of a cat and the body of a fish (see Figure F013.10). It is entitled *ṣūrat al-Dulfīn 17,* 'figure of the dolphin'. There is one named star *Dhanab al-Dulfīn,* 'tail of the dolphin' (ε Delphini).



Figure F013.24 – Zodiac Sign Pisces (photo by Ghulam Mujtaba)

The constellation of the twelfth zodiac sign **Pisces**[1118] is conceived as a pair of fishes swimming in opposite directions. The western fish is engraved on the band of the ecliptic immediately to the west of the vernal equinox, while the eastern fish is shown facing north and touching the midriff of Andromeda, with which it shares the common star (β Andromedae); the tails of these two fishes are joined by a winding stream. These fishes are drawn without any scales. The title of the figure is engraved to the north of

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1117 Cf. Savage-Smith 1985, pp. 157, Fig. 60.

1118 Cf. Savage-Smith 1985, pp. 185-187, Fig. 74.

the western fish *ṣūrat al-Ḥūt 12,* '. A star on its belly is named *Baṭn al-Ḥūt,* 'belly of the fish'.

The last Ptolemaic constellation **Pisces Austrinus**[1119] is also depicted without any scales, drinking water poured by Aquarius from the upturned vessel (see Figure F013.30). It is entitled *ṣūrat al-Ḥūt Janūbī 15,* 'figure of the southern fish'. The star in its mouth carries the name *Fam al-Ḥūt Janūbī,* 'mouth of the southern fish' (α Piscis Austrini, Formalhaut).

3. Anthropomorphic Figures

It is in the rendition of the human figures on this globe that Ḍiyā' al-Dīn's artistic mettle truly comes to the fore. Even though he was unaware of the Greek mythological background of these characters, Ḍiyā' al-Dīn drew these figures with vivid expressive postures and endowed them with appropriate facial expressions.

Cepheus, bending his knees and raising his right arm from behind Cassiopeia's chair, seems to be remonstrating with his wife (see Figure F013.36). There is movement even in the seated Cassiopeia who looks as if she wishes to get away from the husband's entreaties and reach out to Andromeda. Andromeda, left on the rocks to the mercy of the sea monster, is stretching out her arms imploringly, stark horror writ large on her face (Figure F013.37). There is a three-dimensional effect in her large palms; it looks as if she is stretching out her hands towards the observer, beseeching him to rescue her. The posture of Perseus suggests that he is rushing to Andromeda's rescue (Figure F013.29).

It must be noted that the legs and arms are arranged in the way they are mainly in order to include certain stars whose positions are mathematically determined. Even so, these postures on this globe display certain grace, as if these figures are participating in a dance.

The clothing of men and women reflects contemporary styles as seen in Mughal miniature paintings. On this globe, men wear short tunics (*jāmas*) that stop above the knees, while women's *jāmas* are longer and reach to their ankles. In both cases, the tunic is closed in the front up to the sash or the waist band; below the waist the tunic spreads

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[1119] Cf. Savage-Smith 1985, pp. 209-212, Fig. 87.

out to both sides. The sash is simple without any loop, shown by just two parallel lines. Usually only one end of the sash is drawn; it reaches up to the hemline and is richly patterned. Under the tunic, both men and women wear trousers (*shalwār*) that tightly hug the legs below the knees. The bottoms of the trousers are shown by two parallel lines on the ankles; likewise the sleeves of the tunics are indicated by two lines on the wrists.

Women are adorned with bead necklaces and rows of armlets and bracelets on the upper arms and on wrists. Interestingly, both men and women are drawn with two ear rings. All persons on this globe are barefoot, although Ḍiyā' al-Dīn draws shoes in some of his other globes.

There is greater variety in the headgear sported by these figures. Hercules, Ophiuchus, Perseus and Andromeda wear tight-fitting boat-like caps with a trifoliate pom-poms on the top. Cepheus wears a tall conical hat with a feather in the front, while his wife Cassiopeia has a very complex crown on her head . Bootes wears an elegant turban and Auriga a tall hat which is curved at the top. Sagittarius sports a helmet. Aquarius is the only one without a head-gear and without even any hair on his head. The southern figures of Orion and Centaurus are shown with unusual headgear.

The faces of all human figures are drawn with care, paying minute attention to the eye-brows, eyes, nose, mouth and ears. Interestingly, all men save Aquarius have the same style of drooping moustaches, not on the upper lip, but on either side of the mouth.

Even though all the three women, viz. Cassiopeia, Andromeda and Virgo, wear nearly the same kind of clothing and jewellery, they are highly individualized in their facial features and gestures.



Figure F013.25 – Zodiac Sign Gemini (photo by Ghulam Mujtaba)

The twins in the constellation of **Gemini**[1120] are depicted as two unclothed and bald human figures of indeterminate sex; their hands and legs are arranged symmetrically, with one of the hands raised upwards and the other stretched out horizontally towards east and west. The title of the figure is engraved above the head of the second twin: *ṣūrat al-Jawzā’ 3,* ‘figure of the twins’. The star on the head of the first or western twin is named *Rās al-Taw’am al-Muqaddam,* ‘head of the foremost twin’ (α Geminorum, Castor) and the star on the head of the second twin is labelled as *Rās al-Taw’am al-Mu’akhkhar,* ‘head of the rear twin’ (β Geminorum, Pollux).

[1120] Cf. Savage-Smith 1985, pp. 166-168, Fig. 65.



Figure F013.26 – Bootes (photo by Ghulam Mujtaba)

Bootes[1121] is dressed in a short tunic that stops above the knees. The tunic has a wavy hemline decorated by double lines, full sleeves and a round collar. The upper part is closed in the front with a series of round buttons. The parallel lines on the ankles indicate a tightly fitting pair of trousers. His feet are bare. A sash goes around the waist; its two loose ends, decorated with geometrical patterns, fall down in the form of the inverted letter V. He wears an elegant turban on his head; it is wound in such a manner that one loose end is pulled up in the front like an aigrette on the crown.

His face is in three-quarters profile, with the ears, eye-brows, eyes and nose drawn clearly; his mouth is indicated by a short line. He wears ear-rings, thick moustaches on

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[1121] Cf. Savage-Smith 1985, pp. 140-142, Fig. 53.

either side of the mouth and a long thin beard. He stands with his left leg bent, right arm raised high with all the fingers of the hand spread out. With the left hand he holds erect a sword with a broad blade.

He is called *al-ᶜAwwā'* (the howler) because he is seen as a herdsman driving the Great Bear in front of him; he is also given a second name *al-Baqqār* 'ox-driver' or ploughman. The title *ṣūrat al-ᶜAwwā' 5,* 'figure of the howler' is engraved on the upper right side of his tunic and looks like a decoration on the tunic. The star on his forehead is named *Rās al-ᶜAwwā',* 'head of the howler' (β Bootis); that on his right knee *Mufrad Rāmiḥ,* 'the solitary [star] of the lancer' (η Bootis); and the one on the left knee *Simāk Rāmiḥ,* 'armed *Simāk*' (α Bootis).

To the right of Bootes can be seen the figure of Corona Borealis and below it the fierce head of Serpens.

Auriga[1122] is regarded as a charioteer who holds the reins with his left hand and a whip with his right hand; on Islamic globes the hands are reversed. On the present globe, he is depicted as seated, with both legs placed to a side. His clothing is not drawn completely. Of the tunic, only the ends of the sleeves and the neckline are drawn, but not the hemline. Likewise, no lines are drawn on the ankles to indicate the trousers. Three parallel lines in the middle indicate the sash around the waist. His cap is the most unusual, a tall conical cap with its upper part slightly curved; such a cap is not drawn on any Indo-Persian globe. His face is in three quarters profile; drawn nearly in the same manner as the face of Bootes, but without the ear-rings.

[1122] Cf. Savage-Smith 1985, pp. 151-153, Fig. 58.



Figure F013.27 – Auriga (photo by Ghulam Mujtaba)

The posture of his right hand suggests that he is holding the reins; he holds a horse whip in his eastern hand; on Indo-Persian globes, this whip is depicted in various fanciful ways, with or without a pair of lashes. Here it looks like the stem of a cactus plant with a single leaf at the top; the lower part of the handle has a nice trifoliate shape.

The title is engraved above the cap: *ṣūrat al-Mumsik al-Aᶜinnah 12,* 'figure of the one who holds the reins'. The star on the western shoulder is named *al-ᶜAyyūq* (α Aurigae) and that on the eastern shoulder *Mankib dhī al-ᶜInān,* 'the shoulder of the one who has the reins' (β Aurigae). The star on the eastern ankle carries the name of *Kaᶜb dhī al-ᶜInān,* 'ankle or heel of the one having the reins' (γ Aurigae); this star is common to Taurus (β Tauri).



Figure F013.28 – Cepheus (photo by Ghulam Mujtaba)

Cepheus[1123] is clothed in a knee-length tunic. The patterned end of the sash reaches up to the hem of his tunic. His face is drawn in profile with a beard and a high conical hat with a plume. Double earrings can be seen on his left ear. Above his right hand is engraved the label *sūrat Qīqā'ūs,* 'figure of Cepheus'. On his upper left arm is a double star; its name *kawkaba al-firq,* 'stars of the herd' (αβ Cephei) is engraved in large letters across the tunic like a decoration. Likewise, the name of the star on his right ankle *al-Rāᶜī,* 'the shepherd' (γ Cephei), engraved on his calf, suggests the folds of the leg covering, but his left leg is bare.

[1123] Cf. Savage-Smith 1985, pp. 138-140, Fig. 52



Figure F013.29 – Perseus (photo by Ghulam Mujtaba)

Perseus[1124] is shown in front view, with a thin beard. His tunic is rather short and does not reach up to the knees; the sleeves are indicated by the pairs of lines on the wrists, but the neckline is not drawn. The hemline of the tunic is wavy and decorated by double lines as in the case of Bootes. His trousers are not indicated. A thick sash is tied around the waist; the two loose ends, with geometrical decorations, fall together. He wears a tight narrow cap with a trifoliate pom-pom.

[1124] Cf. Savage-Smith 1985, pp. 149-151, Fig. 57.

His face is in a three-quarters profile, the eyes looking to the right. He wears earrings. He holds the sword in his left hand and the severed head of the ogre in his right. His posture looks rather contorted.

The figure is entitled *ṣūrat Parshā'ūs,* 'figure of Perseus'. The star above his waist has two names, pertaining to two different traditions: *Janb Parshā'ūs,* 'side of Perseus' and *Mirfaq al-Thurayyā,* 'elbow of *al-Thurayyā*' (α Persei, Mirfak, Algenib). The double star on his wrist is called *Miʿṣam al-Thurayyā,* 'wrist of *al-Thurayyā'* (hχ Persei).

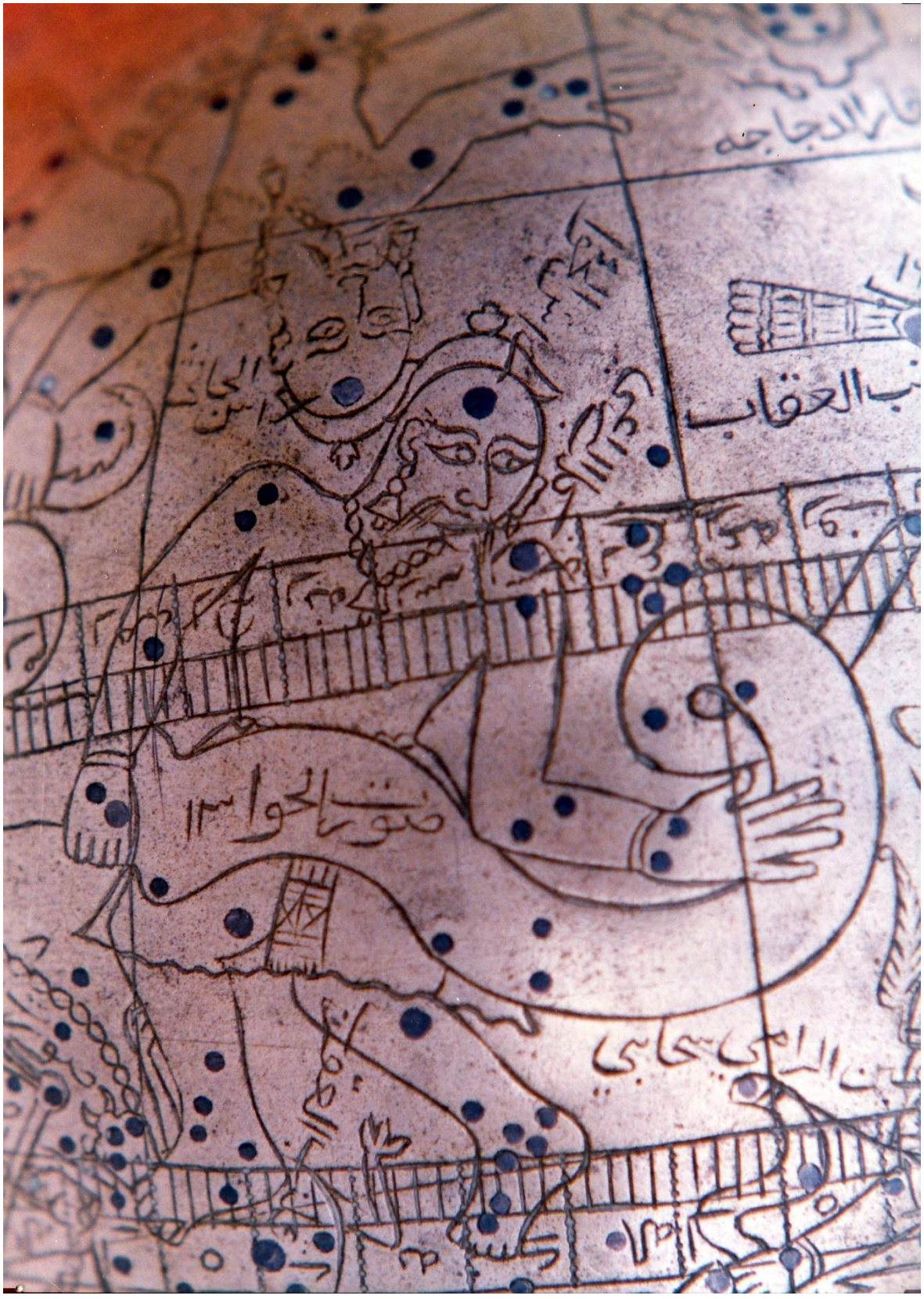


Figure F013.30 – Ophiuchus and Serpens (photo by Ghulam Mujtaba)

The pair of figures of Ophiuchus and Hercules dominate the northern half the zodiac house of Sagittarius. Their heads are next to one another, but the bodies extend

in reverse directions. **Ophiuchus**[1125] holds with both his hands a large serpent which spreads out in a direction parallel to the ecliptic. He is clothed in short tunic with a wavy hemline. His sash is hidden behind the serpent in his hands, but the loose end with geometrical pattern can be seen below the body of the serpent. Both Ophiuchus and Hercules wear identical boat-like caps with trifoliate pom-poms. In fact, the two caps look like the extensions of one another; together they form an S-like curve. Both wear bead-necklaces with small bells at the centre. Similar bells hang from their ear-rings. Both wear moustaches on the sides of their mouths, but no beard.

Ophiuchus appears to be stepping on the scorpion with his right foot. The title of the figure *ṣūrat al-Ḥawwā 13,* 'figure of the serpent charmer' is engraved on the body of the serpent in his hands. The star on his forehead is labelled as *Rās al-Ḥawwā,* 'head of the serpent charmer' (α Ophiuchi, Rasalhague) and that on his left shoulder as *Kalb al-Rāʿī,* 'shepherd's dog' (β Ophiuchi).

Hercules[1126] is drawn as a sturdy figure like a *pahalwan*, an Indian wrestler. He wears a broad belt from which five pommel-like objects are suspended. His upper torso is bare; the lower half is covered by a very short skirt with a wavy outline. The hair on his chest is indicated by short strokes arranged in the form of the letter W. He appears to be stamping on the head of the dragon with his right foot, bending his left knee. The right arm is stretched forward, the left arm is raised high with a sickle in hand.

The figure is entitled *ṣūrat Jāthī ʿalā Rukbītah 7,* 'figure of the one who is resting on his knees' and the star on his forehead carries the name *Rās al-Jāthī,* 'head of the kneeling [man]' (α Herculi).

[1125] Cf. Savage-Smith 1985, pp. 153-155, Fig. 59.

[1126] Cf. Savage-Smith 1985, pp. 142-144, Fig. 54.



Figure F013.31 – Hercules (photo by Ghulam Mujtaba)



Figure F013.32 – Aquarius and Pisces Austrinus (photo by Ghulam Mujtaba)

Aquarius[1127] also wears a tunic like the others, but a longer one, with full sleeves and round neck. The upper half is closed in the front. A sash goes around his waist and the two loose ends with geometrical pattern fall together vertically. The pairs of lines on his ankles indicate the tight pair of trousers. His face is in three quarters profile, with a completely bald head, with no moustaches or beard, and with a child-like expression on his face. His right arm is stretched out above the figure of Capricorn; with the left hand he pours out water from a vessel held upside down. The stream of water flowing out of the vessel follows an undulating course and reaches the mouth of the southern fish on the other side of the ecliptic. The title of the figure of Aquarius is engraved above

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[1127] Cf. Savage-Smith 1985, pp. 183-185, Fig. 73.

his right arm: *ṣūrat al-Dalw 11,* 'figure of the bucket'. The star on his left shoulder is named *Mankib Sākib al-Mā',* 'shoulder of the water pourer' (α Aquarii, Sadalmelik) and the star on the shinbone of his left leg *Sāq Sākib al-Mā' Janūbī,* 'the southern shin of the water-pourer' (δ Aquarii, Skat).

The figure of **Orion**[1128] straddles the equator, with his head occupying the space between Taurus and Gemini. He is depicted as a corpulent person, wearing a very short tunic with a round collar. There is a sash around the waist, but no loose ends are hanging below. The sleeve of his right arm is elongated to accommodate the nine stars in this region and his left arm is raised high holding an unidentifiable weapon. Likewise it is difficult to identify his head-gear. Unaware of his nature, Ḍiyā' al-Dīn attempts to give him an weird look and the posture a person jumping wildly.

The title of the figure *ṣūrat al-Jabbār 6,* 'figure of the giant' is engraved to the right of his waist. There are many named stars in this figure. The star on his forehead is named *Rās al-Jabbār Sahābī,* 'nebulous head of the giant' (λ Orionis). The star on his right shoulder is called *Mankib al-Jawzā' yusrā,* 'left shoulder of *al-Jawzā''* (γ Orionis); the star on his left shoulder *Mankib al-Jawzā' al-Yumnā,* 'the right shoulder of *al-Jawzā''* (α Orionis). The star on his left foot is named *Rijl al-Jawzā' al-Yumnā,* 'right foot of *al-Jawzā''* (κ Orionis, Saiph) and that on his right foot *Rijl al-Jawzā' al-Yusrā,* 'left foot of *al-Jawzā''* (β Orionis, Mintaka). It may be noted that the apparent contradiction between 'right' and 'left' is due to the fact that the star names are given according to the depiction of the figures as seen from the earth while the figures on the Islamic globes are drawn as seen from outside the globe. It may also be noted that the *al-Jawzā'* in the star names refers to the large female form visualised in this region according to a Bedouin tradition.

[1128] Cf. Savage-Smith 1985, pp. 189-192, Figs. 76, 78.



Figure F013.33 – Orion and Lepus (photo by Ghulam Mujtaba)

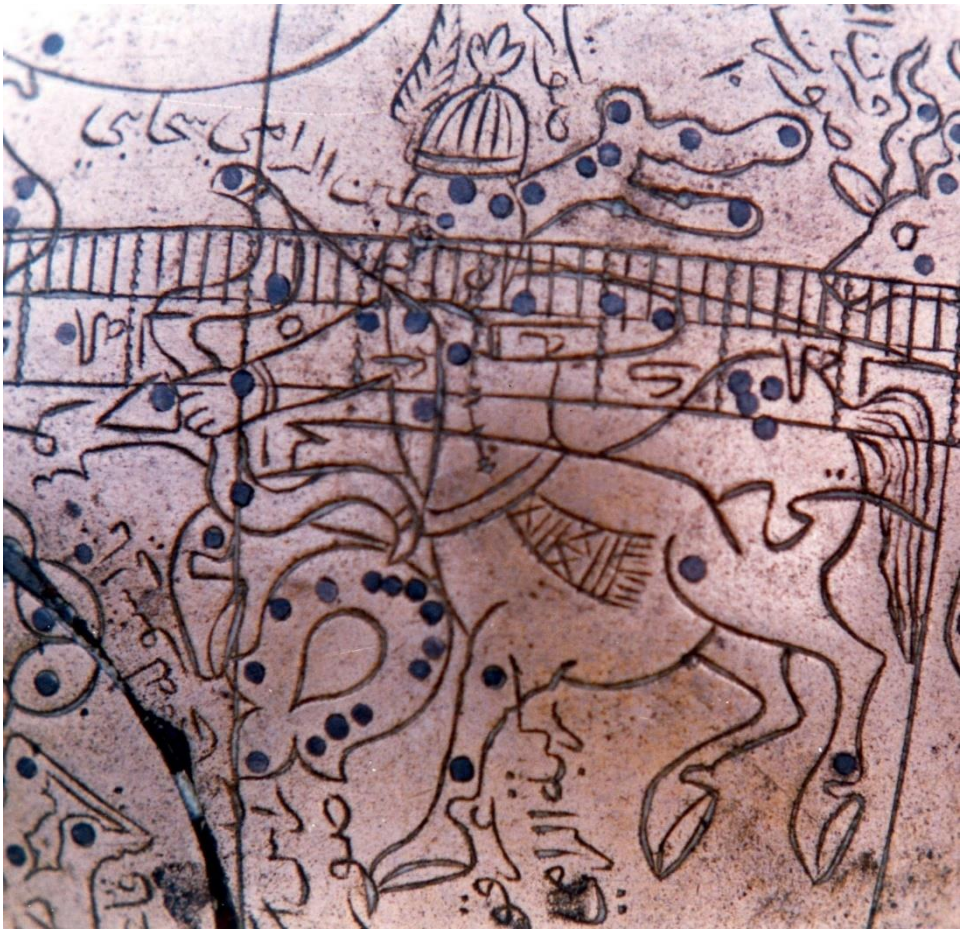


Figure F013.34 – Sagittarius (photo by Ghulam Mujtaba)

Sagittarius and Centaurus are hybrid figures of half-man and half-horse. On this globe, both the human and equine halves of the figure of **Sagittarius**[1129] are well drawn. The human half is clothed in a long-sleeved tunic that reaches up to the waist. There is a round collar; the tunic is closed in the front with a series of clasps. A sash is worn around the waist, one loose end, decorated with geometrical patterns, flutters eastwards suggesting the motion of the figure westwards. There is a ribbed helmet on the head with a trifoliate finial and a leaf-shaped aigrette. From his neck, a head band spreads out eastwards; it is drawn for the purpose of enclosing certain stars in this region.

The figure is shown in the act of shooting an arrow with the bow by pulling the bow-string towards him. The horse, with right foreleg raised high, the two hind legs slightly raised, is making a gallop.

[1129] Cf. Savage-Smith 1985, pp. 179-181, Fig. 71

The title of the figure is engraved to the right of the helmet: *ṣūrat al-Qaws 9,* 'figure of the archer'. The star near the eye is named *ᶜAyn al-Rāmī Sahābī,* 'nebulous eye of the archer' ($\nu^{1,2}$ Sagittarii); the star on the knee of the left foreleg of the horse *Rukbat al-Rāmī,* 'archer's knee' (α Sagittarii, Rukbat, Alrami) and the star a little below on the same leg *Urqūb al-Rāmī,* 'archer's tendon' ($\beta^{1,2}$ Sagittarii).

The southern hemisphere of the globe is dominated by the two large figures of Argo Navis and **Centaurus**.[1130] On this globe, there is a large circular plug on which the front part of the figure of Centaurus and a large part of Lupus had to be engraved. The human half is clothed in the same manner as Sagittarius, but the headgear is different. That worn by Centaurus looks like some kind of turban. The body of the horse, the legs, hooves and tail are drawn well. With the hind legs folded forward, the horse appears to be making a high jump/ gallop. Centaurus holds a vine twig with his right hand and the two hind legs of the wild beast with his left hand. The vine twig has three leaves drawn like mango fruits. The figure is entitled *ṣūrat al-Qanṭūrus 11,* 'figure of the centaur'. The star on the front hoof of the horse is named *Rijl al-Qanṭūrus,* 'foot of the centaur' (α Centauri, Rigil Kentaurus). The star on the head of Centaurus is called *Rās al-Qanṭūrus,* 'head of the centaur'; Ptolemy lists four stars in the head of Centaurus;[1131] it is not clear which of these is meant here; no other globe seems to mention this star.

1130 Cf. Savage-Smith 1985, pp. 205-207, Fig. 84.

1131 Ptolemy, p. 394.



Figure F013.35 – Centaurus (photo by Ghulam Mujtaba)



Figure F013.36 – Cassiopeia and Cepheus (photo by Ghulam Mujtaba)

Coming to the female figures, **Cassiopeia**[1132] is depicted as a slender woman seated on the edge of a high and richly carved chair. Her face is slightly turned towards the left so that her face is in half profile. With her left hand she is holding the left back post of her chair, and pointing the right hand towards Andromeda. Cassiopeia wears a large crown which is decorated on the top with an hour-glass shaped ornament; similar ornaments are also on the tops of the two back posts of the chair. Her long gown reaches almost up to her ankles; below the hemline can be seen the folds of the tight *shalwār.* A bead necklace is around her neck and rows of bangles adorn her wrists and upper arms.

The figure is entitled *ṣūrat Dhāt al-Kursī 10,* 'figure of the one with the chair'. The star on her face is named *Rās al-Dhāt al-Kursī,* 'head of the one with the chair' (ζ Cassiopeiae) and the star on her left hand *Kaff al-Khaḍīb,* 'the dyed hand' (β Cassiopeiae, Caph).

[1132] Cf. Savage-Smith 1985, pp. 147-148, Fig. 56.



Figure F013.37 – Andromeda (photo by Ghulam Mujtaba)

Cassiopeia's daughter **Andromeda** is a striking figure.[1133] She is shown in front view, as a full-breasted plump young woman, with her arms spread wide. She is dressed in an ankle-length gown. A sash goes around her waist and its patterned end reaches up to the hem of the gown. The names of stars written vertically on the left and right edges of the flared gown look like decorative patterns. Here the calligraphy is particularly well integrated with the clothing. She wears a series of armlets and bracelets on her upper arms and wrists, a bead necklace around the neck and two rings each on both the ears, and a somewhat flat cap with a trifoliate pom-pom on the head.

The figure is entitled *ṣūrat Musalsalh 20,* 'figure of the chained [woman]'. The star on her forehead is common to the figure of Pegasus situated above her and therefore carries two names pertaining to the two constellations: *Rās al-Mar'ah al-Musalsalah,* 'head of the chained woman' (α Andromedae, Sirrah) and *Surrat al-Faras,* 'navel of the horse' (δ Pegasi). The star on her right side is common to the eastern fish of the constellation Pisces and likewise carries two names: *Janb al-Musalsalah,* 'Side of the [chained] woman' (β Andromedae, Mirach) and *Baṭn al-Ḥūt,* 'belly of the fish'. The star on her right foot is named *Rijl al-Mar'ah al-Musalsalah Yusrā,* 'the left foot of the chained woman' (γ Andromedae) and that on her right foot *Rijl al-Mar'ah al-Musalsalah Yumnā,* 'the right foot of the chained woman' (φ Andromedae). The apparent contradiction between the 'right' and 'left' is, as in the case of Orion above, due to the depiction of the figures on the Islamic celestial globes as seen from outside the globe.

[1133] Cf. Savage-Smith 1985, pp. 160-162, Fig. 62.



Figure F013.38 – Virgo (photo by Ghulam Mujtaba)

Ḍiyā’ al-Dīn’s most accomplished constellation figure is that of **Virgo**[1134] on this globe. In no other globe did Ḍiyā’ al-Dīn lavish so much detail on Virgo and infuse the figure with an individual personality as he did here. Virgo is depicted as an elegant Mughal princess, walking with a graceful step, perhaps on her way to a rendezvous with a lover. She is drawn in front view, with her face slightly turned to the left. She has a round face, finely arched eyebrows, almond shaped eyes and a smiling mouth. Her hair is parted in the middle and hangs down on the back; some strands are visible on both sides of her slender neck. The breasts are delicately outlined. She wears an ankle-length gown with a very wide skirt below the waist. There is a sash around her waist, one end of which extends beyond the hemline of the gown. Below the hemline, the folds of the *shalwar* are carefully drawn on her ankles.

The celestial equator with its divisions and *Abjad* numbers overlaps her entire body, but it does not obscure her figure. On the contrary, it looks like a decorative feature of her gown. Likewise the two star pointers on her cheeks look more like beauty marks rather than stars. Besides rows of armlets and bracelets on her upper arms and wrists, she also wears anklets on her feet. Around her neck, there is a choker fringed with pearls, besides a long necklace that reaches up to her waist. Her wings are drawn with great detail of feathers.

In drawing her wings, arms and legs, Ḍiyā’ al-Dīn avoids symmetry. Their asymmetric arrangement suggests movement and adds charm to the figure. Both upper arms are held close to the body, but her left lower arm is raised perpendicular to the body. Her right lower arm is slightly raised. It looks as if she is holding a large silver disk in her right palm, to carry it to the lover as a luminous gift. This large silver point actually represents the star *Simāk Aᶜzal,* ‘unarmed *Simāk*’ (α Virginis, Spica), which is the 15th most brilliant star in the heavens. The title of the figure *ṣūrat Sunbulah 6,* ‘figure of the Ear of Wheat’ is engraved above her left hand.

[1134] Cf. Savage-Smith 1985, 172-175, Fig. 68.

STAND



Figure F013.39 – Globe with the horizon ring (photo by S. R. Sarma)

The globe rests on a 150 mm high stand. It consists of a horizon ring (outer diameter 146 mm and inner diameter 120 mm) which is supported by three legs that are slightly curved like the Roman letter *S*. The horizon ring is divided in 1° and 5° and numbered in 5s, from 5 to 90, separately in each quadrant. There are slots in it for the meridian ring and the zenith ring, but these two rings are now missing, so also the axis of the globe. The horizon ring itself was broken and was repaired rather crudely.

Inscription



Figure F013.40 – Southern hemisphere with the globe-maker’s signature (photo by Ghulam Mujtaba)

The globe-maker’s signature is engraved inside the equatorial polar circle thus:

> *ᶜamal aqall al-ᶜibād ḍiyā’ al-dīn muḥammad ibn qā’im muḥammad ibn mullā ᶜīsā ibn shaykh allāhdād asṭurlābī humāyūnī lāhūrī fī sanah 1064 hijrī.*
>
> ‘The work of the least of the servants [of God], Ḍiyā’ al-Dīn Muḥammad, son of Qā’im Muḥammad, son of Mullā ᶜĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the year 1064 Hijrī’.

The year corresponds to AD 1653-54.

Bibliography

Nadvi 1935; Savage-Smith 1985; Sarma 1994c; Sarma 2015a.

F014 CELESTIAL GLOBE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1067 AH (AD 1653-54)[1135]

Diameter 127 mm

London, Victoria and Albert Museum (# 2324-1883 (I.S.))

ESS; Répertoire

The globe is cast as a single hollow sphere with one plug. The stand is missing.

CIRCLES

The equator and the ecliptic are graduated in 1° and 5° and the divisions of 5° are marked by dotted lines, as is done on many astrolabes. On the equator, the groups of 5° are numbered from 5 to 360, starting from the vernal equinox and on the ecliptic from 5 to 30 separately for each zodiac sign. The names of the zodiac signs are engraved along the ecliptic. Ecliptic latitude circles, equatorial tropic circles and equatorial polar circles are also drawn.

The equatorial poles, the constellation figures and many stars are named. The northern constellations, the zodiac signs and the southern constellations are numbered; individual stars within many northern constellations are also numbered.

CONSTELLATION FIGURES AND STARS

The globe is engraved with the full set of 48 constellation figures; the positions of about 1020 stars are marked with inlaid silver points.

INSCRIPTION

> *ᶜamal aqall al-ᶜibād ḍiyā' al-dīn muḥammad ibn qā'im muḥammad ibn mullā ᶜīsā ibn allāhdād asṭurlābī humāyūnī lāhūrī fī sanah 1067.*
>
> 'The work of the least of the servants [of God], Ḍiyā' al-Dīn Muḥammad, son of Qā'im Muḥammad, son of Mullā ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the year 1067 [Hijrī].'

[1135] Entry based on Savage-Smith 1985, no. 22, p. 228.

PROVENANCE

The globe was purchased in Bombay 1882 and was part of the Indian Museum; after the closure of this museum, the entire collection was transferred to the Victoria & Albert Museum.

BIBLIOGRAPHY

Savage-Smith 1985, no. 22, p. 228.

F015 ⊙ CELESTIAL GLOBE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1068 AH (AD 1657-58)

Diameter 113 mm

Cardiff, National Museum of Wales (# 39.573.1)

ESS 23; Répertoire 17



Figure F015.1 – Globe with a modern stand (photo by S. R. Sarma)

The globe is cast as a single hollow sphere with one plug. The original stand is missing. The globe is now mounted on a modern non-functional stand.

Circles

The equator and the ecliptic are graduated in 1° and 5° and the divisions of 5° are marked by dotted lines. The groups of 5° are numbered on the equator from 5 to 360, starting from the vernal equinox, and on the ecliptic, from 5 to 30, separately for each zodiac sign. The names of the zodiac signs are engraved along the ecliptic. Ecliptic latitude circles, equatorial tropics and equatorial polar circles are drawn.

The equatorial poles, the constellation figures and many stars are named. Constellation figures are numbered, the northern constellations, the zodiac signs and the southern constellations separately; individual stars within many northern constellations are also numbered.

Constellation Figures and Stars

All the 48 constellation figures are depicted on this globe and the positions of about 1020 stars are marked with inlaid silver nails. The figure of Argo Navis receives an elaborate treatment with five large dotted pennants and an over-sized leonine figurehead. There are two pavilions; one in the middle and the other at the back. The pavilion in the middle is open on the four sides, with a triangular canopy surmounted by three finials. It rests on two large vase-like structures. The pavilion in the rear is covered by a dome with a trifoliate top. The oars look like large bells suspended by chains. The star Canopus (*al-Suhayl*) is placed on the oar to the right. On the body of the ship is engraved the name of the constellation together with the serial number as *ṣūrat safīnah 7*.

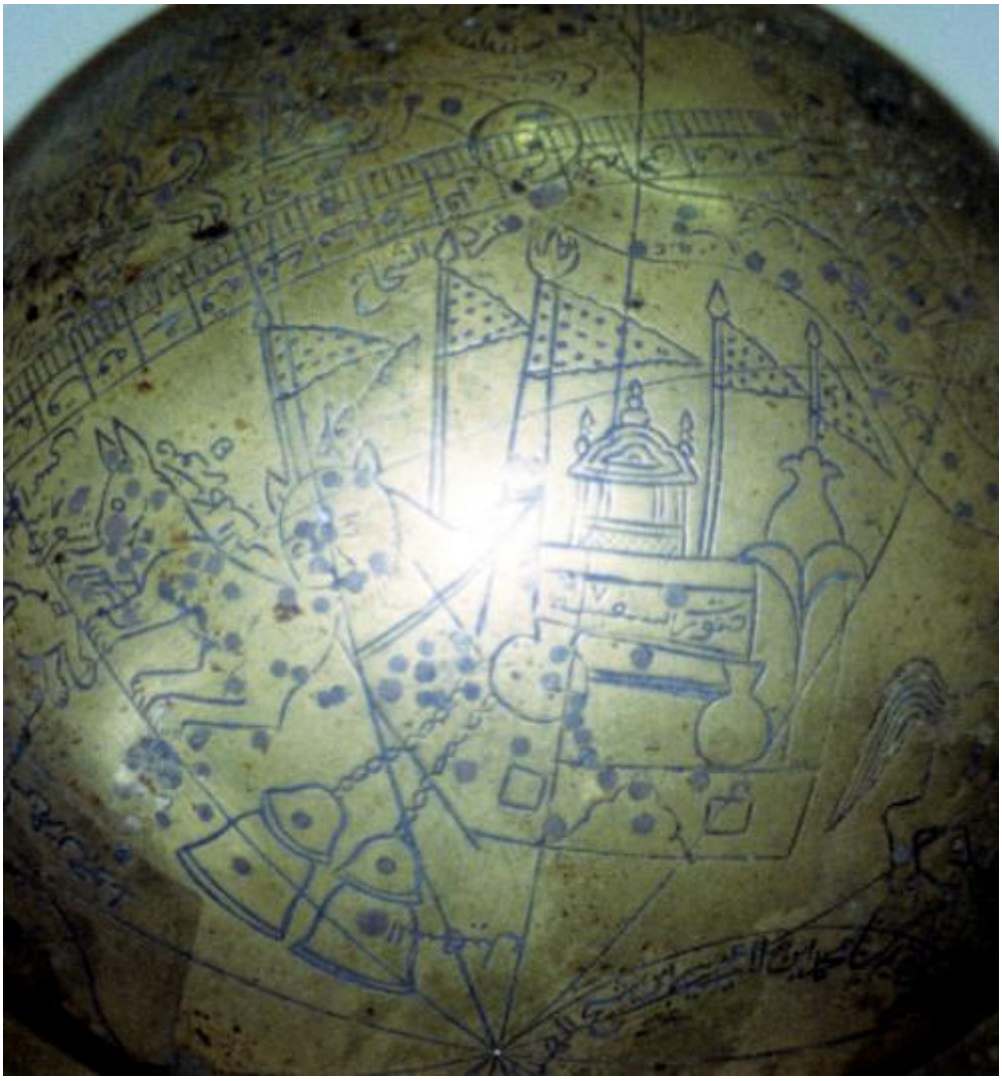


Figure F015.2 – Constellation Argo Navis (photo by S. R. Sarma)

To the left of the figurehead is the figure of Canis Major with the label and serial no. *ṣūrat Kalb al-Akbar 5*. The figure of Hydra occupies the space to the right and above the ship; just above the ship, the serpent crosses the band of equator, making a circular coil on the band, its grinning head can be seen above the equator band, licking its lips at the sight of the Lepus in front, as it were. Here is the star *Minkar al-Shujāʿ* (nose of the serpent) is labelled. The bright star *Fard al-Shujāʿ* is labelled just above the ship.

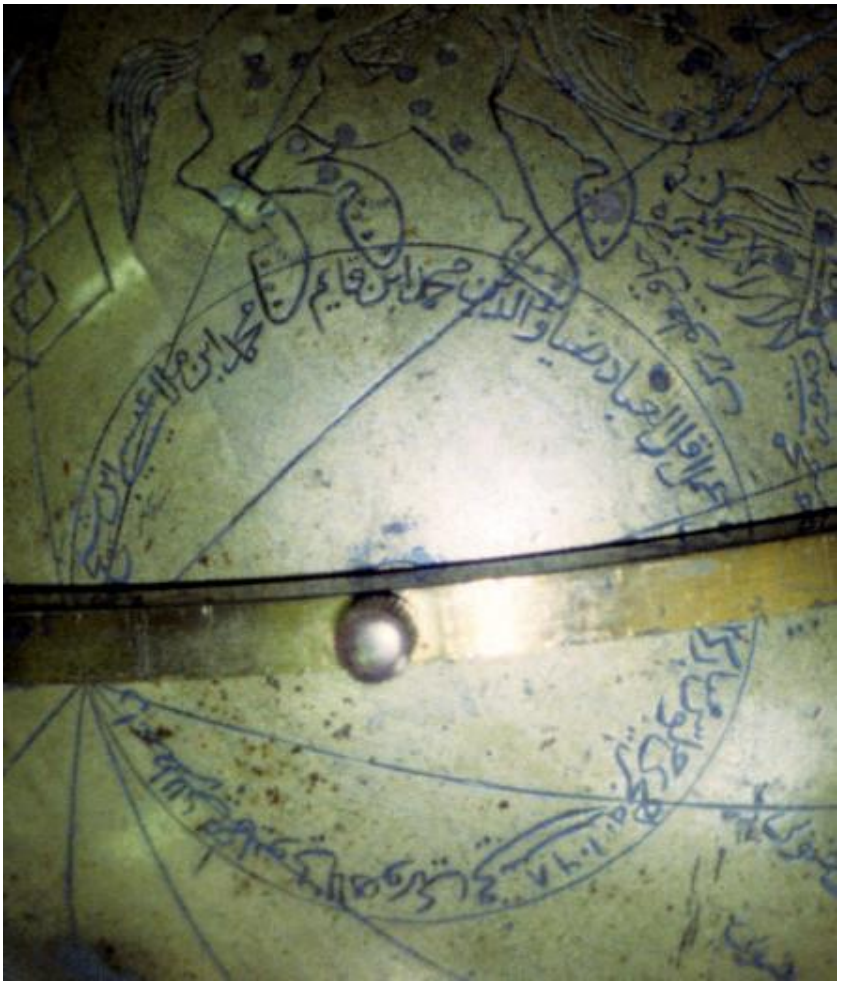


Figure F015.3 – Globe-maker’s signature (photo by S. R. Sarma)

Inscription

The globe-maker’s signature is engraved, as usual, inside the southern equatorial polar circle pole:

> *ᶜamal aqall al-ᶜibād ḍiyā’ al-dīn ibn qā’im muḥammad ibn mullā ᶜīsā ibn shaykh allāhdād asṭurlābī humāyūnī lāhūrī fī sanah 1067 hijrī julūs mubārak 32 shāh jahān.*
>
> ‘The work of the least of the servants [of God], Ḍiyā’ al-Dīn Muḥammad, son of Qā’im Muḥammad, son of Mullā ᶜĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the year 1067 Hijrī, in the thirty-second year of the blessed reign of Shāh Jahān.’

Provenance

Bequeathed to the Museum in November 1939 by John Hubert James who bought the globe in Algiers in 1910.

BIBLIOGRAPHY

Savage-Smith 1985, no. 23, pp.228-229, figs. 39 (Auriga), 44 (Leo), 48 (Argo).

F016 CELESTIAL GLOBE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1068 AH (AD 1657-58)[1136]

Diameter 100 mm

Cairo, Museum of Islamic Art (# 15226)

ESS 24; Répertoire 15



Figure F016.1 – Globe with stand (photo by Dr. Flora Vafea)

The globe is cast as a single hollow sphere with one rectangular plug and one very large plug constituting nearly one-fourth of the globe.

[1136] Entry based on Savage-Smith 1985, no. 24, p. 229, and the photo kindly provided by Dr Flora Vafea, Cairo.

Circles

The equator and the ecliptic are divided in 1° and 5°. The divisions of 5° are marked by dotted lines and numbered from 5 to 360 on the equator, starting from the vernal equinox; and from 5 to 30, separately for each zodiac sign on the ecliptic. Ecliptic latitude circles and the southern polar circle are drawn. Holes are drilled at the ecliptic as well as the equatorial poles. The names of the signs are engraved along the ecliptic; the names of the equatorial poles, the constellation figures and some major stars are engraved.

Constellations Figures and Stars

The full set of the 48 constellation figures are represented on the globe and the positions of about 1020 stars are indicated by inlaid silver points.

Stand

The quadruped stand resting on a circular ring supporting the horizon ring and the semicircular arc below the globe appears to be original but somewhat damaged and the meridian ring is missing.

Inscription

The inscription inscribed around the south equatorial pole states that this globe is

> 'The work of the least of the servants [of God], Ḍiyā' al-Dīn Muḥammad, … in the year [10]68 and the thirty-second blessed regnal year of Shāh Jahān.'

Provenance

Formerly in the Harari Collection, No. 157.

Bibliography

Savage-Smith 1985, no. 24, p. 229.

F017 CELESTIAL GLOBE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1070 AH (AD 1659-60)[1137]

Diameter 60 mm

Cairo, Museum of Islamic Art (# 3800)

ESS 69; Répertoire 21



Figure F017.1 – Globe with stand (photo by Dr Flora Vafea)

The perforated meridian ring is loosely placed upon the horizon ring. The globe is cast as a single hollow sphere; one rectangular peg is visible cutting through the

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[1137] Entry based on Savage-Smith 1985, no. 69, p. 252, and the photos kindly provided by Dr Flora Vafea and Ayman Ali.

equatorial polar circle in the south. There are holes both at the equatorial and ecliptic poles.



Figure F017.2 – Equator and ecliptic on the globe (photo by Ayman Ali)

The ecliptic band is the lower one. Below it are engraved the names of the signs *al-Mīzān* (Libra), *al-ᶜAqrab* (Scorpio), *al-Qaws* (Sagittarius) and *al-Jadī* (Capricorn), from left to right. The great circles perpendicular to the ecliptic are the ecliptic latitude circles. At the bottom is the southern equatorial circle, with a hole at the southern celestial pole.

Circles

The equator and the ecliptic are graduated in 2° and 6°. The intervals of 6° are marked by dotted lines; these are numbered from 6 to 360 on the equator; from 6 to 30, separately for each zodiac sign, on the ecliptic. The names of the signs are engraved along the ecliptic. Ecliptic latitude circles, equatorial tropics and equatorial polar circles are drawn.

Constellation Figures and Stars

There are no constellation figures on this small globe; the positions of about 60 stars are indicated by dots enclosed by circles.

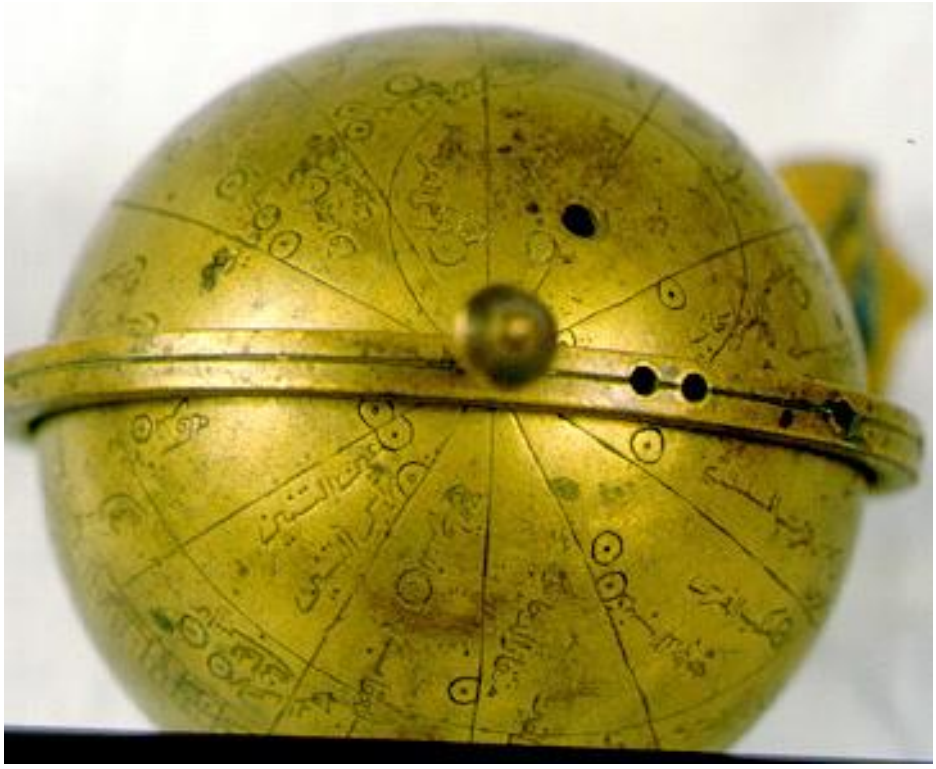


Figure F017.3 – Globe as seen from above (photo by Ayman Ali)

At the centre is the northern ecliptic pole where the ecliptic latitude circles converge and where the meridian ring is attached. Above this, slightly to the right, is the northern equatorial pole at the centre of the hole. The lesser circle around this pole is the northern equatorial polar circle.

STAND

The globe is mounted on a stand consisting of the horizon ring supported by four legs which rest on the base of a circular ring. Inside the ring are two cross bars at the centre of which is a hole. Probably a fifth a leg stood here to support the meridian ring. The meridian ring is graduated in 2° and 6° and numbered in 6s. There are holes in the meridian ring for setting the globe at different latitudes. It is not known whether the horizon ring is graduated. The legs are elegantly shaped with decorative rings. The axis may not be original.



Figure F017.4 – Signature of the globe maker and the graduated meridian ring; the south celestial pole is labelled as *quṭb janūbī* (photo by Ayman Ali)

INSCRIPTION

The globe maker's signature is engraved inside the southern equatorial polar circle and reads as follows:

> *ᶜamal aqall al-ᶜibād ḍiyā' al-dīn muḥammad ibn qā'im muḥammad ibn mullā ᶜīsā ibn shaykh allāhdād asṭurlābī humāyūnī lāhūrī fī sanah 1070 hijrī*
>
> 'The work of the least of the servants [of God], Ḍiyā' al-Dīn Muḥammad, son of Qā'im Muḥammad, son of Mullā ᶜĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the year 1070 Hijrī [= AD 1659-60].'

BIBLIOGRAPHY

Savage-Smith 1985, no. 69, p. 252.

F018 CELESTIAL GLOBE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1071 AH (AD 1660-61)[1138]

Diameter 94 mm

Berlin, Staatliche Museen zu Berlin, Preussischer Kulturbesitz, Museum für Asiatische Kunst (I 1266)

ESS 26; Répertoire 23



Figure F018.1 – Globe (courtesy Museum für Indische Kunst, Berlin)

[1138] I am highly grateful to Regina Hickmann, Deputy Director, Museum für Indische Kunst, for sending me on 27.2.1996 two photos and xerocopies of several other photos some of which are included here.

This globe played an important role in the historiography of the Lahore family of astrolabists. H. von Klüber of the Astrophysikalisches Observatorium, Einstein Institut, Potsdam, while studying this globe, wrote to Syed Sulaiman Nadvi in 1933, asking for information about Ḍiyā' al-Dīn Muḥammad and his ancestors.[1139] This led to Nadvi's article where he listed eight astrolabes and four celestial globes made by the various members of this Lahore family.[1140] The present catalogue, in a way, is the culmination of Nadvi's exercise.

In the same year when Nadvi's article appeared, Klüber published a lengthy description of this globe; it is the first scholarly study of a celestial globe made by the Lahore family. In this study, before describing this globe, Klüber gave an overview of all the Islamic celestial globes known at that time, in particular, those produced at Lahore. Klüber's description of the globe is supplemented by a transcription of all the names of constellations and stars engraved on the globe by Walther Hellige of Berlin.

The globe is cast as a single hollow sphere with a large rectangular plug in the region of Centaurus in the southern hemisphere. Small holes are bored at the ecliptic poles and larger ones at the equatorial poles. The latter are labelled as *quṭb shamālī* (north pole) and *quṭb janūbī* (south pole) respctively.

CIRCLES

The equator and ecliptic are both divided in 1° and 6°. The intervals of 6° are marked by dotted lines. On the equator, these intervals are numbered continuously from 6 to 360 from the vernal equinox onwards; on the ecliptic these are marked separately in each zodiac sign from 6 to 30. The names of the zodiac signs are engraved along the ecliptic. Ecliptic latitude circles are drawn at intervals of 30°. Equatorial tropics and polar circles are traced.

1139 In his description of the globe (Klüber 1935, p. 21, n. 12), Klüber refers to Nadvi's response thus: 'Privatbrief von Pandit S. S. Solaiman Nadvi, Shibli Academy, Azamgarh, Juni 1933.' The honorific 'Pandit' is actually used for Hindus. For a Muslim scholar like Nadvi, 'Janāb' or 'Mawlānā' would have been appropriate.

1140 Nadvi 1935.



Figure F018.2 – Another view of the globe with Ophiuchus in the middle
(courtesy Museum für Indische Kunst, Berlin)

Constellation Figures and Stars

The full set of 48 constellation figures are engraved along with their names and their serial numbers in three sets of the northern constellations (1-21), the zodiac signs (1-12 and the southern constellations (1-15). The positions of about 1020 stars are marked with inlaid silver points. The names of 111 stars are engraved next to the silver points.

Except for minor variations, the iconography of the constellation figures on this globe is the same as in the other globes by Ḍiyā' al-Dīn. The three reptiles, Draco, Hydra and Serpens are drawn in simple outlines without any scales. Many of the human figures (Hercules, Serpentarius, Perseus, Andromeda) wear caps with tassels at the top, as can be seen in the figure below.



Figure F018.3 – Hercules (courtesy Museum für Indische Kunst, Berlin)

The figure of **Hercules** shows him kneeling with both knees bent; his right foot is caught in the coils of Serpens. He wears a short tunic with full sleeves; a sash is tied around the waist. The heads of Hercules and Serpentarius are drawn together so that their caps merge into a single *S*-like curve, separated just by a short line. Above his shoulder is the label *ṣūrat jāthī 7.* The star on his forehead is named *Rās al-Jāthī* (α Herculi) and that on the forehead of Ophiuchus *Rās al-Ḥawwā* (α Ophiuchi).

The figure of Argo Navis on this globe with dotted pennants is akin to the figure on the globe of 1068/1657-58 at Cardiff (see Figure F015.2).

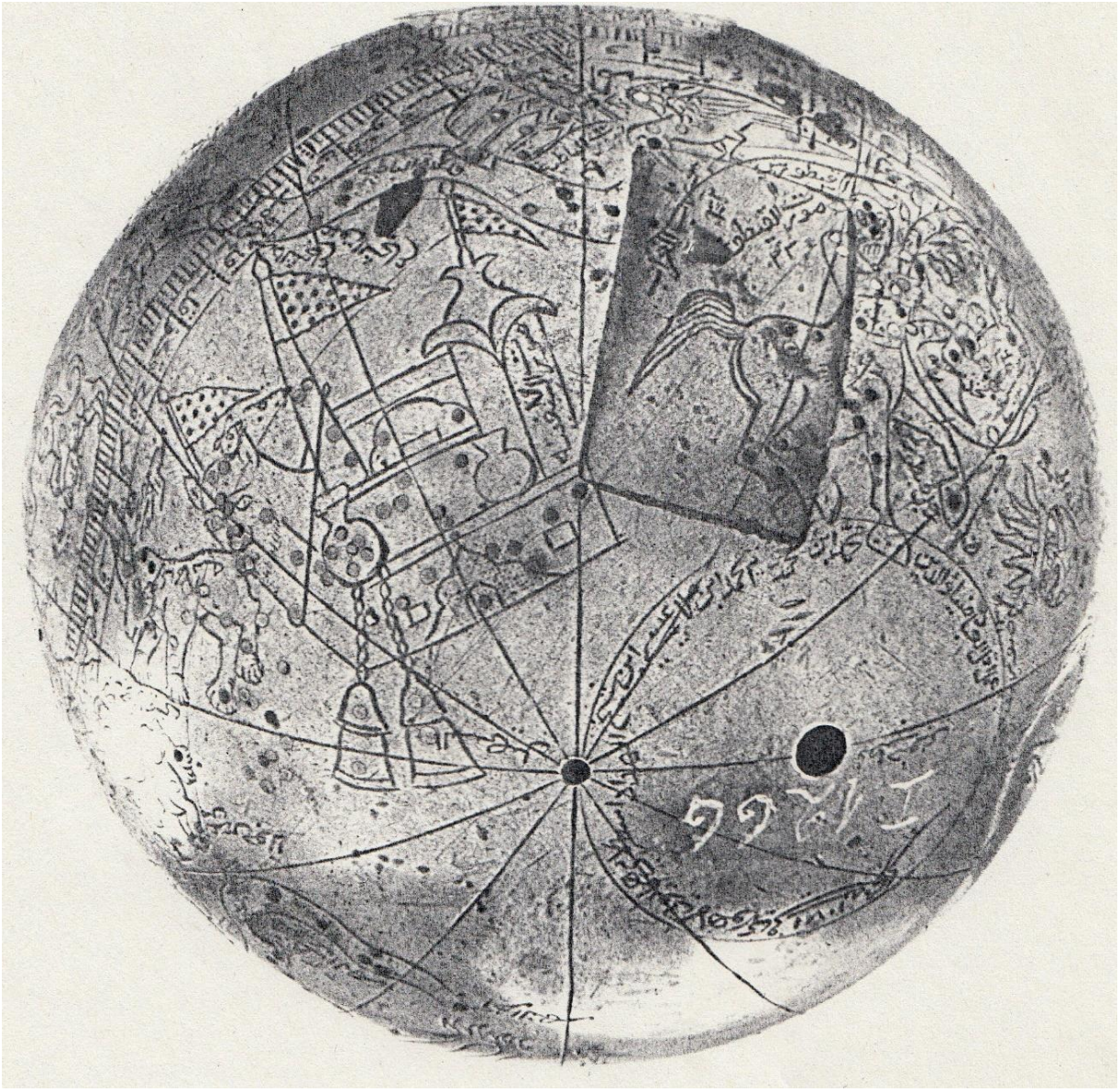


Figure F018.4 – Argo Navis, Centaurus and the Inscription
(courtesy Museum für Indische Kunst, Berlin)

INSCRIPTION

The globe-maker’s signature is engraved inside the equatorial polar circle:

ᶜamal aqall al-ᶜibād ḍiyā’ al-dīn muḥammad ibn qā’im[1141] *muḥammad ibn mullā ᶜīsā ibn shaykh allāhdād asṭurlābī humāyūnī lāhūrī fī sanah 1071 hijrī*

‘The work of the least of the servants [of God] Ḍiyā’ al-Dīn Muḥammad, son of Qā’im Muḥammad, son of Mullā ᶜĪsā, son of Shaykh Allāhdād of Lahore,

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1141 The word *qā’im* appears to have been erased and replaced by *muḥammad.* Probably the word *qā’im* was very faint as it happened to be at the tip of a large rectangular plug; later somebody must have added, helpfully but wrongly, the word *muḥammad*.

the astrolabe-maker to [the Emperor] Humāyūn, in the year 1071 Hijrī [= AD 1660-61].'

PROVENANCE

Acquired in 1912 by the Museum für Völkerkunde at Berlin. In 1963, Indian artefacts in this museum were moved to the newly established Museum für Indische Kunst. This museum was amalgamated in 2006 in the Museum für Asiatische Kunst. Again another reorganization is in the offing: the collections of South-Asian, South-East Asian and Central Asian Art are closed to the public since the beginning of 2016; they will be transferred to the Humboldt Forum which is coming up in the centre of Berlin.

BIBLIOGRAPHY

Klüber 1935.

Savage-Smith 1985, no. 26, p. 230, Fig. 45.

F019 ⊙ CELESTIAL GLOBE BY ḌIYĀ' AL-DĪN MUḤAMMAD 1074 AH (AD 1663-64)

Diameter 167 mm

Hyderabad, Salar Jung Museum (# 113/xxxv)



Figure F019.1 – Globe with stand (photo by S. R. Sarma)

Three globes crafted by Ḍiyā' al-Dīn in the year 1074/1663-64, namely F019, F020 and F021, are extant in public collections. Though slightly different in sizes, these three globes have many common features. In F019 and F020, the stands are alike. There are also similarities in the iconography of the constellation figures; the most striking one being the rendition of Hercules as a woman with large breasts in F019 and F020.[1142]

[1142] I regret very much that while studying the instruments at the Museum of the History of Science, Oxford, I spent much time with the large collection of astrolabes and did not pay adequate attention to the constellation figures on globe F021. Possibly there also Hercules is depicted as a female.

The present globe is cast as a single hollow sphere with two ovoid plugs measuring respectively 50 x 55 mm (on the Great Bear's head) and 20 x 25 mm (on the figure of Centaurus), which have a different colouration suggesting higher copper content. Holes are bored on globe at the two poles of the equator and also at the two poles of the ecliptic so that the globe can be made to turn either around the poles of the equator or around the poles of the ecliptic.

Circles

The equator and the ecliptic are divided in 1° and 5°. The intervals of 5° are marked by dotted lines. On the equator, these intervals are numbered from 5 to 360 from vernal equinox onwards, while on the ecliptic they are numbered from 5 to 30 separately in each zodiac sign. The names of the zodiac signs are engraved along the ecliptic circle. Ecliptic latitude circles, equatorial tropics and equatorial polar circles are represented as single lines. The northern and southern celestial poles are labelled respectively as *quṭb shamālī* and *quṭb janūbī.*

Constellation Figures and Stars

All the 48 constellation figures are finely engraved and numbered in three batches: northern constellations 1 to 21; zodiac signs 1 to 12 and southern constellations 1 to 15. They are labelled without the article *al-*; thus *ṣūrat safīnah 7.* About 1020 star positions are marked on the globe by inlaid silver points of three magnitudes. The silver in these points is disintegrating and the tarnish is spreading.

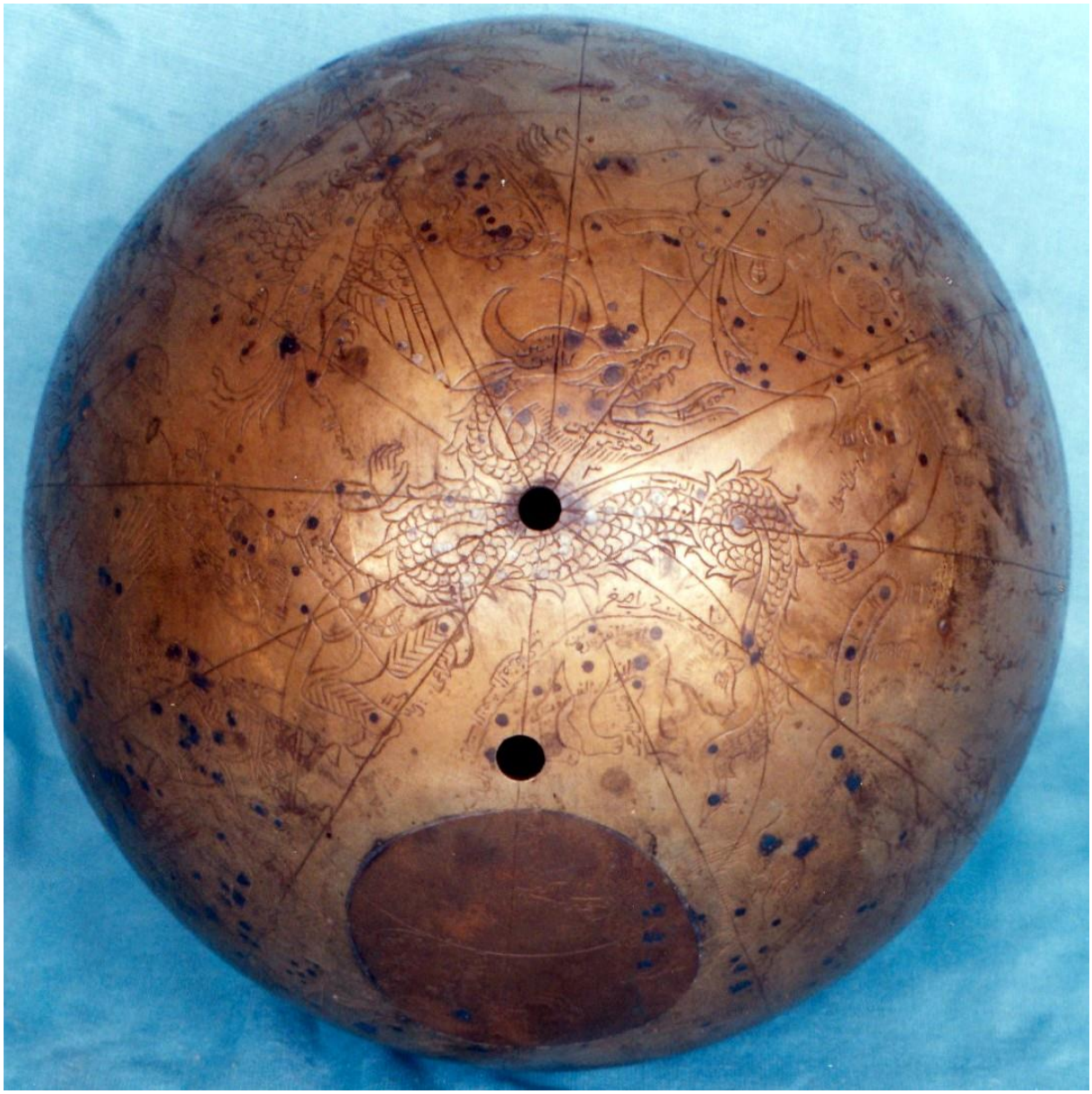


Figure F019.2 – Northern ecliptic pole (photo by S. R. Sarma)

The constellation figure Draco coils around the northern ecliptic pole in the north. It is rendered as a kind of dragon. Its underside is bare; on the upper side are sharply projecting spikes. In between are small scales, meticulously drawn all over the body. Two fierce horns rise above its large head, which is hairy on the underside. Its mouth is wide open, with fangs above and below, and the forked tongue jutting out.

On the lower jaw is engraved the name of the figure *ṣūrat Tinnīn,* followed by the serial number 3. Several named stars are situated on its body. The star at the base of one of the horns is named *Rās al-Tinnīn* (head of the dragon, γ Draconis). The star on the forked tongue is named *al-Rāfiḍ* (the wandering [camel], μ Draconis).

Below the curve of Draco is the figure of Ursa Minor with the label *ṣūrat Dubb Aṣghar 1.* Around Draco are the figures, starting at the top and proceeding clockwise, of Hercules drawn as if he is stamping on Draco's head with his foot, Bootes and Ursa Major; on the other side of the large plug is Cepheus the king, with a high crown and knee-length boots with geometrical patterns; his left hand which is seen above the spikes of Draco is delicately rendered. Above him is the large figure of Cygnus.

Andromeda, Cassiopeia and Perseus are drawn with full faces, while Virgo, Ophiuchus and Hercules are shown in three quarters profiles, all with large almond-shaped eyes.

Andromeda is depicted with an ankle-length gown (*jāma*); a sash (*paṭkī*) with geometric patterns is wrapped around the waist forming a large loop on her left; one loose end of the sash hangs down on the right-hand side of the gown, reaching up to the ankles. Through the diaphanous skirt of the gown can be seen her plump legs. Her hair is depicted as two strands, falling down on either side. She wears no cap. She is decked with a series of armlets and bracelets, the outer ones being larger and thicker than the inner ones. Two bead necklaces, one short and the other long, but both of double strands, adorn her neck. She stretches out both her arms, pleading for protection from the sea-monster Cetus. The left hand, which is closer to the viewer, is much larger than the right hand. She is barefoot.

Above her left shoulder is engraved the label of the figure *ṣūrat Musalsalah 20,* short for *ṣūrat al-Mar'ah al-Musalsalah* (figure of the chained woman). Some of the stars in this figure are common to the constellation Pegasus as well and therefore, carry double names: the large star on Andromeda's forehead is labelled as *Rās al-Mar'ah al-Musalsalah,* 'head of the chained woman' (α Andromedae) and also as *Surrat al-Faras,* 'navel of the horse' (δ Pegasi).

The star above her left hand carries the name *Janāḥ al-Faras,* 'wing of the horse' (γ Pegasi). The star on her waist, just above the sash on the right, is given the name *Janb al-Musalsalah,* 'the side of the chained one', which is written on the gown. This star is common to the fish figure on her right; so it has a second name *Baṭn al-Ḥūt,*'belly of the fish' (β Andromedae). The star on her left foot has the name *Rijl al-Musalsalah,* 'the foot of the Chained One' (γ Andromedae). She is standing, as it were, upon the sword of her rescuer Perseus. The sword has an ornate hilt.



Figure F019.3 – Andromeda, Cassiopeia and Perseus (photo by S. R. Sarma)

To Andromeda’s lower left is the figure of her mother Cassiopeia seated on a high chair. She wears a full-length gown and pointed shoes. The two ends of the sash at her waist are stretched towards her back. She also wears two necklaces like her daughter, but of a single strand, and series of armlets and bracelets. Her hair is shown as two strands falling on either side of the face; she wears a high cap which is curved at the top.

Cassiopeia’s chair or throne received great attention from the engraver. The legs are short and shaped like hour-glasses. The seat is engraved with a symmetrical pattern.

The two back-posts are high, topped with ornaments which look like large pomegranate fruits.[1143]

She is labelled as *ṣūrat Dhāt al-Kursī 10* (figure of the one with the chair). On the back rest of the chair is engraved the name *Kaff al-Khaḍīb,* 'the dyed hand' (β Cassiopeiae) in two lines. This refers to a star usually marked on the left elbow of Cassiopeia. But here, the silver point is not on her elbow but on the back-rest, probably by mistake. There are two other silver points on her wrist and on the back of her hand, but these are not named. The star on her knee is named *Rukbat al-Kursī,* 'knee [of the one with] the chair' (δ Cassiopeiae).

To Andromeda's lower right is the figure of Triangulum, which is labelled as *ṣūrat Muthallath 21.* The star at the apex of the triangle is named *Rās al-Muthallath* (α Trianguli).

Below the figure of Andromeda, is the figure of Perseus with a large sword in his left hand and the head of the ghoul in his right hand. The hilt of his sword and his two hands are carefully drawn, but not his face and that of the ghoul; both have long beards; eyes, nose and mouth are faintly visible in the profusion of hair. The label *ṣūrat Parsā'ūs wa Huma Ḥāmil Rās al-Ghūl 11* (figure of Perseus, that is, the bearer of the ghoul's head) is engraved under his upraised left arm. The star on his chest carries two names: *Janb Barsā'ūs,* 'side of Perseus' and *Mirfaq al-Thurayyā,* 'elbow of *Thurayyā'* (α Persei, Algenib / Mirfak). The star on his left wrist is named *Miʿṣam al-Thurayyā Sahābī,* 'the nebulous wrist of *al-Thurayyā*' (hχ Persei).

The figure of Virgo is drawn on the two double-banded scales of equator and ecliptic, immediately after their intersection at the autumnal equinox. Her face is depicted in three-quarters profile, with large almond-shaped eyes and long nose. She has an elaborate coiffeur, hair combed high into a series of upright curls. Her left wing is very elaborately patterned in the same manner as the wings and feathers of the figure Corvus on the left. Virgo wears a long gown that reaches up to her feet. Above the left foot can be seen the folds of her *chūrīdār pāyjāma,* worn under the gown. A simple sash goes around her waist; one loose end with geometrical patterns falls up to her feet. Her

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[1143] This motif occurs frequently in the figures of Argo Navis.

breasts are indicated by two curves. She wears a short necklace with large beads which goes around the neck. Another long necklace is wound around the neck and then let fall to reach up to the girdle. She wears series of armlets and bracelets, which are drawn as parallel lines, as in the case of Cassiopeiae. Her feet are adorned with anklets.

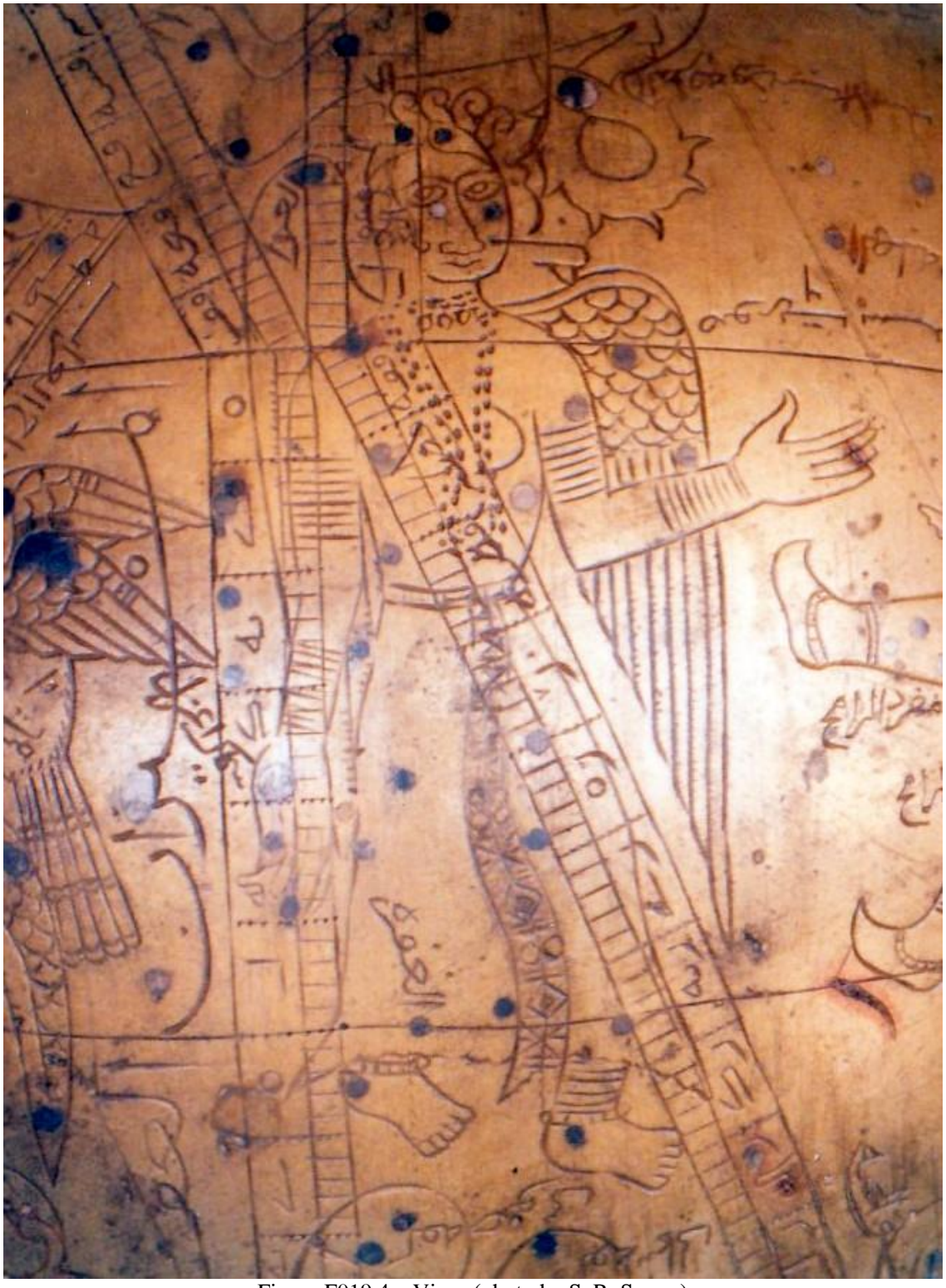


Figure F019.4 – Virgo (photo by S. R. Sarma)

The label *ṣūrat Sunbulah 6* is engraved near her wing. On her right palm, which rests on the band of ecliptic, is the star named *Simāk Aʿzal* (α Virginis, Spica,). Above the hemline of the gown is the label *al-Ghafrah* which is the collective designation of the three stars, one on the right foot and two on the hemline, (ικλ Virginis), which form the fifteenth lunar mansion.[1144]



Figure F019.5 – Ophiuchus (photo by S. R. Sarma)

[1144] Savage-Smith 1985, pp. 174-175.

The figure of Ophiuchus straddles the double bands of equator and ecliptic, his right foot resting on the figure of Scorpio. He wears a short knee-length tunic with an elaborate sash around the waist. The neckline is marked with three parallel lines. Below the sash, the tunic is flared with several vertical folds. A bell-like purse is suspended from his sash. On the upper arms, lower arms and wrists are drawn series of parallel lines (as in the case of Cassiopeia and Virgo); it is not clear whether these are meant to be patterns on the sleeves or armlets and bracelets. His hair looks like horizontal strands of twigs tied up vertically by a triple cord, with the loose ends placed on the right. He is holding the Serpens with both his hands. Unlike Draco and Hydra, this third serpent is not patterned with scales; this figure is drawn just with the parallel lines. On the chest is written the label *ṣūrat Ḥawwā 13.*



Figure F019.6 – Hercules as a female (photo by S. R. Sarma)

The figure of Hercules is depicted, most unusually, as a female with large breasts, with bare upper body and with a very short skirt covering the lower half. A sash is around the waist. From this sash hang down three loose ends with ornate terminals at the left, right and middle of the figure; also a semi-circular purse with a flap to close it (?) and two circular objects. The oval face is shown in three-quarters profile, the two lines of eyebrows merge with the bridge of the nose; the eyes are large and almond-shaped, the pupils are indicated by small circles without hatching. The hair falls in two strands on either side of the face. There are bracelets at the two wrists; the left arm holding a sickle is raised high, the right arm is stretched forward; both knees are bent and the right foot rests on the fierce head of Draco. The label is engraved on the chest: *ṣūrat Jāthī 7.*



Figure F019.7 – Argo Navis (photo by S. R. Sarma)

The figure of Argo Navis looks more like a Mughal pleasure pavilion than a ship. On the left-hand side is a large figurehead, with human face, with two large horns on

the head, and long strands of hair falling down. On the right is a circular dome with two-tiered finial. Stylized sails are gathered and tied to the mast; from there two chains reach up to the figurehead on either side. There are three pennants filled with dots. Above the dome is engraved the label *ṣūrat Safīnah 7.* Towering above the ship is the body of Hydra with minutely engraved scales.

STAND

The globe is mounted on a sturdy but simple stand, with a height of 135 mm, consisting of the horizon ring, which is 15 mm thick and 12 mm wide, supported by three stout *S*-shaped legs. A semicircular arc is attached to the underside of the horizon ring at its east and west points to support the meridian ring. There are indents at the north and south points of the horizon ring and at the middle of the semi-circular arc through which the meridian ring can pass, but it is now missing. The horizon ring is graduated in 1° and 5°.



Figure F019.8 – Globe maker’s signature (photo by S. R. Sarma)

INSCRIPTION

The globe maker’s signature is engraved inside the equatorial polar circle and reads as follows:

> *ᶜamal aqall al-ᶜibād ḍiyā’ al-dīn muḥammad ibn qā’im muḥammad ibn mullā ᶜīsā ibn shaykh allāhdād humāyūnī asṭurlābī lāhūri 1074 hijrī.*

‘The work of the least of the servants [of God] Ḍiyā’ al-Dīn Muḥammad, son of Qā’im Muḥammad, son of Mullā ʿĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, [in the year] 1074 Hijrī.’

BIBLIOGRAPHY

Sarma 1996a, pp. 24-26, pl. 13.

F020 ⊙ CELESTIAL GLOBE BY ḌIYĀ’ AL-DĪN MUḤAMMAD, 1074 AH (AD 1663-64)

Diameter 146 mm

Edinburgh, Royal Scottish Museum (# 1890-331)

ESS 27; Répertoire 28



Figure F020.1 – Globe with stand (© Royal Scottish Museum, Edinburgh)

The globe is cast as a single hollow sphere, with three plugs.

Circles

The equator and ecliptic are divided in 1° and 5°. In both scales, the intervals of 5° are marked by dotted lines. These are numbered on the equator from 5° to 360° starting from the vernal equinox; but on the ecliptic, separately in each zodiac sign from 5 to 30. The names of the zodiac signs are engraved along the ecliptic circle. Ecliptic latitude circles are drawn at intervals of 30°. Equatorial tropics and equatorial polar circles are engraved. The names of the equatorial poles are engraved.

Constellation Figures and Stars

The full set of 48 constellation figures are depicted very elegantly. Next to the figures are inscribed their names and the serial numbers in three batches. The positions of about 1020 stars are indicated by inlaid silver nails. Many features are common in the human figures on this globe and on the previous globe F019; even so, Ḍiyā' strives to add variations in each figure.



Figure F020.2 – Globe with stand. Another view of the globe, showing in the upper row, from left to right, Bootes, Serpens and Hercules; below Virgo on the left and Ophiuchus on the right; under the horizon ring can be seen the figures of Hydra, Centaurus and Lepus. (© Royal Scottish Museum, Edinburgh).



Figure F020.3 – Figure of Andromeda (detail of Figure F020.1)

The figure of Andromeda is almost similar to the figure on F019 in outline, in the physical posture, in her hair and her gown and sash, but the facial expression is different, and her ornaments are different. More important, her feet are tied in chains; it is one of the rare depictions where the chains are actually shown. She is decked with a necklace of large beads and with wide and patterned armlets and bracelets. The star names engraved here are the same as in the previous globe.

To her lower is the figure of Cassiopeia, depicted almost as in F019, but without a cap; the star on her forehead receives the name *Rās Dhāt al-Kursī,* 'head of the one with the chair' (ζ Cassiopeiae). The star on her knee is named *Rukbat al-Kursī,* 'knee [of the one with] the chair' (δ Cassiopeiae).



Figure F020.4 – Figures of Hercules (left) and Bootes (upside-down) (detail of Figure F020.2)

Bootes wears a peculiar cap; he is standing with an upraised sword-like weapon in his left and the right arm raised as if calling for attention. He wears a knee-length tunic, flared at the bottom. Its flaps are closed under the right-hand side. There is a sash tied around the waist, its two ends falling down in front. Three large circles dangle from his sash, which can be pouches. His tight trousers reach up to the calves, as indicated by two parallel lines. There are pointed boots on his feet.

His name is written above his right arm *ṣūrat al-ᶜAwwā’ 5.* The star on his forehead is named *Rās al-Awwā’* (β Bootis). Beneath the hem of his tunic are two stars named *Simāk al-Rāmiḥ* (α Bootis) and *Muṛrid al-Rāmiḥ* (η Bootis). To his lower left is the constellation figure of Serpens, labelled *Ṣūrat Ḥayyah 14.* The star on its neck is named *ᶜUnuq al-Ḥayyah* (α Serpentis). Immediately to the left is the constellation figure of Corona Borealis, drawn with two concentric circles; it is labelled as *Ṣūrat Fakkah* without the serial number 6. The star situated on its rim is named *Nayyir Fakkah* (α Coronae Borealis).

Further left is the figure of Hercules, rendered as in F019, as a full-breasted female, with long strands of hair on either side of the face, with a very short skirt, bending on both knees, with a sickle in the upraised left hand. The name is below the neck *ṣūrat Jāthī 7.* The star on the forehead is named *Rās al-Jāthī* (α Herculis).

Stand

The stand with a height 170 mm consists of the horizon ring supported by four legs which rest on a circular plate. The horizon ring is graduated in 1° and 5° and numbered from 5 to 90, starting at the east and west points and ending at the north and south points. The four cardinal points are labelled. There are notches at the north and south point for the meridian ring and at the east and west points for the semicircular arc to mark the zenith and the prime vertical. This arc is now missing. The meridian ring is not graduated, but has holes so that the globe can be set up at six different terrestrial latitudes. The axis may or may not be original.

Inscription

The maker's signature is inscribed inside the southern equatorial polar circle thus:

> *ᶜamal aqall al-ᶜibād ḍiyā' al-dīn muḥammad ibn qā'im muḥammad ibn mullā ᶜīsā ibn shaykh allāhdād asṭurlābī humāyūnī lāhūrī fī sanah 1074 hijrī.*
>
> 'The work of the least of the servants [of God], Ḍiyā' al-Dīn Muḥammad, son of Qā'im Muḥammad, son of Mullā ᶜĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the year 1074 Hijrī [= AD 1663-64].'



Figure F020.5 – The globe maker’s signature (© Royal Scottish Museum, Edinburgh)

PROVENANCE

Bought in 1890 from F. Du Cane Godman. Displayed at the ‘Science in India: A Festival of India Exhibition’ at the Science Museum, London, from 1 March to 1 August 1982.

BIBLIOGRAPHY

Anderson 1982, no. 124, p. 34.

Savage-Smith 1985, no. 27, pp. 230-231, figs. 16 and 35.

F021 ⊙ CELESTIAL GLOBE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1064 AH (AD 1653-54)

Diameter 175 mm

Oxford, Museum of the History of Science (# 45247)

ESS 28; Répertoire 29



Figure F021.1 – Globe with stand (photo by S. R. Sarma)

The globe is cast as a single hollow sphere with two plugs and has a dull black finish.[1145]

CIRCLES

The equator and the ecliptic are divided in 1° and 5°. In both circles the intervals of 5° are marked by dotted lines. On the equator, groups of 5° are numbered from 5 to

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[1145] Inside the globe, Savage-Smith found three rolled-up pieces of paper with writing, probably as amulets; these were pushed inside by means of a metal probe and the hole was closed by a plug.

360, from the vernal equinox onwards, while on the ecliptic, these are numbered from 5 to 30, separately for each zodiac sign. The names of these signs are engraved along the ecliptic. There are ecliptic latitude circles and equatorial polar circles.

Constellation Figures and Stars

The full set of 48 constellation figures are drawn and the positions of about 1020 fixed stars are marked with inlaid silver points. All the constellation figures, some major stars and the two equatorial poles are labelled. The constellation figures are numbered in the three batches.

Stand

The globe is mounted on a simple but sturdy stand, consisting of the horizon ring which is supported by three *S*-shaped legs. The horizon ring is calibrated in 1° and 5°, and numbered from 5 to 90, separately in each quadrant. To the underside of the horizon ring is attached a semicircular arc to support the meridian ring; this is a replacement.

Inscription

The maker’s signature is engraved, as usual, along the southern equatorial polar circle and reads as follows:

> *ʿamal aqall al-ʿibād ḍiyā’ al-dīn muḥammad ibn qā’im muḥammad ibn mullā ʿīsā ibn shaykh allāhdād asṭurlābī humāyūnī lāhūrī fī sanah 1074 hijrī.*
>
> ‘The work of the least of the servants [of God], Ḍiyā’ al-Dīn Muḥammad, son of Qā’im Muḥammad, son of Mullā ʿĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the year 1084 Hijrī [= AD 1663-64].’

Provenance

Formerly in the private collection of Henri Michel; acquired by J. A. Billmeir and gifted to the Museum.

Bibliography

Savage-Smith 1985, no. 28, p. 231, figures 40, 43 and 47.

F022 CELESTIAL GLOBE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1078 AH (AD 1667-68)

Diameter ?

PLU

Répertoire 35

The Répertoire states that a globe by Ḍiyā' al-Dīn Muḥammad, dated 1078 Hijrī, is with the Museum of Islamic Arts at Cairo, with the inventory number 15226 I, and that it carries the following inscription. But I have been informed by a reliable source that the Museum never owned such a globe.

> *ᶜamal aqall al-ᶜibād ḍiyā' al-dīn muḥammad ibn qā'im muḥammad ibn mullā ᶜīsā ibn shaykh allāhdād asṭurlābī humāyūnī lāhūrī fī sanah 1078* [*julūs mubārak 42*] *jahān shāh* [sic!].
>
> 'The work of the least of the servants [of God], Ḍiyā' al-Dīn Muḥammad, son of Qā'im Muḥammad, son of Mullā ᶜĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the year 1078 [Hijrī = AD 1667-68] [in the blessed regnal year 42 of] Shāh Jahān.'

F023 ⊙ CELESTIAL GLOBE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1087 AH (AD 1676-77)

Diameter 65 mm

NewDelhi, Red Fort, Mumtaj Mahal Museum (# 40-414)

ESS 71; Répertoire 37



Figure F023.1 – Globe with stand (photo by S. R. Sarma)

The globe is cast as a single hollow sphere with three plugs. A rectangular plug can be seen behind the horizontal ring in Figure F023.1.

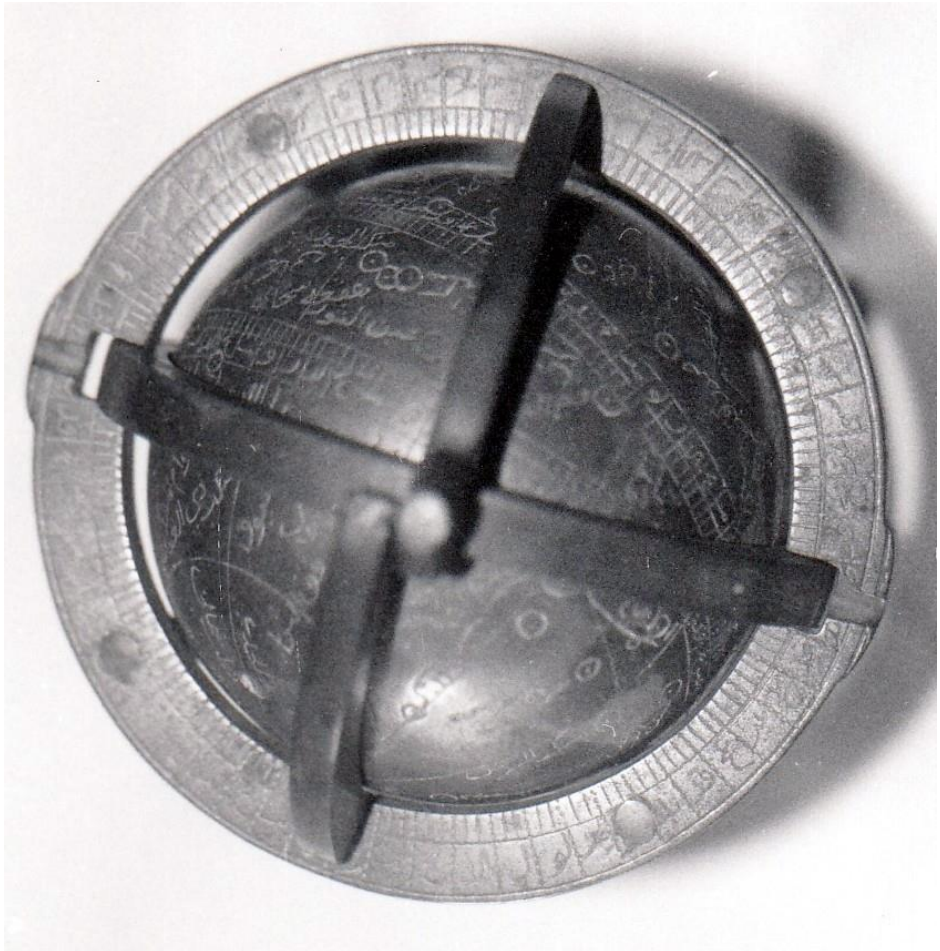


Figure F023.2 – The globe and horizon ring as seen from above (photo by S. R. Sarma)

The graduated circles of the equator and ecliptic, the ecliptic latitude circles, the polar circle in the south and several star positions can be seen here.

Circles

The equator and the ecliptic are divided in 2° and 6°. The intervals of 6° are marked by dotted lines and numbered from 6 to 90, separately in each quadrant, on the equator, but from 6 to 30, separately for each zodiac sign, on the ecliptic. The names of the signs are engraved along the ecliptic circle. Ecliptic latitude circles and equatorial tropics and equatorial polar circles are drawn. Holes are bored at the two equatorial poles and their names are engraved as *quṭb shamālī* and *quṭb janūbī.*

Constellation Figures and Stars

There are no constellation figures on this small globe; the positions of 92 stars are indicated by dots enclosed in small circles and most of their names are engraved. Kaye 1921 reproduced the names of these stars together with their longitudes and latitudes,

compared them with those given by Ulugh Beg and concluded that the star positions as marked on the globe were valid for 1664.

STAND

The globe is mounted on a stand consisting of the horizon ring supported by four straight legs which rest on an eight-lobed ring. Inside the ring are cross-bars at the centre of which is the fifth leg to support the meridian ring. The horizon ring is graduated in 2° and 6°; the intervals of 6° are marked by dotted lines as on the globe, and numbered from 6 to 90, starting at the east and west points and ending at the north and south points. The meridian ring is not graduated. Perpendicular to it is the semicircular zenith arc which is broken in the middle. There appears to have been some kind of handle attached to this arc; this is broken and there remains just the stump.[1146] The original axis is missing and the replacement is fixed with a nut.

INSCRIPTION

The maker’s signature is engraved inside the polar circle in the south; here attributes of Allāhdād are abridged clumsily with the result the word *humāyūnī* makes no sense without the term *asṭurlābī.* It appears that the engraver began with too large letters and realized at the end that there is not enough space to write *asṭurlābī humāyūnī lāhūrī.:*

> *ᶜamal aḥqar al-ᶜibād ḍiyā’ al-dīn muḥammad ibn mullā qā’im muḥammad ibn ḥāfiẓ ᶜīsā ibn shaykh allāhdād [asṭurlābī] humāyūnī [lāhūrī fī] sanah 1087.*
>
> ‘The work of the weakest of the servants [of God], Ḍiyā’ al-Dīn Muḥammad, son of Mullā Qā’im Muḥammad, son of Ḥāfiẓ ᶜĪsā, son of Shaykh Allāhdād [of Lahore], [the astrolabe maker to the Emperor] Humāyūn, [in] the year 1087 [Hijrī = AD 1676-77].’

[1146] Surprisingly Kaye does not mention this arc, nor does the figure published by him show it.



Figure F023.3 – The globe-maker's signature (photo by S. R. Sarma)

BIBLIOGRAPHY

Kaye 1921, pp. 16-19, Fig. 9.

Behari & Govind 1980, p. 99.

Savage-Smith 1985, no. 71, p, 253.

F024 CELESTIAL GLOBE BY ḌIYĀ' AL-DĪN MUḤAMMAD, 1087 AH (AD 1676-77)[1147]

Diameter 60 mm, height 110 mm

PLU, ex-London, Sotheby's 2005



Figure F024.1 – Globe with stand (from Sotheby's catalogue 2005)

[1147] Entry based on Sotheby's, London, *Arts of the Islamic World,* auction catalogue, 27 April 2005, lot. 44, pp. 64-65.

Cast as a single hollow sphere, no plugs are visible in the published photo.

Circles

The equator and ecliptic are divided in 2° and 6°; the divisions of 6° are marked by dotted lines. On the ecliptic, groups of 6° are numbered from 6 to 30, separately for each zodiac sign. The names of the zodiac signs are engraved along the ecliptic. On the equator, the groups of 6° appear to have been numbered from 6° to 90°, in each quadrant starting from the vernal equinox.[1148] Ecliptic latitude circles, equatorial tropics and polar circles are drawn.

Constellation Figures and Stars

There are no constellation figures. The positions of a few stars are marked with inlaid silver points.

Stand

The stand consists of four legs resting on a ring with 8 lobes. Two bars at right angles to one another reinforce the ring; at the centre of the ring where the two bars intersect is a fifth leg which supports the semicircular arc which supports the meridian ring. This semicircular arc is attached to the underside of the horizon ring at its east and west points. On the upper side of the horizon ring, there are two pairs of clips at the east and west points where probably a semi-circular arc is hinged; this arc would be at right angles to the meridian ring and represents the prime meridian. But this arc is missing; so also the meridian ring. It is not known whether the horizon ring is graduated.

Inscription

The maker's signature is engraved inside the southern celestial polar circle and reads thus:

> *ʿamal aḥqar al-ʿibād ḍiyā' al-dīn muḥammad ibn qā'im muḥammad ibn hāfiz ʿīsā ibn shaykh allāhdād [asṭurlābī] humāyūnī [lāhūrī] fī sanah 1087.*

[1148] Surprisingly the description in the Sotheby's catalogue is not accurate at many places; the catalogue states: 'the ecliptic and equatorial scales are labelled for each 5° and subdivided for each 1°'; but the photo shows that these two scales are divided in 2° and 6° labelled in 6s. The catalogue states further: 'The constellations are illustrated in the typical Lahore fashion.' But not a single figure can be seen in the photo! The inscription as recorded in the catalogue is not complete.

‘The work of the most contemptible servants [of God], Ḍiyā’ al-Dīn Muḥammad, son of Qā’im Muḥammad, son of Hāfiz ʿĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the year 1087 [Hijrī].’

F025 CELESTIAL GLOBE BY ḌIYĀ' AL-DĪN MUḤAMMAD, [1]087 AH (AD 1676-77)

Diameter 120 mm

Qatar, Doha, Museum of Islamic Art (# MW.279.2006), ex-London, Sotheby's 2006[1149]



Figure F025.1 – Globe (from Sotheby's catalogue 2006)

The globe appears to have been cast as a single hollow sphere; no plugs are visible in the published photo. The stand is not extant.

CIRCLES

The equator and the ecliptic are divided in 1° and 5° and labelled in 5s. The catalogue does not mention other circles.

CONSTELLATION FIGURES AND STARS

The constellation figures are said to be engraved in the usual fashion of the Lahore globes. The star positions are marked by inlaid silver points; in some cases, the silver points got detached and mere holes remain.

[1149] Entry based on Sotheby's, London, *Arts of the Islamic World,* auction catalogue, 11 October 2006, L06222

INSCRIPTION

The inscription around the south celestial pole translates:

> ‘The work of the wretched of slaves [of God], Ḍiyā’ al-Dīn Muḥammad, son of Qā’im Muḥammad, son of Mullā ʿĪsā, son of Shaykh Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, in the [1]087 Hijrī [AD 1676-77].’

Beneath this inscription there is another inscription in a later hand which translates:

> ‘Copied (*nuqilat*) from a brass plate (*lawh*) inscribed in the hand of Aristotle in the treasury (*khazina*) of Cairo, [the city] protected [by God].’

The meaning and purpose of this addition are not clear.

F026 OPENWORK CELESTIAL GLOBE BY ḌIYĀ' AL-DĪN MUḤAMMAD FOR THE EMPEROR AURAGZEB, 1090 AH (AD 1679-80)

Diameter 163 mm

Chicago, Adler Planetarium (# A-398)

ESS 30; Répertoire 38



Figure F026.1 – Pierced globe (from Linton 1980, no. 185)

Ḍiyā' al-Dīn Muḥammad fashioned this remarkable celestial globe for the Mughal Emperor Aurangzeb in 1090/1679-80. It is made in two hemispheres and joined loosely at the equator in such a manner that the two hemispheres can be taken apart and again put together. Leaving aside the reference circles and the constellation figures, the rest

of the globe has been cut off so that the constellation figures appear as silhouettes.[1150] Thus, it can be considered a three-dimensional version of the zoomorphic retes crafted by Muḥammad Muqīm in his two astrolabes A026 and A051. The positions of about 1020 stars are perforated as small holes; some of these appear to be filled with glass or mica. Both the outer surface and the inner surface are covered with gilt finish and varnish, which is intact on the inner surface, but is worn off at places on the outer surface.

The inscription calls this object a terrestrial-celestial sphere (*kurāh … arḍwī samā'ī*). It may, therefore, be assumed that originally a small terrestrial sphere must have been placed inside this celestial globe. Perhaps it was also illuminated from inside so that the stars could be seen as points of light from outside. But now the terrestrial sphere, the stand and the rings are missing.

Circles

The equator and the ecliptic are represented as bands of about 15 mm width; these are divided in 1° and 5°; the divisions of 5° are marked with dotted lines. The equator is numbered in 5s, continuously from 5 to 360 from the vernal equinox onwards. The ecliptic is numbered separately in each zodiac sign from 5 to 30; the names of the zodiac signs are engraved along the ecliptic. Equatorial tropics, ecliptic latitude circles, equatorial and ecliptic polar circles are represented as bands of about 6 mm width. These bands constitute the frame which holds together each perforated hemisphere. Holes are bored at both the equatorial and ecliptic poles.

Constellation Figures

All the 48 constellation figures are represented, together with their labels and serial numbers. A remarkable feature of the iconography is that the faces of the human figures are delineated as perfectly circular, with clearly marked long eye brows, eyes with pointed edges, nose and a smiling or grinning mouth. The two long eye brows and

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[1150] A similar attempt was made by the modern American sculptor Paul Manship (1885-1966) whose openwork celestial globe made in 1934 is with the Busch-Reisinger Museum at Harvard. A more spectacular openwork globe by him is set up in front of the Palais des Nations, the United Nations Office at Geneva.

the outline of the nose is drawn together in one continuous line. Even the face of Dolphin (see Figure F026.8) is depicted in this fashion. These faces are reminiscent of folk paintings of Orissa and other parts of India. Ḍiyā' al-Dīn must have chosen this style so that the faces stand out and could easily by recognized; because of the profusion of perforations, other parts of the body are not so immediately recognizable, except for the feet or shoes in some figures.



Figure F026.2 – Vernal Equinox (accession no. A-398)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Vernal Equinox

In Figure F026.2, the horizontal band is the equator and the oblique band the ecliptic, both graduated for every 1° and labelled for every 5°. The equatorial tropics are parallel to the equator in the north and south; these are occasionally interrupted by

constellation figures. The ecliptic latitude circles are at right angles to the ecliptic and converge at the ecliptic pole, a little left to the top.

Immediately above the equator can be seen the figure of Dolphin on the left followed by the fore legs and the elaborate mane of Pegasus. On the right, the figure of Andromeda is placed in an almost horizontal position on the northern tropic. Above her are visible the two back posts of Cassiopeia’s chair. Below the equator on the right is the bird-like body of Cetus, its head rising above the equator.



Figure F026.3 – Andromeda (detail from Figure F026.2)

In the figure of Andromeda, her face and the outstretched arms are much larger than the figure itself. The outline of her knee-length tunic, the neckline, the sash at the waist, the ends of the sash hanging up to the hemline are clearly shown.



Figure F026.4 – Summer Solstice (accession no. A-398)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Summer Solstice

The horizontal band is the equator, in which the joint of the two hemispheres can be clearly seen. The ecliptic is above it like a curved arc. In the centre, between the ecliptic and equator is Orion with upraised arms. Above him is the figure of Auriga with the horse-whip in his hand. His beard and the circular turban are clearly shown. Below the figure of Orion is Lepus. To its right is Canis Major and the circular figurehead of Argo Navis. To the right of Orion, are the heads of the twins in Gemini, drawn on the ecliptic band.



Figure F026.5 – Autumnal Equinox (accession no. A-398)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Autumnal Equinox

On the ecliptic can be seen Leo on the left; its four legs and the curl in the tail are clearly shown. In the figure of Virgo, only the face and upper part of her left wing are discernible. The lines indicating the eye-brows, nose and mouth, if they were drawn at all, are no more visible. Below the equator on the right is the figure of Libra, the balance with the two suspended pans is fully delineated. In the upper right corner is the figure of Bootes.



Figure F026.6 – Bootes (detail from Figure F026.5)

The figure of Bootes with his grinning face is well developed. The complete outline of his long-sleeved knee-length tunic along with the neckline is shown; there is a wide sash at his waist; its two loose ends reach up to the hemline of the tunic. Beneath the hemline can be seen his two legs clothed in *chūrīdār payjāmā;* the folds in the *payjāma* and pointed half-shoes are well represented. On his left upper arm is engraved the label *ṣūrat al-ᶜAwwā'*



Figure F026.7 – Winter Solstice (accession no. A-398)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Winter Solstice

Here the prominent figures are Ophiuchus and Hercules, whose heads, placed in opposite directions occupy the centre of the image. The Serpens in the hands of Ophiuchus is shown as an arc, its head and fangs are near the raised hand of Hercules. The circle of the northern tropic is clearly visible as also the northern ecliptic pole and the northern ecliptic polar circle.

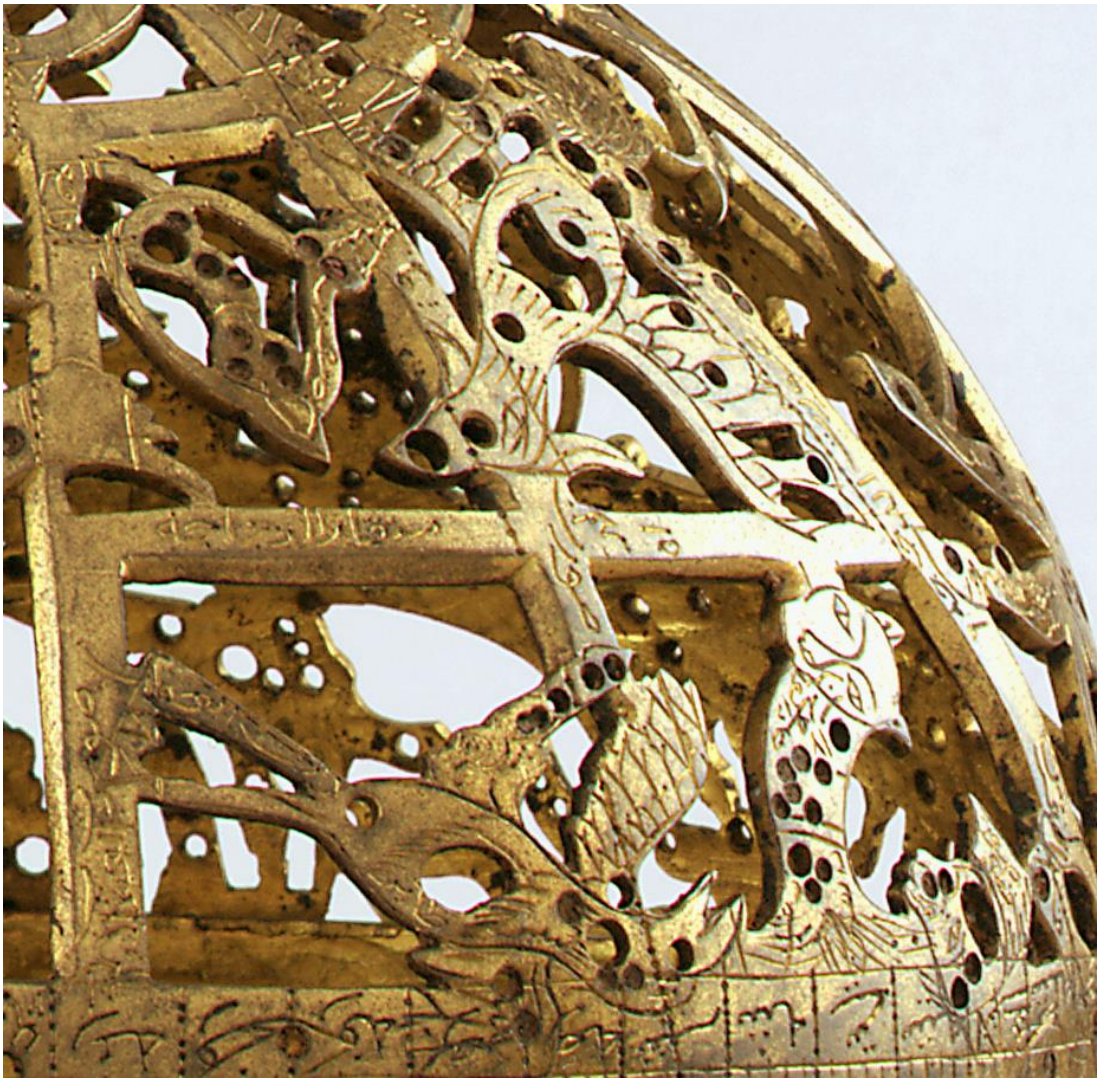


Figure F026.8 – Detail of Figure F026.7.

In Figure F026.8, in the lower row can be seen the figures of Aquila, Sagitta and Dolphin, the last one with a human face and pointed ears. In the vertical bar on the left is the title of the figure *ṣūrat al-ᶜUqāb.* The star at the beginning of the tail is named *Dhanab al-ᶜUqāb,* 'tail of the eagle' (ζ Aquilae). Under the belly of the eagle is the long shaft of the arrow constituting the constellation Sagitta; its name is engraved on the vertical bar immediately above as *ṣūrat Sahm 15.* Under the face of the dolphin is its title *ṣūrat Dālfīn 17.*

In the upper row, above the band of the northern tropic, is the figure of Lyra with the label *ṣūrat Shulyāq 8.* The prominent star on its north-west corner has the name *Nasr Wāqī* (α Lyrae), but only the second part is clearly visible. To the right of Lyra is the large figure of Cygnus with its prominent crest and the large wings spread out on both sides along the band of the ecliptic latitude circle. The actual latitude circle is marked as a dotted line on the band. The title of the figure is inscribed along the dotted line:

ṣūrat Dajājah 9. The name of the large star on its beak is engraved on the band of the tropic: *Minqār al-Dajājah,* ‘beak of the fowl’ (β Cygni).

PROVENANCE

Formerly in a private collection in London. It was sold off on 9-10 October 1980 in an auction at Paris, along with the major collection of Leonard Linton.

INSCRIPTION

The maker’s signature and the dedication are engraved in five parts along the two southern polar circles:

> *dar ᶜahad haḍrat muhyī al-din muḥammad awrangzayb bahādur ᶜālam gīr*
> *īn kurah ikhtirāᶜī bi-farmāyish nawāb mustaṭāb muᶜalī alqāb siyādat wa niqāb panāh*
> *īn kurah ikhirāᶜī arḍwī samā’ī ᶜamal aḍaᶜf al-ᶜibād ḍiyā’ al-dīn*
> *muḥammad ibn mullā qā’im muḥammad ibn ḥāfiẓ ᶜīsā ibn*
> *shaykh allāhdād humāyūnī*
> *fī sanah 1090 hijrī mubārak.*
>
> ‘In the reign of His Majesty Muḥyī al-Dīn Muḥammad Awrangzayb Bahādur ᶜĀlamgīr, this sphere was invented (*ikhtirāᶜī*) by the order of (*bi-farmāyish*) this excellent nawab, an exalted and publicly esteemed sovereign and learned builder. This invented terrestrial-celestial sphere (*kurah arḍwī samā’ī*) is the work of the weakest of the servants [of God] Ḍiyā’ al-Dīn Muḥammad, son of Mullā Qā’im Muḥammad, son of Ḥāfiẓ ᶜĪsā, son of Shaykh Allāhdād, [the astrolabe maker to the Emperor] Humāyūn, in the blessed year 1090 Hijrī.’[1151]

BIBLIOGRAPHY

Linton 1980, no. 185, pp. 130-131.
Savage-Smith 1985, no. 30, pp. 232-233, fig. 17.

[1151] Translation by Savage-Smith 1985, p. 232, slightly modified.

F027 ⊙ CELESTIAL GLOBE ATTRIBUTABLE TO ḌIYĀ’ AL-DĪN MUḤAMMAD

Not dated, 17th Century

Diameter 141 mm

Rampur, Rampur Raza Library (# 717 D)



Figure F027.1 – Globe with stand (courtesy Rampur Raza Library)

This celestial globe bears neither the maker’s signature, nor a date. But it exhibits a close affinity in its construction and in the iconography of the constellation figures

with the globes made by Ḍiyā' al-Dīn Muḥammad, in particular with his globe of 1663 (F019). Therefore, it can be attributed to him.

There are, however, certain unusual features in this globe. (i) The names of the zodiac signs are not engraved along the ecliptic; these are engraved only on the bodies of the figures. (ii) Several labels are with larger letters, more deeply and with *serif*. (iii) In the labels of constellation figures, the prefix *ṣūrat* and the article *al-* are dropped and only the name is mentioned. (iv) The solstitial colure is graduated and numbered.

The globe is cast as a single hollow sphere. There are two dark brown plugs: a semi-circular plug (d. 32 mm) near the South Pole and a tear-drop shaped one (13 mm across) near Pegasus. There is also a semi-circular plug (d. 15 mm) at the junction of the solstitial colure and the equator, covering a part of the left shoulder of the figure of Ophiuchus. This one appears to be a crude patch work made in more recent times, and not by the original globe maker himself. On the other hand, there are two small patches that merge well with the surrounding brass: an oblong patch on the leg of the horse of Sagittarius and a small square patch near the mouth of Virgo.

The globe is in a good state of preservation, but there are some dents near the constellation Ophiuchus. The original stand, meridian ring, and horizontal ring are lost.

Circles

The equator and the ecliptic are divided in 1° and 5°. On the equator, the groups of 5° are numbered continuously from 5 to 360 from the vernal equinox onwards, and on the ecliptic from 5 to 30 separately in each sign. There are ecliptic latitude circles and equatorial tropics, but no polar circles. The solstitial colure which passes through the two solstices, the two ecliptic poles as well as the two poles of the celestial equator, is graduated in single degrees, and every fifth is marked by longer lines; groups of 5° are numbered from 5 to 90, starting from the ecliptic circle and ending at the northern ecliptic pole or the southern ecliptic pole.[1152] Holes are made at the equatorial poles, through which the axis passes.

[1152] See Figure F027.1, Figure F027.6, Figure F027.10 etc. According to Savage-Smith 1985, p. 65, such graduated solstitial colures are unusual. The only other case is an unsigned globe no. 113, pp. 271-272, Fig. 34.

Constellation Figures and Stars

The figures of forty-eight constellations are meticulously engraved and labelled just with the names. But a few figures like Taurus and Aquarius are not labelled. The positions of about 1020 stars are marked by inlaid silver nails of three magnitudes; the names of several major stars and those of the lunar mansion are engraved.



Figure F027.2 – North Ecliptic Pole (courtesy Rampur Raza Library)

At the north ecliptic pole converge the ecliptic latitude circles, including the graduated solstitial colure. A small circle with a radius of 12° is described around the ecliptic pole. The area around this pole is dominated by the coiled figure of Draco with large curved horns on its head. Its underside is bare; the middle part is filled with small scales and the upper part with spikes. An ear is drawn under the horns, a forked tongue coming out of the mouth and fangs beneath the lower jaw. The name of the constellation is written as *Tinnīn,* but an unnecessary stroke under the first dot makes it appear as *Mirnīn.* The star at the base of the horns is named as *Rās Tinnīn,* ‘head of the dragon‘ (γ Draconis). The star on the forked tongue is labelled as *al-Rāfiḍ,* ‘the wandering [camel]’ (μ Draconis).

Beneath the figure of Draco is Ursa Minor. Its name *Dubb Aṣghar* is engraved on the body. The last star at the top of the front leg is named *Anwar Farqadayn,* 'brighter one of the two calves' (β Ursae Minoris, Kochab). The smaller star above it is called just *Farqadayn* and not with the full name *Akhfā Farqadayn,* 'the more obscure of the two calves' (γ Ursae Minoris).

Diametrically opposite Ursa Minor is the crown-like figure of Lyra labelled as *Shulyāq.* The bright star in it is named *Nasr Wāqiʿ,* 'falling eagle' (α Lyrae, Vega).



Figure F027.3 – Great Bear (photo courtesy Rampur Raza Library)

From the view point of iconography, the figure of the bear in the constellation Ursa Major is not much different from its counterparts on other globes. The names, however, are abridged. The title of the constellation *Dubb Akbar* is written on the body of the figure. The star on the back is labelled merely as *Ẓahr,* 'back' (α Ursae Majoris) and not *Ẓahr Dubb al-Akbar.* The star on the base of the tail has the label *Maghriz,* 'base' (δ Ursae Majoris). The stars on the tail are named respectively as *Jawn,* 'black horse' (ε Ursae Majoris), *ʿAnāq,* 'goat' (ζ Ursae Majoris) and *Qā'id,* 'leader' (η Ursae Majoris). The faint star next to *ʿAnāq* is called *Suhā,* 'overlooked [star]' (*g* Ursae Majoris, Alcor). This is one of the few globes where this star is marked. The twin stars on the rear paw are named *Qafzah al-Ulā,* 'first leap' (νξ Ursae Majoris), those on the

middle paw *Qafzah Thānī,* 'second leap' (λμ Ursae Majoris) and those on the lower front paw *Qafzah al-Thālithah,* 'the third leap' (ικ Ursae Majoris).

Zodiac Signs

From the vernal equinox, where the equator and the ecliptic intersect, the zodiac figures are drawn from left to right. Aries (*Ḥamal*) is shown as a ram, with its head turned backwards. The full body, the four legs and the tail are depicted in a realistic manner. The name *Ḥamal* is written on the ecliptic belt. A star on the head of the goat is labelled *Sharaṭayn,* which is the name of the first lunar mansion, and a star on the rear shank is designated as *Buṭayn,* the name of the second lunar mansion. Beneath the legs of the goat can be seen the snarling dog's head of Cetus.



Figure F027.4 – Zodiac Sign Aries (courtesy Rampur Raza Library)

Of the next zodiac sign Taurus (*Thawr*), only the front half of the body is shown. It looks as though the body has been sawn off in a straight line just behind the hump and the forelegs. Even so the figure makes a powerful impression: with a bent head, the bull is ready to charge with his horns. A star near its eye is called *Dabarān* (α Tauri) which is also the name of the fourth lunar mansion.

To the east of Taurus is the figure of Orion, labelled *Jabbār* on his chest. The cluster of four star above his head is called *Haqᶜah,* which is the name of the fifth lunar mansion.



Figure F027.5 – Zodiac sign Taurus (courtesy Rampur Raza Library)

The third sign Gemini (*Jawzā'*) is depicted as a pair of male infants with their bodies joined. The name *Jawzā'* is written on the shank of the second infant. The star on the forehead of the first twin is named *Rās Taw'am Muqaddam,* 'head of the foremost twin' (α Geminorum, Castor) and that on the forehead of the second twin *Rās Taw'am Mu'akkhar,* 'head of the rear twin' (β Geminorum, Pollux). The star beneath the foot of the second twin carries the label *Hanᶜah,* the name of the sixth lunar mansion. Between the heads of the twins is engraved the name of the seventh lunar mansion *Dhirāᶜ*.

The figure of the crab in the sign of Cancer is depicted with a heart-shaped main body with two eyes at the eastern end, two knobbly claws with half-moon like ends, one to the north and one towards the south, and several tentacles spread on either side of the ecliptic. The name of the constellation *Saraṭān* is written above the ecliptic belt. On the body is written *Nathrah,* the name of the eighth lunar mansion. Below the body is written the name of the middle star on the body *Maᶜlaf,* (M44 Cancri).



Figure F027.6 – Zodiac signs Gemini and Cancer (courtesy Rampur Raza Library)

Below the crab can be seen the figure of Canis Minor; the dog is facing the east. Its name *Kalb Aṣghar* written across the body. Procyon, the eighth largest star in the sky, is marked with a large silver point on its middle with the name *Shirāʿ Shāmī,* 'northern *Shirāʿ*' (α Canis Minoris). There is a smaller star marked on its body with the name *Mirzam* (β Canis Minoris).



Figure F027.7 – Zodiac sign Leo (courtesy Rampur Raza Library)

The figure of the lion in the zodiac sign of Leo straddles the ecliptic and occupies nearly 60° of it. Though drawn in profile, the head is turned towards the observer with both eyes drawn in full. On the forehead is a star named *Ra's al-Asad Shamālī,* 'northern head of the lion' (μ Leonis). A little lower to the right is *Ra's al-Asad Janūbī,* 'southern head of the lion' (ε Leonis). On the left nostril is situated *Mankhar al-Asad,* 'the nose of the lion' (κ Leonis); a very large star on the upper part of the lower forearm is *Qalb al-Asad,* 'heart of the lion' (α Leonis); on the rump there is *Ẓahr al-Asad,* 'back of the lion' (δ Leonis). A vertical row of four stars from the neck downwards has a collective designation *Jabhah,* which the name of the tenth lunar mansion. The tail is lifted upwards and the tip curls into an ornate circle; on the tip is situated a bright star called *Dhanab al-Asad,* 'tail of the lion' (β Leonis).[1153] It is also called *Ṣarfah,* the name of the twelfth lunar mansion.

[1153] In other globes usually the ornate curl of the tail encloses this star. See Savage-Smith 1985, pp. 170-172; Fig. 67.



Figure F027.8 – Zodiac sign Virgo (courtesy Rampur Raza Library)

The next zodiac sign Virgo also receives larger space and greater artistic attention.[1154] Her shoulders rest on the autumnal equinox where the equator intersects the ecliptic. Her right arm hangs down along the ecliptic. She is depicted as a very feminine person, draped in an ankle-length dress. There is a sash around the waist; its two loose ends hang down in the front. Her hair is long; eyebrows and eyes are quite symmetrical; the nose is shown in profile. The mouth, however, is not clearly visible. There occurs a small square plug here. Her left wing is drawn with great detail of feathers. The right wing overlaps the ecliptic divisions. She wears thick armbands. The title of the constellation *Sunbulah* is written in bold letters across her body. On her right hand is situated *Simāk Aʿzal,* 'unarmed *Simāk*' (α Virginis, Spica), the 15th most brilliant star in the heavens. A star below her neck is called *ʿAwwā',* the name of the thirteenth lunar mansion. Just above the hemline of her gown is the label *Ghafr,* which

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1154 Savage-Smith 1985, pp. 172-175; Fig. 68.

refers to the three stars, i.e., the star on her southern foot and the two stars on the hemline (ικλ Virginis); it is also the name of the fifteenth lunar mansion.



Figure F027.9 – Zodiac signs Libra and Scorpio (courtesy Rampur Raza Library)

The next zodiac sign Libra is represented by a balance with two pans; these are not shallow pans, but deep vessels with thick rims to which the strings are attached. The name *Mīzān* is engraved between the two pans. The star in the northern pan is named *Kiffa Shamālī,* 'northern pan' (α Librae) and the star in the other pan *Kiffa Janūbī,* 'southern pan' (β Librae).

The body of the scorpion in the sign of Scorpio extends quite wide and long but the knobbly parts are overshadowed by the divisions on the ecliptic. The name *ᶜAqrab* is engraved below the ecliptic band. On the body of the scorpion is the name of the seventeenth lunar mansion *Iklīl.* A star near the base of the tail is named *Qalb al-ᶜAqrab,* 'heart of the scorpion' (α Scorpii); it is also the eighteenth lunar mansion. At the tip of its tail is a star which is given the name of the nineteenth lunar mansion *Shawlah.*

The zodiac sign Sagittarius is conceived as half man and half horse. The upper human half holds a bow and arrow. The arm holding the arrow covers the entire upper body; the bow itself is not clearly visible. In the lower half, the body, legs and tail of the horse are very well delineated. The head is covered by a helmet from which a band flutters eastwards. The name *Qaws* is written in large letters across the body. There are several named stars. The star near the eye is named *ᶜAyn al-Rāmī,* 'archer's eye' ($\nu^{1,2}$

Sagittarii) and the stars on the foreleg *ᶜUrqūb al-Rāmī,* 'archer's tendon' ($\beta^{1,2}$ Sagittarii) and *Rukbat al-Rāmī,* 'archer's knee' (α Sagittarii).



Figure F027.10 – Zodiac sign Sagittarius (courtesy Rampur Raza Library)

In front of the forelegs of Sagittarius is the figure of the Corona Australis; its name *Iklīl Janubī* in bold letters fills the entire figure. To the west of these two figures runs the graduated and numbered solstitial colure, separating the houses of Sagittarius and Capricorn. To the west of this line, a little above the figure of Corona Australis, is a star marked with the name of the twentieth lunar mansion *Naᶜā'im.* Just below the headband is a star which carries the name of the twenty-first star *Baldah.*



Figure F027.11 – Zodiac signs Capricorn and Aquarius (courtesy Rampur Raza Library)

Capricorn is also a composite figure of a goat and a fish. The goat faces east; the fore part consists of the head with horns and ears, forelegs and rump; the rear part of the fish is curled backwards and the tail fins stick out from behind the rump. The figure is placed under the arm of Aquarius. The name of the figure is engraved as *Jadī* on the ecliptic scale. A star is named as *Dhanab al-Jadī,* ‘tail of the goat’ (δ Capricorni). On the horns of the goat is the twenty-second lunar mansion *Dhābiḥ.*

The figure of Aquarius is depicted as a pleasant elderly man in a long tunic, with his hair combed backwards; he pours water out of a pitcher which is drunk by the southern fish below. His right arm is stretched westwards up to the horns of the goat. Three stars near the wrist are labelled with the name of the twenty-third lunar mansion *Bulaᶜ*. On the right shoulder is written *Suᶜūd,* which is the name of the twenty-fourth

lunar mansion. On the wrist of the left arm is the name of the twenty-fifth lunar mansion *Akhbīyah.*

The name of the fish is written below it *Ḥūt Janūbī* (southern fish). Near the mouth, there is *Fam al-Ḥūt al-Janūbī,* 'mouth of the southern fish' (α Piscis Austrini, Formalhaut).

Northern Constellations

Many of the human figures are concentrated in the northern hemisphere. As in the globes signed by Ḍiyā' al-Dīn, here also the human figures are drawn very elegantly, with vivid expressive postures, with a great variety of dress and accoutrement. Some figures are with full faces, some in profile and some in three-quarters profile. All figures are clothed in *jāmas* or tunics, where the lower half is flared with many folds. Interestingly, the hair on the heads of the human figures is curly and not straight as on the globes signed by Ḍiyā' al-Dīn. The eyes are drawn mostly without pupils.

Some of these figures are connected to the Greek legend of Cepheus, king of Ethiopia and his haughty wife Cassiopeia, their daughter Andromeda who was chained to the rocks on the sea-coast as an offering to the sea-monster Cetus, and Perseus who rescued her. Ḍiyā' al-Dīn depicts these four figures very vividly on all his globes. The rendition of these figures on this globe, in particular, indicates that these figures were drawn by Ḍiyā' al-Dīn himself.



Figure F027.12 – Cassiopeia and Cepheus (courtesy Rampur Raza Library)

Cassiopeia is seated demurely on an ornate chair, holding with her left hand the elaborately carved high back post of her chair. The folds on her long dress and her shoes are neatly delineated. The curly hair on her head is parted in the middle and falls on both sides of the face. The short thick legs of the chair are shaped like hour glasses, the sides are carved with a floral pattern, and the two back posts are equipped with elegant trifoliate finials. The name of the constellation *Dhāt al-Kursī* is engraved under the seat of the chair. A large star on her upper arm (it should actually be on her hand) is named *Kaff al-Khaḍīb,* 'dyed hand' (β Cassiopeiae, Kaff).

Cepheus is dressed in knee-high boots with geometrical patterns and a knee-length tunic which is closed in the front, a sash at the waist, one end of which hangs down, a conical cap with a trifoliate top with three feathers. Bending his left knee and raising his right arm, he seems to be remonstrating to his wife against her audacity. The upraised right arms of both Cassiopeia and Cepheus are drawn almost in the same manner. The left hand stretched above the dragon is also delicately drawn. The name of the constellation *Qīqā'ūs* is written across his shoulder. The star on his forward foot is named *Rāᶜī,* 'shepherd' (γ Cephei).



Figure F027.13 – Andromeda (courtesy Rampur Raza Library)

Andromeda is dressed in a calf length dress; a sash at the waist with a loop on one side and the two loose ends hanging on the other are faintly drawn. But no neckline is indicated, nor lines on the arms to indicate the ends of the sleeves; therefore the upper part of her body looks bare. Her face is very well drawn; her hands are outstretched imploringly. The name of the constellation *Mar'ah Musalsalah* (chained woman) is written across her body. The star on her forehead carries the name *Surrat al-Faras,* 'navel of the horse' (δ Pegasi); but the second name, which is actually related to Andromeda, viz. *Rās al Musalsalah,* 'head of the chained [woman]' (α Andromedae) is not engraved. Likewise, the large star just above her waist on the left is called *Rishā[ᶜ],* the name of the twenty-eighth lunar mansion, but the second name, *Batn al-Ḥūt,* 'belly of the fish' (β Andromedae) is omitted. The star on her forward foot is given the name *Rijl al-Musalsalah,* 'foot of the chained [woman]' (γ Andromedae).



Figure F027.14 – Perseus and Auriga (courtesy Rampur Raza Library)

The figure of Andromeda’s rescuer Perseus is well drawn with bold strokes. His bearded head and the bearded head of the Gorgon which he holds in his right hand are rendered alike. His clothing received greater attention than any figure in this group. Like Cepheus, he wears knee-length boots with spurs, but with a different pattern. His knee-length tunic is tied at the waist with a sash; there are lines on the wrists and arms to indicate the sleeves. The posture of his body and the many folds in the skirt of his tunic suggest movement, as if he is rushing to rescue Andromeda. The name of the constellation is engraved to the right of the figure as *Ḥāmil Rās al-Ghūl,* ‘the bearer of the head of the ghoul’, omitting his more common name *Barsā’ūs.* The star on his body is named *Janb,* ‘side’ (α Persei, Algenib); a star on his left wrist is designated as *Miʿṣam al-Thurayyā,* ‘wrist of *al-Thurayyā*’ (hχ Persei). Above his left knee is written the name *Mirfaq al-Thurayyā,* ‘elbow of *al-Thurayyā’* (α Persei, Mirfak). Two stars on his right foot are named *ʿĀtiq al-Thurayyā,* ‘shoulder blade of *al-Thurayyā’* (oζ Persei); the star on his right shin-bone is called *Mankib al-Thurayyā,* ‘the shoulder of *al-Thurayyā’* (ξ Persei). The star in the head of the ghoul is named *Rās al-Ghūl,* ‘head of the ghoul’ (β Persei, Algol).

In the lower right of Perseus is the constellation figure Auriga, with the ecliptic belt below him and the graduated and numbered scale of the solstitial colure to his right. He is seated with his left leg crossed over his right leg, and holding the horse-whip upright in his left hand. His head is covered with a turban, which is tied in a complex manner, with one end fluttering westwards. He wears a long tunic with a double neck line. The two ends of the sash around the waist hang downwards.

The title of the constellation is written on the lower part of his body as *Mumsik al-Aᶜinnah* (He who holds the reins). On his westward shoulder is a large star *ᶜAyyūq* of uncertain meaning (α Aurigae, Capella) which occurs on most astrolabes; it is sixth brightest star.



Figure F027.15 – Ophiuchus and Serpens (courtesy Rampur Raza Library)

The constellation figure Ophiuchus wears a tunic with long sleeves and a sash at the waist with a loop; the lower part of the tunic flared; his face is in three quarters

profile; he is walking on the ecliptic band, almost stepping on Scorpio, and the equator band passes through his chest. Above the waist band is written his name *Ḥawwā.* The star on his forehead is named *Rās al-Ḥawwā,* 'head of the serpent charmer' (α Ophiuchi, Rasalhague). The Serpent which he is holding in both hands, is well drawn with the bare underside, scales on the upper side, the long snout, the forked tongue and an ear. It makes a coil near the head and another coil near the tail end, but the tail end appears to have been erased because a plug which came loose must have been reattached at this area.

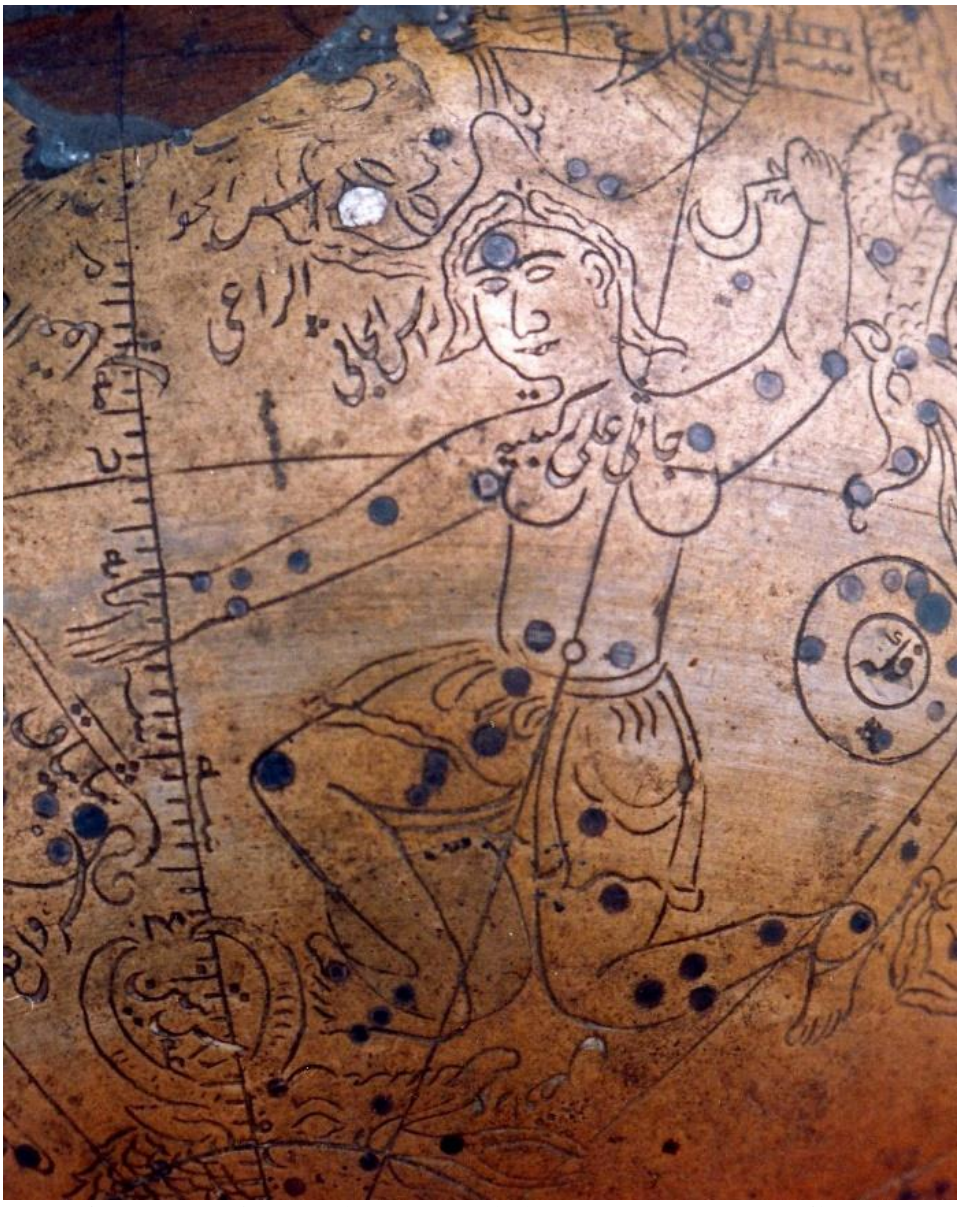


Figure F027.16 – Hercules as a Female (courtesy Rampur Raza Library)

As in the two globes F019 and F020, Hercules is rendered here as a female with ample breasts and a very short skirt; the long tresses of hair, the face in three quarters

profile, the nose and he mouth and one ear are all well drawn. S/he holds a sickle in one hand and the other hand stretched out. The graduated solstitial colure passes through the right palm. The title of the constellation is written in bold letters across the chest as *Jāthī, ᶜAlī Rakbiyah;* the star on his forehead is named *Rās al-Jāthī,* 'head of the kneeling man' (α Herculi).

Southern Constellations



Figure F027.17 – Orion, Lepus, Canis Minor and Canis Major (courtesy Rampur Raza Library)

The constellation figure of Orion straddles the equator and is partly in the northern hemisphere and partly in the southern hemisphere, with the three stars on his belt lying exactly on the equator. His hair is standing upright which he tries to tame with a head-band; but he himself is jumping like a madman, with dilated pupils of the eyes. He has quite an expressive face, showing mad fury. The proximity of Taurus and Orion creates the impression as though the bull is charging at Orion, who is stamping his feet to arrest the bull's attack.

He is said to wrap a lion's skin on his arm; on Islamic globes the lion's skin becomes a long sleeve on his western arm and accommodates nine stars; he holds a club-

like weapon in his left hand. His name *Jabbār* (gaint) is written across his body. The cluster of four star above his head is called *Haqᶜah,* which is the name of the fifth lunar mansion. The large star on his western foot is named *Rijl Jawzā' [al-Yusrā],* 'the left foot of Orion' (β Orionis, Rigel).

Below him is the figure of hare in Lepus; the name *Arnab* is engraved on his body. To the right of Orion is the figure of Canis Minor named *Kalb Ashghar.* The large star on his body is named *Shiᶜrā Shāmī,* 'the northern *Shiᶜrā*' (α Canis Minoris, Procyon). Below him is Canis Major, named *Kalb Akbar;* the last star on his snout is named *Shiᶜrā Yamānī,* 'the southern *Shiᶜrā*' (α Canis Majoris, Sirius).



Figure F027.18 – The sea-monster Cetus (courtesy Rampur Raza Library)

The sea monster Cetus occupies a large area in the southern hemisphere with its head extending northwards beyond the equator. While the Greeks saw the constellation as a huge whale, on Islamic celestial globes it has a composite form: a snarling dog's head with a collar, bird's feet, and a feathered fish tail. The title of the constellation is engraved on the body as *Qayṭus.* A star near the mouth is named *Fam al-Qayṭus,* 'mouth of Cetus' (γ Ceti) and the star on the lower jaw *Kaff al-Jadhmā,* 'the cut-off hand' (α Ceti). The two fins of the fish tail are called respectively *Dhanab Qayṭus Shamālī,*

'norther tail of *Qayṭus'* (ι Ceti) and *Dhanab Qayṭus Janūbī,* 'southern tail of *Qayṭus'* (β Ceti).



Figure F027.19 – Argo Navis (courtesy Rampur Raza Library)

Another large figure in the southern hemisphere is the ship Argo Navis. On all the Lahore globes, the ship is depicted with a huge figurehead at the prow and an ornate pavilion at the stern. On the present globe, the figurehead is shaped like a lion's head, which is looking downwards with its mane neatly combed back. The main mast is quite large and thick. The pavilion at the back is covered by an onion-dome with a trifoliate finial. A larger trifoliate finial is at the top of the main mast. Three narrow and long pennants fly from the figurehead, the main mast and the main deck. In front of the main mast is a vase-like stricture which occurs on all Lahore globes, either singly or in pairs. Half cartouches decorate the main deck and the hull. The name of constellation *Safīnah*

is engraved on the main body. There are two large candle-stick oars on either side of the prow. The large star on the lower oar is labelled as *Suhayl* (α Carinae, Canopus).



Figure F027.20 – Centaurus with Lupus (courtesy Rampur Raza Library)

The most impressive of the southern constellations is Centaurus, another composite figure of man and horse. Both the halves---the rearing horse and the bearded, broad-shouldered human wearing a jaunty hat--- are very powerfully drawn on this globe. The horse is very realistically depicted with the long hairy tail, the hooves and even the genitals. The human torso is clothed in a tunic which is closed in the front and a sash at the waist. The title of the constellation *Qanṭūrus* is engraved below the sash. A star on the hoof of the higher foreleg carries the name *Rijl al-Qanṭūrus,* 'foot of the centaur' (α Centauri). It is the third brightest star and the nearest to us. The centaur holds three vine leaves with his right hand and with the left hand a wild beast named *Sabᶜ* by its rear legs.

STAND

The globe is mounted on a four-legged stand (height 170 mm) with a horizontal ring. The legs are held in position at the bottom by two horizontal cross-pieces at the junction of which a circular box-like object is attached. Upon its lid are two upright pieces. The meridian ring passes through the groove created by these two upright pieces. The meridian ring is attached to the globe with modern screws. The stand and the meridian ring are not calibrated; they are not original.

BIBLIOGRAPHY

Sarma 2003, no. 6, pp. 65-72, Figs. 6.1-6.6.

F028 CELESTIAL GLOBE ATTRIBUTABLE TO ḌIYĀ' AL-DĪN MUḤAMMAD[1155]

Not dated, 17th Century

Diameter 217 mm

Washington DC, National Museum of American History (# 330781)

ESS 38

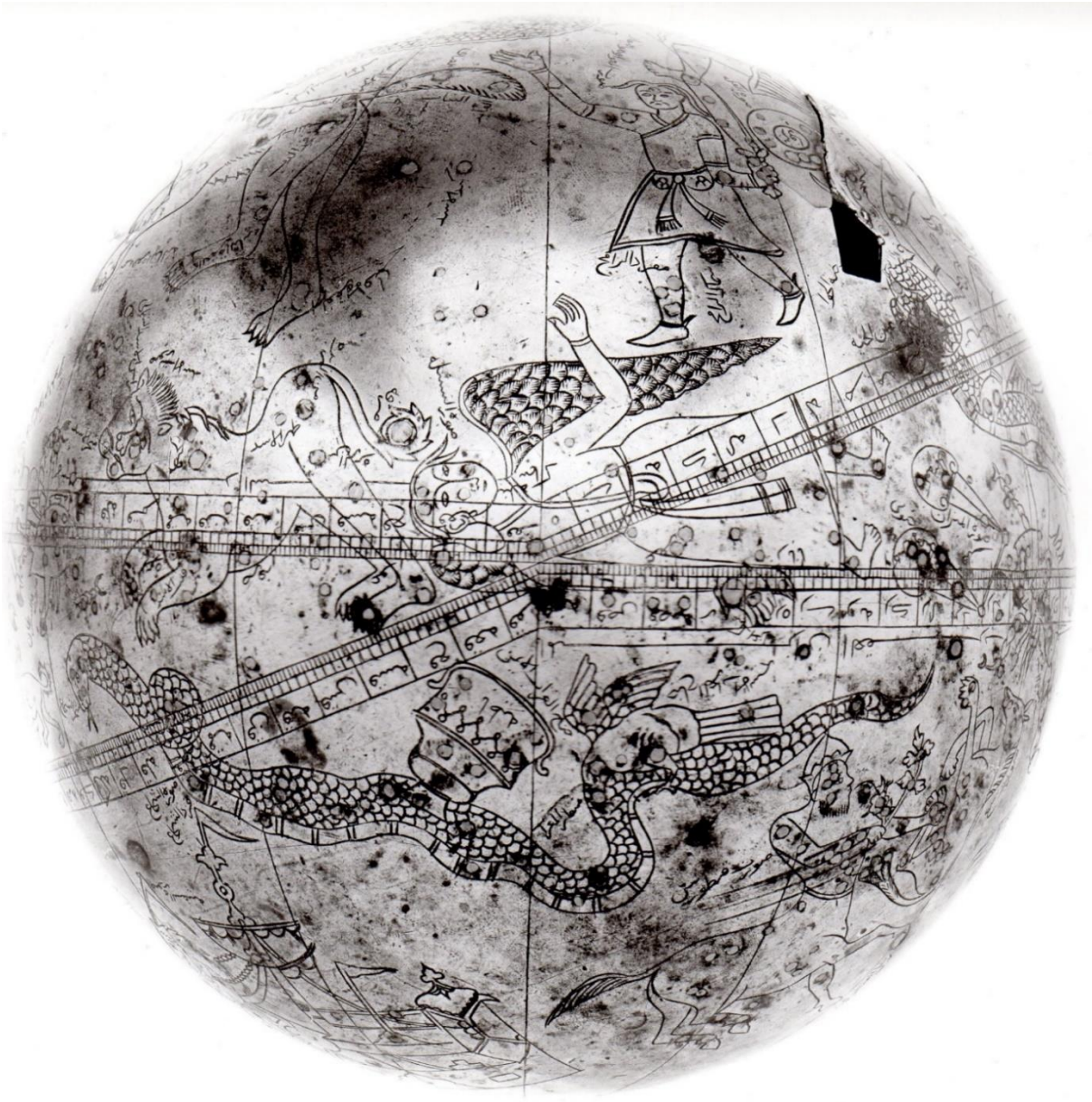


Figure F028.1 – Globe (courtesy National Museum of American History)

[1155] Entry based on Savage-Smith 1985.

This unsigned celestial globe, known as the Smithsonian globe, is the main subject of Emilie Savage-Smith's pioneering work on the *Islamicate Celestial Globes,* where it is admirably discussed from astronomical, art-historical, linguistic and metallurgical viewpoints. Indeed, no other medieval scientific instrument has ever been discussed so thoroughly as this one was. Even so, as I have explained in the introduction to this section, I cannot share Savage-Smith's attribution of this globe to Qā'im Muḥammad. I think the sophisticated style of rendition of the human figures on this globe can only be attributed to Ḍiyā' al-Dīn Muḥammad and not to his father. Therefore, the focus in the present entry will be limited to the human figures depicted on this globe.

With a diameter of 217 mm and a weight of 2976.7 grams, it is the largest celestial globe produced by the Lahore family. It is cast as single hollow sphere by the lost wax method; there are several plugs throughout. Only the globe is extant; the rings and stand are lost. The globe itself was damaged at some point. There is a crack running through the lower part of the figure of Hercules up to the head of Serpens where there is a large hole, as can be seen in the upper right corner on Figure F028.1.

Circles

The ecliptic and equator are divided in ½° and 5°; the ecliptic is numbered from 5 to 360 continuously from the vernal equinox, which is unusual; the equator is numbered twice from 5 to 180, staring from each equinox. The names of zodiac signs are engraved along the ecliptic on one side and the names of the lunar mansions on the other side at a distance roughly of 13°. The ecliptic latitude circles are drawn at intervals of 30°. The circle of the northern equatorial tropic is drawn partially and incorrectly and was not continued. There are no polar circles. Holes are made at the two equatorial poles.

Constellation Figures and Stars

The full set of 48 constellations are engraved along with their names, but without their serial numbers. The positions of 1019 stars are marked by inlaid silver nails and the names of certain prominent stars are engraved.

Although the rendition of the human figures is far superior to that by Qā'im Muḥammad, it is somewhat uniform and lacks the variety which is seen in the globes by Ḍiyā' al-Dīn. The male figures are generally clothed in short tunics and the female

figures in longer gowns. In both cases the sleeves are long. Pairs of parallel lines are drawn on the wrists, above the elbows and on the upper arms as decorations on the sleeves or to indicate folds in the sleeves. Decorative double lines are drawn occasionally also at the hemlines and the collars. A sash is tied around the waist; the two loose ends are knotted in front to form a loop and then are made to dangle. Sometimes trousers are indicated by lines on the ankles. Perseus and Cepheus wear patterned breeches and pointed shoes with spurs.

The hair of the female figures of Andromeda, Cassiopeia and Virgo is depicted in a uniform manner: the hair is parted in the middle, one thick strand is arranged on the left and two strands on the right. However, the facial features of Andromeda and Virgo are well done.

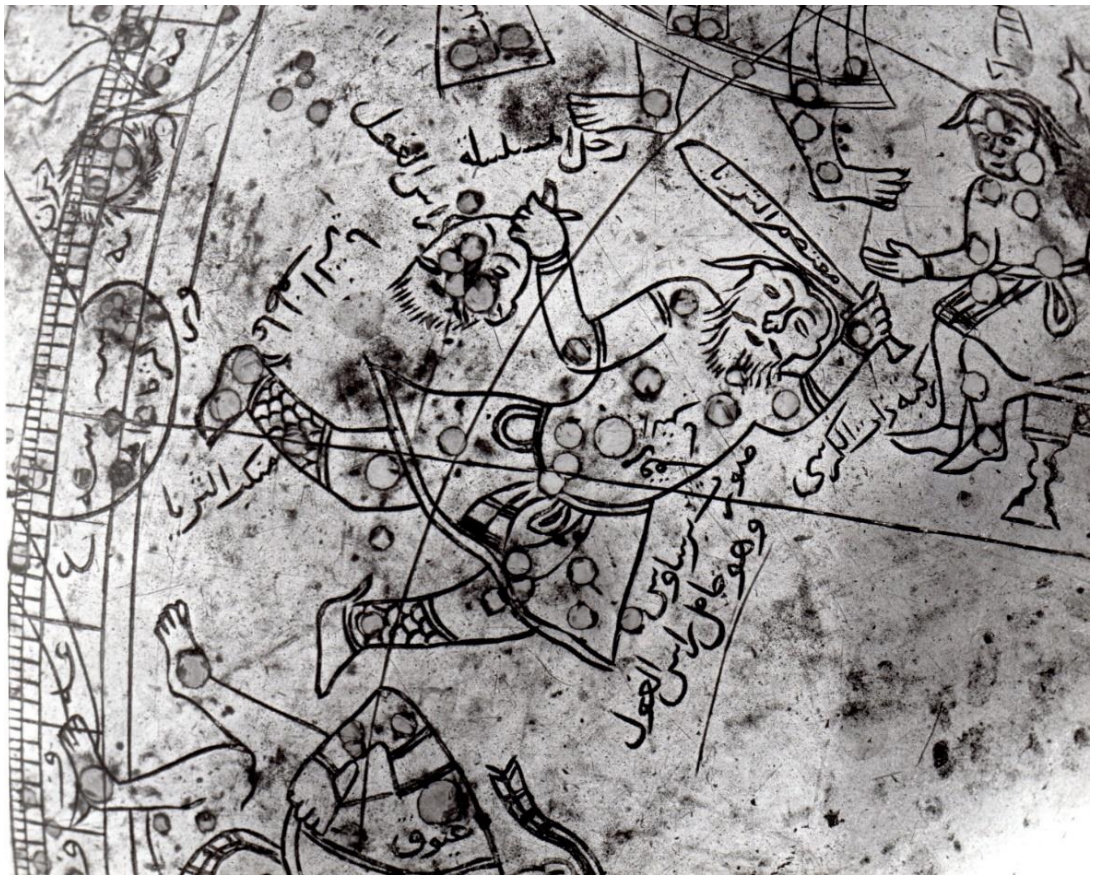


Figure F028.2 – Perseus and Cassiopeia (courtesy National Museum of American History)

Perseus is dressed in a knee-length tunic; the two parallel lines on his wrists indicate that the tunic has full sleeves. There are such pairs of parallel lines just above his elbows and on his upper arms; these may be the folds in the sleeves. On the hemline of the tunic are also double lines. A sash is tied around his waist; the two loose ends fall one parallel to the other. Between these two ends there is a loop. On the right hand side,

under the sash, is a pocket or a pouch. He wears patterned breeches and shoes with spurs. His beard as well as the beard on the demon's head are drawn with a few deft strokes. With his left hand he wields a sword which is raised high above his head. The sword has a simple handle and a wrist-guard.

The title of the figure is engraved to the right of the figure as *ṣūrat Barsā'ūs wa Huwa Ḥāmil Rās al-Ghūl,* 'Perseus, that is, the bearer of Ogre's head'. The star on his stomach is named *Mirfaq al-Thurayyā,* 'elbow of *Thurayyā*' (α Persei, Mirfak). A star on the heel of his right leg has the name *ᶜĀtiq al-Thurayyā,* 'shoulder-blade of *al-Thurayyā*' (ος Persei); the star on the toes of the same foot is given the name *Mankib al-Thurayyā,* 'shoulder of *al-Thurayyā*'' (ξ Persei); on the blade of the sword is engraved *muᶜtaṣam al-Thurayyā.* 'the refuge of the Pleiades'; it is error for *Miᶜṣam al-Thurayyā,* 'wrist of *al-Thurayyā*' (hχ Persei). The star on the head of the ogre is called *Rās al-Ghūl,* 'head of the Ghoul' (β Persei, Algol).

On the right-hand side of the image is the figure of Cassiopeia, seated on a high chair. She is dressed in a knee-length tunic with long-sleeves and trousers reaching up to her ankles. A sash is tied around the waist with a loop; the two loose ends are spread on her lap. She wears pointed shoes. The chair on which she is seated is rather simple, with hour-glass-shaped legs and two back post with trifoliate finials.

The title of the figure is engraved above her head as *Dhāt al-Kursī,* 'one with the chair', omitting the prefix *ṣūrat*. The star on her left elbow is given the name *Kaff al-Khaḍīb,* 'dyed hand' (β Cassiopeiae, Caph) and that on her knee *Rukbat Dhāt al-Kursī,* 'knee of the one with the chair' (δ Cassiopeiae).



Figure F028.3 – Cepheus (courtesy National Museum of American History)

The figure of **Cepheus** is situated behind Cassiopeia’s chair. He is depicted as if he is walking towards her. He is also dressed in a short tunic with long sleeves and round collar. A sash goes around the waist with the two loose ends dangling in the front. Like Perseus, he too wears breeches and shoes, but with different patterns. His face is in full profile with a nicely trimmed pointed beard. The most striking feature of this figure is the conical cap on which three feathers are arranged like the petals of a flower. This cap is almost similar to the cap worn by Cepheus on the previous globe (Figure F027.12). The figure is entitled *ṣūrat Qīqā’ūs,* ‘figure of Cepheus’. There is just one named star between his legs, *Rā’ī,* ‘shepherd’ (γ Cephei).



Figure F028.4 – Aquarius (courtesy National Museum of American History)

Aquarius wears a tunic which is slightly longer than those of the other male figures. But no lines are drawn on the wrists or around the neck to indicate the upper part of the tunic. Consequently, he looks naked in the torso with just a cover below the waist. Very unusually, there is a bead necklace around his neck, like the one worn by Andromeda. There is a sash around the waist; but no loose ends. His face in full profile; his hair is combed back with thick strands falling behind the neck; his beard is marked with a few vertical strokes. He pours water out of a vessel, whose mouth is above and not below where it should be. The figure is entitled *ṣūrat Sākib al-Mā'*, 'figure of the water pourer'.



Figure F028.5 – Centaurus (courtesy National Museum of American History)

The figure of **Centaurus** is one of most successful renditions on this globe with both the halves, the human and equine, well-proportioned. It is similar to the figure of Centaurus in the previous globe (Figure F027.20). The face of the human half is in full profile with the nose, eye and mouth neatly drawn and the beard indicated by a few short vertical lines. The torso is bare; on the head there is triangular cap, with an ornate rim. In the equine half, the tail, legs and hooves of the horse are well drawn. The title of the figure is engraved to his right as *ṣūrat Qanṭūrus.* The name of star on the hoof of the right foreleg is engraved incorrectly as *Rijl al-Qanṭūrī*; it ought to be *Rijl al-Qanṭūrus,* ‘foot of the centaur’ (α Centauri). Centaurus holds with his right hand a vine twig and with the left hand the wild beast entitled *ṣūrat Sabᶜ*.

The globe is slightly damaged in this region; there are three parallel scratches in the middle of the figure of Centaurus.



Figure F028.6 – Andromeda (courtesy National Museum of American History)

Like Centaurus, the female figures of Andromeda and Virgo receive special attention from the globe-maker. **Andromeda** wears an ankle-length dress with long sleeves. The lower half is pleated with a border on the hem. Pairs of parallel lines are drawn on the wrists, above the elbows and on the upper arms, suggesting folds or decoration on the sleeves. A sash tied loosely around the waist; the loose ends make two loops and fall down together. On the ends there are decorative borders. She wears a bead necklace, but no chains on her feet.

The title is engraved above her head as *al-Mar'ah al-Musalsalah,* 'the chained woman'. The star on her forehead is common to the figure of Pegasus and carries the two names pertaining to the two constellations: *Rās al-Mar'ah al-Musalsalah,* 'head of the chained woman' (α Andromedae) and *Surrat al-Faras,* 'navel of the horse' (δ Pegasi). Likewise the star on the right side of her body is common to the constellation of Pisces and is given two names: *Janb al-Musalsalah,* 'side of the chained [woman] (β

Andromedae, Mirach) and *Baṭn al-Ḥūt,* 'belly of the fish' . The star on her right foot is named *Rijl al-Musalsalah,*'foot of the chained one' (γ Andromedae, Almach).



Figure F028.7 – Virgo (courtesy National Museum of American History)

The most successful rendition on this globe is that of **Virgo**, with her delicately drawn figure. Virgo is dressed in an ankle-length gown, with a V-neck and closing in the front. The collar and the hem are decorated with double lines. A thin sash is tied around the waist; the loose end forms a loop and hangs down vertically reaching almost up to the hemline. It has decorated borders. Only a small upper part of the wing on her right is visible; the rest is covered by her right arm and the graduated scale of the equator; but her left wing is shown in full; each feather is painstaking engraved with a number of short strokes. Her hair is drawn as in the case of Andromeda, with one strand

to the left and two to the right. Her face is in three quarters profile; the eye-brows, nose, eyes and mouth neatly drawn. Title *ṣūrat Sunbulah,* 'figure of the ear of wheat'; the star on her right palm is named *Simāk Aʿzal,* 'unarmed *Simāk*' (α Virginis, Spica).

PROVENANCE

Formerly in the collection of Ernst Nagel of San Francesco; acquired by the museum in 1974.

BIBLIOGRAPHY

Savage-Smith 1985, Figs. 49-68 and 78-88.

F029 CELESTIAL GLOBE ATTRIBUTABLE TO ḌIYĀ' AL-DĪN MUḤAMMAD[1156]

Not dated; 17th century

Diameter 115 mm

Chicago, Adler Planetarium (# A-115)

ESS 44



Figure F029.1 – Northern hemisphere (accession no. A-115)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

[1156] Entry based on detailed photos generously provided by Dr Pedro Raposo, the Curator of the Adler Planetarium.

This celestial globe displays close affinity to the globe made Muqīm in 1049/ 1639 (F007) and to the globe made by Ḍiyā' al-Dīn in 1057/1647 (F009).

The globe was cast as a single hollow sphere by the *cire perdue* process; three plugs are visible, in the constellation figures of Perseus (Figure F029.3), Lupus (Figure F029.5) and Eridanus (Figure F029.6). The globe is fully engraved with all the 48 constellation figures and marked with about 1020 star positions by inlaid silver nails, but no holes are drilled at the two equatorial poles for inserting the axis. Consequently, no stand was prepared to mount the globe. Emilie Savage-Smith conjectures that the globe was left unfinished because of a wrong parallel circle to the equator in the south:

> '… it appears that a circle with the south equatorial pole as centre was begun but not finished; the circle would have been between the south tropic circle and the south polar circle had it been completed. For this reason work was probably stopped on the globe and no holes were drilled at either equatorial or ecliptic poles, and the signature of the maker was not put on it.'[1157]

The unfinished parallel circle can be seen faintly below the figure of Sagittarius in Figure F029.5, but this could not have been the reason for abandoning the globe after completing all the engravings, that too quite competently. It is inconceivable that one discards a globe after so much hard labour. On the other hand, a similar parallel circle was drawn completely with a dotted line on F009 and this globe was not abandoned; on the contrary, it was signed by Ḍiyā' al-Dīn with his full genealogy and dated 1057 Hijrī.

On the two equatorial poles and on the ecliptic poles, large dots are drilled, probably to indicate the positions where the holes are to be drilled. There are two large and accurately drilled holes opposite each other about 25° east of the two equinoxes, which do not serve any known purpose. If these were drilled by an inattentive assistant of Ḍiyā' al-Dīn, this could not have been the reason for abandoning the globe either; the holes could easily have been filled and the surface polished and fresh holes made at the correct places. As mentioned in the introduction to this section, there exist several astrolabes and celestial globes which were definitely created by members of the Lahore family, but which do not carry any signature although no faults can be detected on them.

[1157] Savage-Smith in Pingree 2009, p. 232.

Therefore, it is impossible to formulate a universal theory to explain why these were instruments were not signed.

Circles

The equator and ecliptic are divided in 1° and 5°; the equator is numbered continuously from 5 to 360, starting at the vernal equinox; the ecliptic from 5 to 30 separately in each zodiac sign. The names of the signs are engraved along the ecliptic. Ecliptic latitude circles are drawn, but no tropics or polar circles. As mentioned above, there is also a faintly drawn arc of a circle parallel to the equator in the south.

Constellation Figures & Stars

All the 48 constellation figures are drawn and about 1020 star positions are marked with inlaid silver nails. The titles of the constellation figures and names of several prominent stars are engraved. But neither the constellation figures, nor the stars in each constellation are numbered serially.

The twelve figures of the zodiac signs are drawn with dotted outlines as on F007. All the animals figures and human figures are drawn, with minor variations, as in the other globes by Ḍiyā al-Dīn, with two exceptions. The sea-monster Cetus is depicted with lion's forelegs and head, instead of bird's legs and dog's head (Figure F029.2). The ship in Argo Navis does not have a leonine or avian figurehead, instead the front is depicted with a strange curve.

The human figures are uniformly clothed in short tunics; the sleeves and collars are marked sometimes. The trousers are rarely indicated. As in F007, the sashes around the waist are drawn in the same manner nearly in all the figures with two short loose ends in the form of the inverted letter V. Also as in F007, the figures of Auriga and Orion wear elaborate turbans.

Figure F029.1 shows the northern hemisphere. The northern ecliptic pole is at the centre, where all the six ecliptic latitude circles converge. The equatorial pole is to the left. Neither pole is named. The figure of the dragon Draco is spread around the ecliptic pole, making two coils. Around this figure are ranged clockwise the northern constellations of Cygnus, Lyra, Hercules, Bootes, Ursa Major, Ursa Minor, Cepheus and Cassiopeia, with the usual titles and star names. The last two deserve special attention, for these are drawn exactly in the same manner as in F007. Here also

Cassiopeia wears the same kind of turban and is seated on the same bizarre chair in which the four legs rest on feet which look like human feet.



Figure F029.2 – Vernal equinox (accession no. A-115)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Figure F029.2, vernal equinox is at the centre. On the ecliptic circle are the dotted figures of the zodiac signs Aquarius, Pisces, Aries and Taurus, ranged from left to right. The figure of Aquarius is remarkable with youthful looks and bare torso. Not only his full body is drawn with dotted lines, but also the vessel in his left hand and the stream of water flowing from the vessel up to the mouth of the southern fish. Likewise, in the next constellation Pisces, the two fishes, one on the ecliptic and the other under the arm of Andromeda, and the stream that connects them are all in dotted outlines.

In the upper register are the figures of Pegasus and Andromeda with the usual labels and star names. In the southern hemisphere, the figure of Cetus has an unusual iconography. Instead of the bird legs, it is invested with the crouching forelegs of a lion, exactly as in the figure of Leo. The head, situated above the equator, is also like the head of a lion. Interestingly, the star names *Kaff al-Jadhmā* and *Fam al-Qayṭus* engraved to a large part on the lion’s head, look like the lines of the lion’s face.

At 25° to the east of the vernal equinox, is a large hole bored into the sphere; it is inexplicable why it was drilled at the place and when it was drilled.



Figure F029.3 – Summer Solstice (accession no. A-115)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Figure F029.3 exhibits summer solstice at the middle, where the ecliptic and equator maintain the maximum distance. On the ecliptic are the dotted figures of Aries, Taurus, Gemini, Cancer and Leo. In the upper register are the figures of Perseus, Auriga

and Ursa Major. The ghoul's head carried by Perseus is much larger than his own head; amusingly it is sticking its tongue out! Auriga's turban is very elaborate and large. In the lower half are the figures of Orion with a turban, Lepus, Canis Minor, Canis Major and Hydra with the usual titles.



Figure F029.4 – Autumnal equinox (accession no. A-115)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Figure F029.4 shows the autumnal equinox with the figures of the zodiac signs Leo, Virgo and Libra, drawn with dotted outlines on the ecliptic. Virgo is dressed in a full-length gown, its hemline coincides with the ecliptic latitude circle. Her two wings and the two arms are fully drawn. The lines on her ankles indicate the bottom of the trouser legs. As in F009, her two feet point to different directions. A novel feature is the long scarf with a border which hangs down from her left shoulder.

The lower half is dominated by the long figure of Hydra, and the figures of Crater and Corvus above it. At the bottom of the image are the figures of Argo Navis on the left and Centaurus on the right.



Figure F029.5 – Winter solstice (accession no. A-115)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Figure F029.5 depicts winter solstice. Here the equator is above and the ecliptic is below. The figures of the zodiac signs Libra, Scorpio, Sagittarius, Capricorn and Aquarius are drawn in dotted lines upon the ecliptic with their titles and the names of certain prominent stars in them. Like Auriga and Orion, Sagittarius also wears a large turban. Above the ecliptic circle are the figures of Ophiuchus holding the serpent with both his hands on the left and Cygnus on the right. In the lower half, below the figures of Sagittarius and Piscis Austrinus is the faintly drawn arc of a circle parallel to the equator.



Figure F029.6 – Southern hemisphere (accession no. A-115)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Figure F029.6 shows the southern hemisphere with the southern ecliptic pole at the centre; the southern equatorial pole is to its south-east. Ranged clockwise around the centre are constellation figures of Centaurus, Ara, Eridanus, Lepus, Canis Major and Argo Navis. The ship in the last constellation is depicted as a rectangular structure. The figurehead is not shaped as a lion's head or parrot's head as in other Lahore globes; instead there is a rectangular form which takes a curve to the right and tapers to a point. There are three masts with pennants at the tops; at the back there is a domed pavilion. The title of the constellation is engraved twice above the ship; once correctly as *ṣūrat al-Safīnah* (left) and the second time without one consonant as *ṣūrat al-fīnah* (left).[1158]

BIBLIOGRAPHY

Savage-Smith 1985, no. 44, p. 241.

Emilie Savage-Smith in Pingree 2009, pp. 233-233.

[1158] I refrain from suggesting that this could be the reason for not signing the globe.

F030 ⊙ CELESTIAL GLOBE ATTRIBUTABLE TO ḌIYĀ' AL-DĪN MUḤAMMAD

Not dated, 17th Century

Diameter 110 mm

London, National Maritime Museum, Greenwich (# GLB0175)

ESS 42



Figure F030.1 – Globe with stand (© National Maritime Museum, Greenwich)

This unsigned globe carries many features which are characteristic of Ḍiyā' al-Dīn's work and can, therefore, be attributed to him. It is cast as a single sphere, but no plug is visible. It is slightly dented and there is a large hole near the southern equatorial pole.

Circles

The equator and the ecliptic are divided in 1° and 6°. The equator is numbered in 6s from 6 to 180, twice from one equinox to the other. The ecliptic is numbered from 6 to 30 separately in each zodiac sign. The names of the zodiac signs are engraved along the ecliptic circle. Ecliptic latitude circles are drawn at intervals of 30°. The equinoctial and solstitial colures are drawn as dotted circles. There are no equatorial tropics or polar circles.

Constellation Figures and Stars

The full of set of 48 constellation figures is drawn together with their titles. As in F007, F029 and F031, here also the figures of the zodiac signs are drawn with dotted outlines. The tiny scales on the three reptiles Draco, Serpens and Hydra and on the southern fish are painstakingly engraved. The positions of about 1020 stars are marked with inlaid silver points and the names 74 of these stars are engraved.[1159]

[1159] Ackermann 1999, pp. 180-181, records these names and adds that the ecliptic longitudes of several stars have been ascertained and their epoch is estimated as 1622, with an uncertainty of 24 years.



Figure F030.2 – Detail of the globe (© National Maritime Museum, Greenwich)

Figure F030.2 shows, from left to right, the zodiac signs Scorpio, Sagittarius and Capricorn, drawn in dotted outlines on the ecliptic. These are labelled respectively as *ṣūrat ʿAqrab, ṣūrat al-Qaws* and *ṣūrat al-Jadī.* Below these, from left to right, are Lupus (*sūrat al-Sabāʿ*), Ara (*sūrat al-Mijmarah*), Corona Australis (*sūrat Iklīl Janūbī*) and Piscis Austrinus (*sūrat Ḥūt Janūbī*). The dotted great circle intersecting the ecliptic at right angles in front of the figure of Sagittarius is the solstitial colure.

Stand

The stand consists of the horizon ring supported by four elegantly tapering baluster-like legs which rest on a thick circular ring. The horizon ring is graduated in 1° and 6° and numbered from 6 to 90, starting from the east and west points and reaching up to the north and south points. The cardinal points are labelled as *maghrib, janūb, mashriq* and *shamāl.* The outer rim of the horizon ring is embellished with engraving. To the underside of the horizon ring is attached a semicircular arc with an indent in the middle to support the meridian ring, which is missing. The axis is also missing.

PROVENANCE

Purchased through Maggs in May 1936 and gifted to the museum by Sir James Caird.

BIBLIOGRAPHY

Savage-Smith 1985, no. 42, p. 240.

Ackermann 1999, pp. 180-181.

F031 CELESTIAL GLOBE ATTRIBUTABLE TO ḌIYĀ' AL-DĪN MUḤAMMAD

Not dated, 17th century

Diameter 116 mm

Lahore, Lahore Museum (# M.m. 44. G)



Figure F031.1 – Globe with the stand (photo by Mubashir Ul-Haq Abbasi)

The globe is cast as a single hollow sphere with a small circular plug near the northern ecliptic pole and a triangular plug near the southern ecliptic pole. Holes are made at both the equatorial and ecliptic poles.

Zodiac figures are drawn in dotted outlines as in F030, but in certain other respects the constellation figures on this globe differ from those on F030. Even so, this globe follows the general style of Ḍiyā' al-Dīn and can safely be attributed to him.

CIRCLES

The equator and ecliptic are divided in 1° and 5°. The equator is numbered from 5 to 180 from the vernal equinox to the autumnal equinox and again in the same manner

from the autumnal equinox to the vernal equinox. The ecliptic is numbered separately in each sign from 5 to 30. The names of the signs are engraved along the ecliptic in long flowing style. There are ecliptic latitude circles, but no equatorial tropics or polar circles.

CONSTELLATION FIGURES AND STARS

The full set of 48 constellation figures is drawn on the globe and their names are engraved with the prefix *ṣūrat,* but without a serial number. The positions of about 1020 stars are indicated by inlaid silver points; some of these silver points are heavily tarnished and some others fell off. The names of some prominent stars are engraved next to the silver points. The celestial poles are labelled as *quṭb shamālī* and *quṭb janūbī* respectively. As in the globe at Greenwich (F030), here also the figures of the zodiac signs are drawn with dotted lines, but no scales are shown on Hydra and the southern fish as was done on F030. There are variations in other constellation figures as well.

At the top of the Figure F031.2 can be seen the zodiac figures of Gemini, Cancer and Leo, drawn in dotted lines across the ecliptic belt. Below Gemini is the figure of Canis Minor facing east and not west as is the general practice. The title *ṣūrat Kalb Aṣghar* is written below the figure. The large star on the back is named *Shiʿrā Shāmī,* 'northern *Shiʿrā*' (α Canis Majoris, Procyon).

The figure of the serpent Hydra occupies a large part of the right-hand side. Its outline is drawn with two parallel lines; the roundness of the body is indicated by a series of curved lines in the lower part of the body. The coil on the equator belt is shown as a simple circle. Its head with the forked tongue is above the equator. The serpent is looking amiably at Canis Minor which is facing him. The name of the figure is written above the head as *ṣūrat Shujāʿ*. The star above its mouth is designed as *Mankhar Shujāʿ,* 'nose of the serpent' (σ Hydrae). Another star below the equator bears the name *Fard al-Shujāʿ,* 'isolated [star] of the serpent' (α Hydrae).

The constellation figure Crater is rendered as a cup with a base between the equator belt and Hydra, with the label *ṣūrat Bāṭiyah*; a star on its base is given the name *Qā'idat Bāṭiyah,* 'base of the bowl' (α Crateris).



Figure F031.2 – Southern hemisphere with Argo Navis (photo by Mubashir Ul-Haq Abbasi)

The lower half of the Figure F031.2 is dominated by the figure of Argo Navis with the leonine figurehead, two long pennants, and the pavilion at the stern. The pavilion has a conical roof with a vase-like finial and a framed window to the front. Between the main mast and the prow, there is large jar with a lid. The title of the figure *ṣūrat Safīnah* is written above the jar. The large star on the oar is labelled as *Suhayl* (α Carinae, Canopus); a star on the figurehead is given the name *Ṭaraf al-Safīnah,* ‘side of the boat’ (ρ Puppis).



Figure F031.3 – Virgo facing south (photo by Mubashir Ul-Haq Abbasi)

The zodiac figure of Virgo is most unusual in the sense that she is depicted facing south as against the normal practice of her facing north. This is perhaps the only globe which displays this peculiarity. Both her arms and wings are drawn fully and well. Her face is in profile, with the hair combed back. The label *ṣūrat Sunbulah* is engraved above her northern wing.



Figure F031.4 – Zodiac signs drawn in dotted lines (photo by Mubashir Ul-Haq Abbasi)

Figure F031.4 shows the zodiac figures of Scorpio, Sagittarius, Capricorn and Aquarius, which are drawn with dotted lines on the ecliptic. Below them are the figures of Ara (*sūrat Mijmarah*), the southern crown (*ṣūrat Iklīl Janūbī*) and the southern fish (*ṣūrat al-Ḥūt Janūbī*). At the bottom left is the name of the star *Rijl al-Qantūrus,* ‘foot of Centaurus’ (α Centauri), followed by the name of the south celestial pole (*quṭb janūbī*).



Figure F031.5 – Vernal equinox (photo by Mubashir Ul-Haq Abbasi)

Figure F031.5 shows, in the northern hemisphere, the truncated body of Pegasus and the head and arms of Andromeda. On the ecliptic belt are the figures of the last three zodiac signs, Capricorn, Aquarius and Pisces. Not only their figures, but also the stream of water connecting the two fishes in the zodiac sign Pisces and the stream of water flowing down from Aquarius's vessel are rendered in dotted lines. At the left in the lower row is Piscis Austrinus with the label *ṣūrat al-Ḥūt al-Janūbī* ; the star in its mouth is named *Fam al-Ḥūt al-Janūbī,* 'mouth of the southern fish' (α Piscis Austrini, Formalhaut). On the right is the hind part of Cetus. The two stars at the tips of tail are

named respectively as *Dhanab al-Qayṭus Shamālī,* 'northern tail of Cetus' (ι Ceti) and *Dhanab al-Qayṭus Janūbī,* 'southern tail of Cetus' (β Ceti).

The knee-length tunic worn by Aquarius is drawn in greater detail. A sash is tied around the waist, with its two ends hanging down in the form of the inverted letter V. There are no lines to indicate where the sleeves end. Interestingly, the upper part of the tunic is fastened on the left-hand side in the Hindu fashion.[1160] A turban is indicated but not fully drawn. The circular object under his left hand must be the vessel from which he is pouring water.



Figure F031.6 – A part of the northern hemisphere (photo by Mubashir Ul-Haq Abbasi)

Figure F031.6 shows a part of the northern hemisphere with the constellation figures (anticlockwise from left) of Auriga, Perseus, Triangulum, Andromeda, Cassiopeia and Cepheus. But here the faces and garments of the human figures are not well developed. In the case of Perseus, the lower half of the tunic is flared; the two ends

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[1160] The Mughal Emperor Akbar is said to have decreed that Muslims should fasten their tunics on their right- hand side and Hindus on their left-hand side. This custom is reflected in several Mughal paintings; cf. Sarma 2008a, p. 101.

of the sash fall in the form an inverted V, but the upper half of the tunic is not shown; there are no lines to indicate the neckline and the sleeves. His upraised sword looks like a simple stick. Andromeda's gown is drawn in mere outline; her necklace is indicated by a series of dots; but there is no sash around the waist and her feet are poorly represented. Cassiopeia's figure is also not well developed, nor is her throne.



Figure F031.7 – Eridanus on the left; Orion and Lepus in the centre; Canis Major and Argo Navis on the right (photo by Mubashir Ul-Haq Abbasi).

In Figure F031.7 the winding river Eridanus is on the left; it starts from the forward foot of Orion and ends near the feet of Cetus. The name *ṣūrat al-Nahr* is engraved near the second bend. Just below the equator is engraved the name of the star *Tālī Maṣāf al-Nahr,* 'length of the river' (γ Eridani). At the end of the river near the feet of Cetus is the star named *Ākhir al-Nahr,* 'end of the river' (θ Eridani, Acamar).

At its first bend, the river touches the front of the bird Cetus with which it shares four stars. One of these is named *Ṣadr al-Qayṭus,* 'breast of Cetus' (π Ceti).

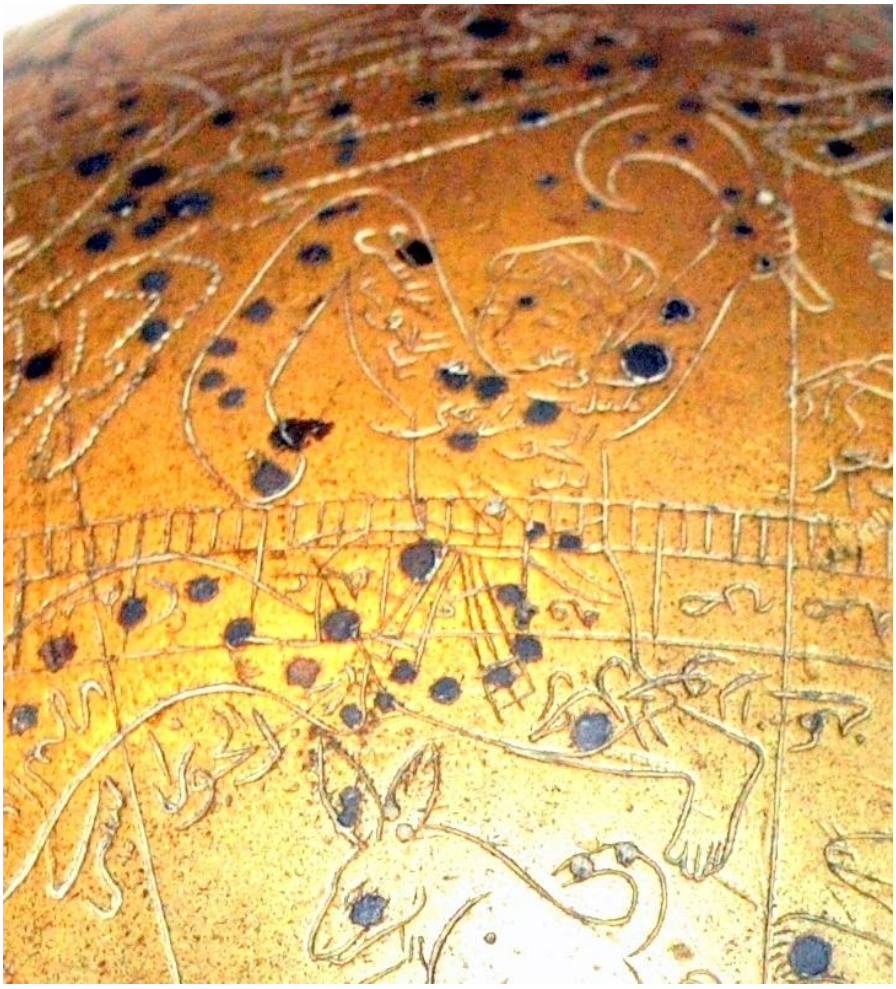


Figure F031.8 – Orion (detail of Figure F031.7)

In the centre of the image is the figure of Orion straddling the belt of equator. He is clothed in a knee-length tunic of which only the flared lower part below the sash is visible. The upper part of the tunic is not defined either by the neckline or by the lines to indicate sleeves; but his right arm is covered by an elongated sleeve which accommodates nine stars. His left arm is raised and carries a sickle. A long dagger is stuck inside the sash wound around the waist; the two ends of the sash hang down in the form of the inverted letter V. His face is in profile; eyes closed or downcast, a pleasant mouth and chin; face looks like that of a pleasant young man; a turban is faintly visible.

The title of the figure appears to be engraved at the base of the upraised arm, but is not clearly decipherable. On his chest is engraved the name of the star *Yad al-Jawzā' Yumnā,* 'the right hand of *al-Jawzā'* (α Orionis, Betelgeuse); one of the stars on the long sleeve of the right arm carries the name *Yad al-Jawzā' Yusrā,* 'the left hand of *al-Jawzā''* (γ Orionis, Belletrix); the star on the left foot is designated as *Rizl al-Jawzā'*

Yumnā, ‘right foot of *al-Jawzā’’* (β Orionis, Rigel); and the star on the right foot *Rizl al-Jawzā’ Yusrā,* ‘left foot of *al-Jawzā’’* (κ Orionis, Saiph).

This confusion between the ‘right’ and ‘left’ arises because, as explained in the introduction to this section, the star-names are related to figures which should be drawn according to the Greek fashion looking into the globe, whereas the figures on this globe (and other Islamic globe) are drawn as the mirror images of the Greek figures, with the ‘right’ and ‘left’ sides reversed.

STAND

The globe is mounted at present on a modern wooden stand. There is a graduated horizon ring which may or may not be original.

F032 CELESTIAL GLOBE ATTRIBUTABLE TO ḌIYĀ' AL-DĪN MUḤAMMAD

Not dated, 17th Century

Diameter 115 mm

PLU; ex-London, Spink & Son

ESS 39



Figure F032.1 – Globe (from Spink & Son 1980)

Savage-Smith 1985, p. 238, attributes this globe to the Lahore workshop with the remark that the star positions relative to equinoxes are same as those of Lahore workshop and that the globe closely resembles the globe made by Ḍiyā' al-Dīn Muḥammad in 1068 ah/ ad 1657-58 (F015) although certain features are reminiscent of

the work of Qā'im Muḥammad. However, the equator and ecliptic scales which can be seen in the only available photo are unlike the characteristic scales in every globe made by the Lahore family. Here these scales consist of a single band divided only in 5°; there are no divisions of 1°. Even so, the iconography of the constellation figures generally resembles the iconography of the globes signed by Ḍiyā' al-Din.

The globe is cast as single hollow sphere with small plugs.

Circles

The equator and ecliptic are shown as single bands divided in 5°. The equator is numbered in four segments from 5 to 90 while the ecliptic is numbered separately in each group from 5 to 30. Ecliptic latitude circles are drawn at intervals of 30°. Names of the zodiac signs are engraved along the ecliptic.

Constellation Figures and Stars

The globe is engraved with a full of 48 constellation figures and positions of about 1020 fixed stars are marked by inlaid silver points.

Stand

The original stand is missing. The globe is now mounted 'on a gimble ring, on a later base.'

Bibliography

Spink & Son, London, *Islamic Art from India,* auction catalogue, 24 April – 10 May 1980. Item 5.

Savage-Smith 1985, no. 39, p. 238.

F033 ⊙ CELESTIAL GLOBE BY ḤĀMID, 1065 AH (AD 1655)

Diameter 99.3 mm

Cambridge, University of Cambridge, Whipple Museum of History of Science (# 1255)

ESS 68; Répertoire 2



Figure F033.1 – Globe (photo by S. R. Sarma)

The globe is cast as a single hollow sphere; one very neat circular plug of diameter 40 mm is on the equator; several small dark plugs are visible elsewhere. Holes are made at the equatorial poles and the hole in the north has a rim. The axis, stand and rings are missing.

CIRCLES

The ecliptic and the equator are divided in 1° and 5°. Groups of 5° are numbered on the equator from 5 to 180 from equinox to equinox; on the ecliptic they are numbered separately in each zodiac sign. The names of the signs are engraved along the ecliptic. Ecliptic latitude circles are drawn, but not the tropics or the artic circles.

CONSTELLATION FIGURES AND STARS

There are no constellation figures. The positions of some 67 stars are indicated by inlaid silver points on which dots enclosed in circles are neatly engraved. Both the ecliptic poles are also similarly marked with inlaid pegs. All the stars and the two equatorial poles are labelled.



Figure F033.2 – Maker's signature (photo by S. R. Sarma)

INSCRIPTION

The inscription is engraved in an arc around the southern ecliptic pole.

ṣan[ᶜa]t qalīl al-ᶜibād ḥāmid ibn muḥammad muqīm
ibn ᶜīsā ibn allādād asṭurlābī lāhūrī humāyūnī
taḥrīr fī al-tārīkh 21
shahar shawwāl
sanah 1060.

'The work of the unworthy servant [of God], Ḥāmid, son of Muḥammad Muqīm, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, accomplished on the date 21 of the month Shawwāl in the year 1060 [= 24 August 1655].'

BIBLIOGRAPHY

Savage-Smith 1985, no. 68, p. 252.

F034 ⊙ CELESTIAL GLOBE BY ḤĀMID IBN MUQĪM 1094 AH (AD 1683)

Diameter 203 mm

Hyderabad, Salar Jung Museum (# 114/xxxv)



Figure F034.1 – Globe with stand (courtesy Salar Jung Museum, Hyderabad)

This globe is the only globe signed by Ḥāmid which carries the constellation figures; but it differs from the globes made by Qā'im Muḥammad and Ḍiyā' al-Dīn both in respect of the iconography of the constellation figures and the reference circle. The globe is cast as a single hollow sphere, with two circular plugs of diameters 65 mm and 50 mm respectively, one near each pole.

Circles

The ecliptic and equator are marked by double bands, which are graduated in 1° and 6° and numbered in 6s. The equator is numbered from 6 to 360 continuously from the vernal equinox onwards and the ecliptic from 6 to 30 in each sign separately. But these scales are not clearly visible throughout the surface of the globe; in many parts, for example, near autumnal equinox, they are rather faint. Both the ecliptic and the equator are divided by six great circles each that cut across them perpendicularly and converge at their respective poles. Tropics are marked by double lines and polar circles by single lines. Interestingly, Ḥāmid also draws diurnal circles of some zodiac signs and engraves their names.

Constellation Figures and Stars

All the 48 constellation figures are represented on the globe together with their names. In the globes made by Qā'im Muḥammad and Ḍiyā' al-Dīn Muḥammad, the names of the constellation figures are preceded by the term *ṣūrat* (صورث). Ḥāmid introduces a variation here: only the names of the 12 zodiac figures are preceded by the term *ṣūrat* (صورة), but without any serial number. The names of the other figures are preceded by the term *kawākib* (كواكب) and followed by the serial number; the northern constellations and the southern constellations are counted separately as in the globes by Ḍiyā' al-Dīn.

The positions of about 1020 stars are marked; here also a distinction is made between the stars constituting the zodiac signs and those forming the northern and the southern constellations. The stars related to the zodiac signs are marked by six-pointed asterisks of apparently three different sizes and those belonging to the northern and southern constellations are indicated by inlaid silver points. The silver has disintegrated and tarnished the surrounding areas. There occur also frequently symbols resembling the Roman letter **C;** their significance is not clear. The stars within each of the northern

and the southern constellations are numbered serially, but not those in the zodiac signs. The serial numbers are written with the common Arabic/Persian numerals.

The human figures are depicted as contemporary men and women of distinction and not as figures of mythology. Thus, Hercules and Ophiuchus, placed head to head, are draped in contemporary Mughal clothing; elaborate turbans on the head, knee-length flared tunics with long sleeves, tight *pāyjāmas* and pointed shoes. The tunic of Hercules is closed in the front. He wears a sash around the waist; its two ends fall down in the form of an inverted V. His face is drawn in three-quarter profile with long thin mustaches. The figure is labelled as *kawākib Jāthī 7.*



Figure F034.2 – Hercules (photo by S. R. Sarma)

Above the head of Hercules can be seen the head of Ophiuchus; his figure is drawn in the opposite direction and labelled as *kawākib Ḥawwā 5*.

The graduated circle in two bands at the top, passing through the neck of Ophiuchus is the celestial equator. Below it there are three parallel circles, named *madār Thawr wa Sunbulah* (circle of Taurus and Virgo), *madār Jawzā' wa Asad* (circle of Gemini and Leo) and *madār Saraṭān* (circle of Cancer) respectively.

Though endowed with two large wings, Virgo also looks more like a contemporary woman, draped in ankle-length dress; the sash at the waist is indicated by just two

parallel lines. Her face is in full profile, the long tresses of hair are combed back. There are bracelets on her wrists. In her southern hand she is holding what looks like a large bunch of grapes; probably it is the ear of wheat denoted by the terms *sunbulah* and 'Spica' which came to designate the whole constellation figure.[1161] Her northern arm is raised, finger pointing to Bootes. Her feet are bare.

The graduated vertical line on the left is the ecliptic and the graduated oblique line passing through the body on the left is the equator.[1162] The dotted lines perpendicular to these two intersect at the point of autumnal equinox, which is to the left of Virgo's neck.

The name of the constellation figure is engraved between the equator and the left edge of Virgo's dress as *sūrat sunbulah.* Below this, also along the equator is written *minṭaqat falak aᶜjam muᶜaddal* (celestial equator). Autumnal equinox is named *minṭaqat iᶜtidāl kharif.*

The positions of several stars are marked with asterisks. Most prominent is the star on her right palm, which is labelled as *Simāk Aᶜjal* (α Virginis). Above the hemline of her gown is the *Ghafr,* which is a collective designation for the star on her right foot and two stars on the hemline (ικλ Virginis).

1161 Savage-Smith 1985, p. 174: 'Al-Bīrūnī (*Astrol.,* sec. 159) describes the Ptolemaic figure as being "in the form of a maid with two wings, in a flowing skirt and in her hand an ear or two of wheat directed to the bottom of her skirt." In all the globes that were examined the constellation is depicted with wings, with her northern arm extending towards Bootes, but without an ear of wheat in her lower hand.'

1162 Here the second band numbered in 6s is not visible at all.



Figure F034.3 – Zodiac figure Virgo (photo by S. R. Sarma)



Figure F034.4 – Centaurus (photo by S. R. Sarma)

Centaurus, half human and half horse, is also shown as a contemporary man of distinction with a turban and a long-sleeved tunic closed in the front. The hooves of the horse are well drawn, but its body is rather fat and it is squatting down on all four legs. In contrast, the horse in the lower part of Sagittarius is well drawn, although the human half consists just of the head. With his left hand, Centaurus holds the wild beast Lupus by its hind legs, and three vine leaves with long stalks with his right hand.

The label engraved above his head reads: *kawākib Qīnṭūrus;* here the serial number 11 is missing. Several star pointers are marked on his body. The one on the hoof of the left hind leg is labelled as *Rijl Qīnṭūrus* (α Centauri); it is third brightest star and the star nearest to us. The label of the wild beast reads *kawākib Sabuᶜ 12*.



Figure F034.5 – Leo depicted as a Tiger (photo by S. R. Sarma)

It is most unusual that Ḥāmid depicts the zodiac sign Leo as a tiger with stripes.[1163] This happened probably due to the fact that in north India, the Persian word *sher* is used for both lion and tiger and this confusion extends sometimes to art as well.[1164] The horizontal line passing through the lower part of the figure is the ecliptic. Below the ecliptic on the right is written *miṇṭaqat falak burūj sunbulah,* 'zodiac sign Virgo', thus marking the house of Virgo on the ecliptic. The oblique line passing through the neck of the tiger is the Tropic of Cancer. Along this line is the title of the figure Leo *sūrat Asad.*

Several stars are marked on the body with asterisks of different sizes and four of these are named but not numbered. In the curl of the tail is the star *Ṣarfah* (β Leonis). Just above the front paw is the star *Qalb Asad,* 'heart of the lion' (α Leonis). Near the head is the star *Rās Asad,* 'head of the lion' (*μ Leonis*) and on the nose is *Mankhar Asad,* 'nose of the lion' (κ Leonis).

1163 There is another globe, not signed, but dated 1255/1839-40, where Leo is rendered as a tiger with stripes; see section G.

1164 The Hindi word *bāgh* (from Sanskrit *vyāghra*) denotes tiger, but it is rarely used.

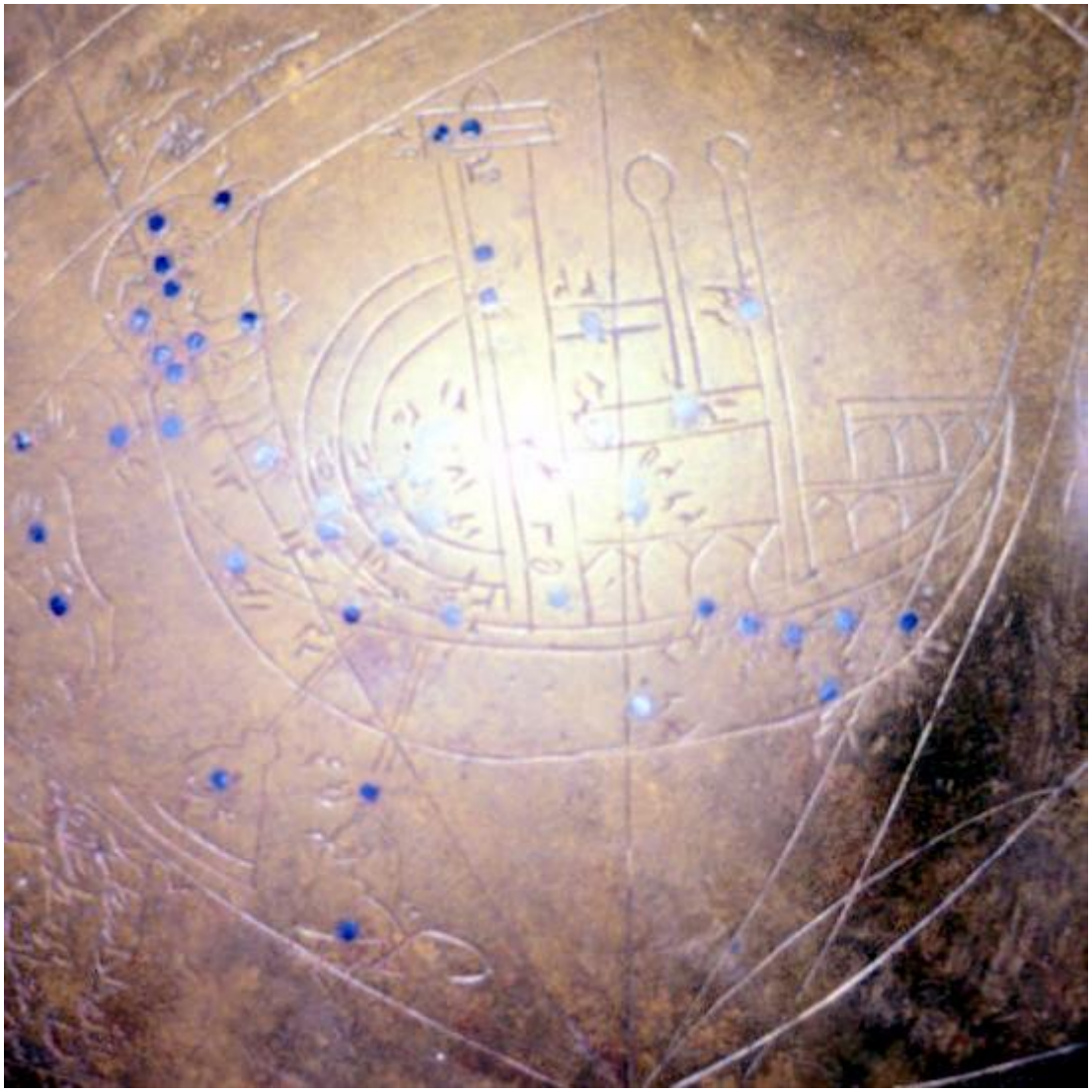


Figure F034.6 – Argo Navis (photo by S. R. Sarma)

Finally, Ḥāmid's rendition of the boat in the constellation Argo Navis, with a curved bottom, extremely huge figurehead in the form of a bird's head turned backwards, railings resembling the battlements on Mughal forts, circular mastheads and no pennants is a total departure from the globes of his family. Several stars are numbered. Canopus carries the title and number: *Suhayl 43.*

STAND

At present the globe is mounted on a stand which clearly does not belong to it. It appears to be an early nineteenth century product of European style and closely resembles the stand in a globe manufactured by Muḥammad Faḍl Allāh in 1808 (G005) in the same collection at the Salar Jung Museum of Hyderabad.

In this stand, the horizontal frame is supported by two semicircular arcs which pass through a heavy cylindrical unit with a cone-shaped bottom. The meridian ring also

passes through this unit. It is supported by three curved legs. Between these legs, a mirror is affixed in which the cone is reflected. The height of the stand up to the horizon ring is 320 mm. The horizon ring and the meridian ring are not calibrated. The latter can, however, be adjusted approximately to the local latitude.



Figure F034.7 – Globe-maker's signature (photo by S. R. Sarma).

Below the signature can be seen a part of the figure of Eridanus; the various stars in this constellation are numbered consecutively from 23 to 33. The last star is named *Ākhir al-Nahr,* 'the end of the river' (θ Eridani).

INSCRIPTION

The maker's inscription is engraved in two lines below the ecliptic pole in the south and above the stretch of the River Eridanus; it reads as follows:

> *ᶜamal aqall al-ᶜibād ḥāmid ibn muḥammad muqīm ibn ᶜīsā ibn allāhdād asṭurlābī lāhūrī humāyūnī taḥrīr fī al-tārīkh 21 shahar shaᶜbān al-muᶜaẓẓim sanah 1094.*
>
> 'The work of the least of the servants [of God] Ḥāmid, son of Muḥammad Muqīm, son of ᶜĪsā, son of Allāhdād of Lahore, the astrolabe maker to [the

Emperor] Humāyūn, accomplished on the date 21 of the holy month of *Shaʿbān* in the year 1094 [Hijrī = 14 August 1683].'

BIBLIOGRAPHY

Sarma 1996a, pp. 26-27, pl. 14.

F035 ⊙ CELESTIAL GLOBE BY ḤĀMID, 1102 AH (AD 1690-91)

Diameter 110 mm

Pune, Raja Dinkar Kelkar Museum (# PMC 106)



Figure F035.1 – Globe with stand (photo by S. R. Sarma)

The globe is rather small with a diameter of about 110 mm. It is cast as a single hollow sphere. There is a circular plug of approximately 37 mm radius around the north celestial pole. The plug got loose at a later point and was welded to the sphere, in the same crude fashion as the axis was welded.

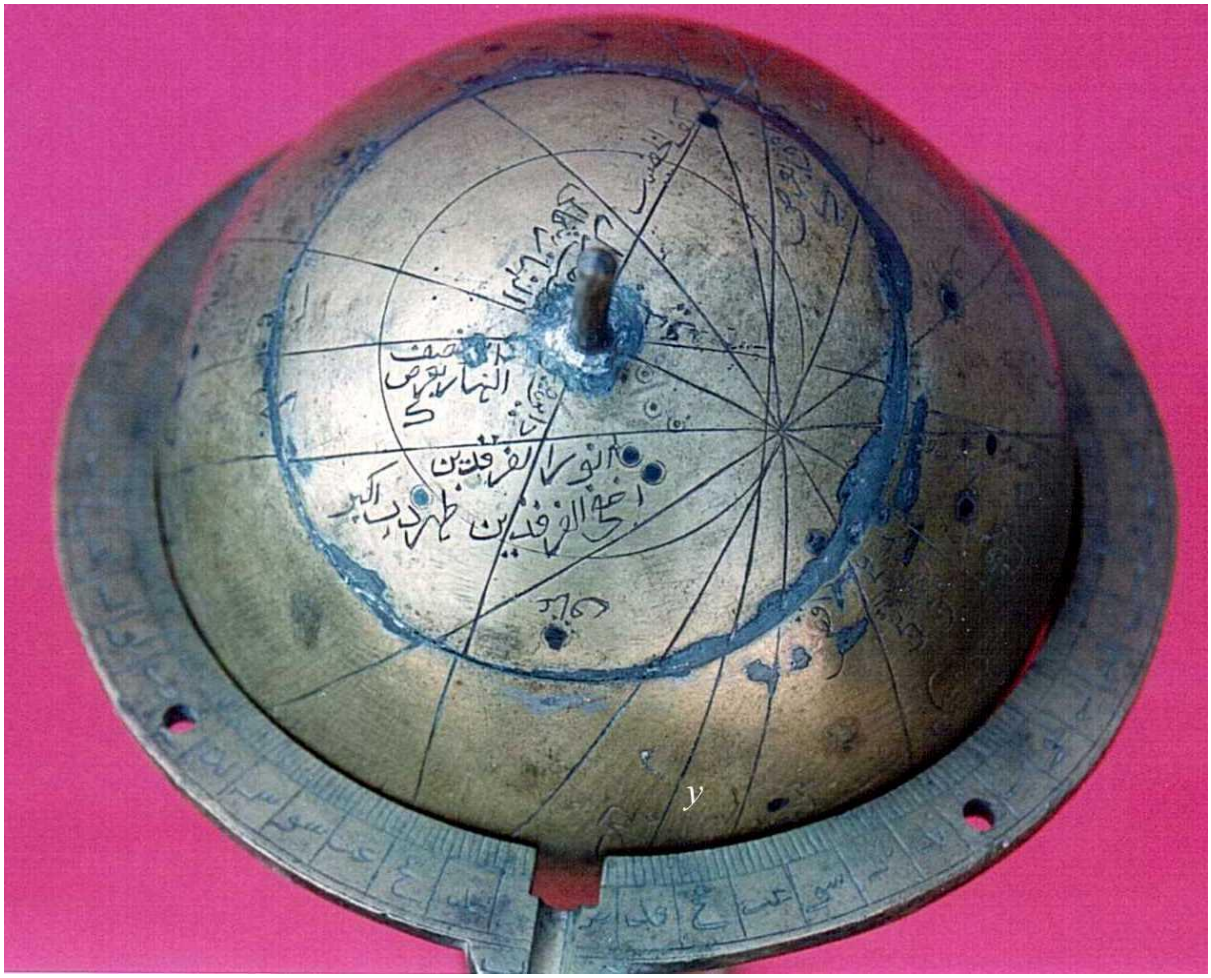


Figure F035.2 – North Celestial Pole (photo by S. R. Sarma)

CIRCLES

The ecliptic and the equator are divided in 1° and 6°. In the ecliptic, the groups of 6° are numbered separately for each sign (6, 12, 18, 2, 30). To the north and south of the ecliptic band are engraved the names of the signs in Arabic script with flourishes that extend to the entire area occupied by the sign. In the equator, the groups of 6° are numbered from 6 to 180, separately from the vernal equinox and from the autumnal equinox.

The tropics of Capricorn and Cancer, and the polar circles are shown by single lines. The northern and the southern celestial poles are labelled respectively as *quṭb muʿaddil al-nahār shamālī* (north pole of the celestial equator) and *quṭb muʿaddil al-*

nahār janūbī (south pole of the celestial equator). Similarly the ecliptic latitude circles and the solstitial and equinoctial colures are represented as single circles. There is one more circle, a little off from the ecliptic, but not quite parallel to it; is this to represent the moon's path? We have marked it as *x* in Figure F035.3; another circle cuts through the ecliptic at 19° of Aries, but does not converge at the ecliptic pole; this is marked as *y*. It is not known what these circles exactly are.

Constellation Figures and Stars

There are no constellation figures on this globe. Star positions are marked in three different styles. The majority of them are marked by inlaid silver points and named. There are 31 stars thus named to the north of ecliptic and 17 to the south. Twenty-eight stars which are close to the ecliptic are marked by dots enclosed by large circles of inlaid silver. These are numbered in Devanagari script from 1 to 28, but not named; however, no. 15 is farther from the ecliptic and is close to the star labelled as *Nayyir Fakkah* (α Coronae Borealis). These 28 stars appear to be the lunar mansions of Sanskrit tradition (*nakṣatras*). It cannot be determined whether these are original or added later by a Hindu astronomer. The second alternative is more probable, because no other influence of Hindu astronomical tradition can be seen in Ḥāmid's work.

Several stars are marked by dots encircled by small circles but not named. Some of these appear to have been punched and not engraved.

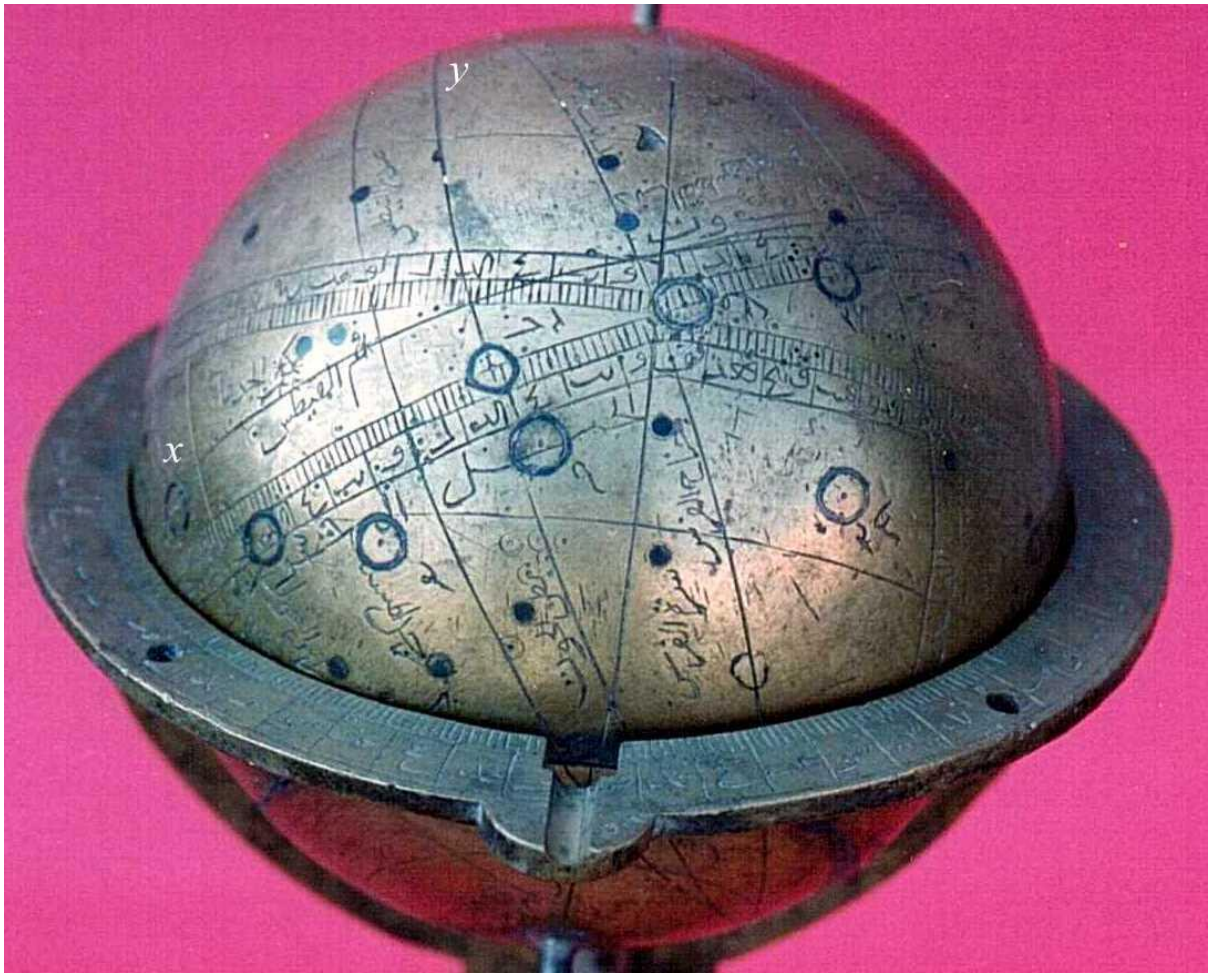


Figure F035.3 – Vernal equinox (photo by S. R. Sarma)

Lunar mansions are marked by dots enclosed in large circles and numbered in Devanagari numerals; from the right to the left, the numbers 25, 26, 27, 28, and 1, 2, 3 can be seen here.

STAND

Of the original stand, only the horizon ring and the semicircular arc attached to its underside to support the meridian ring, are extant. The ensemble is now mounted on a modern non-functional stand of about 210 mm height, the horizontal ring is above ground level by 280 mm.

The horizon ring has an outer diameter of 135 mm and a width of 12 mm. There is a grove cut for the meridian ring, which is missing. On the horizon ring, the inner band is calibrated in 1° and the outer and wider band is marked for 6° and labelled as 6 … 90; 6 … 90; 6 … 90; 6 … 90. Approximately at the middle of each of the four

quadrants, holes are drilled in the width of the ring. Probably the horizontal ring was joined at these holes to the original stand which is missing.



Figure F035.4 – Maker's signature below southern celestial pole (photo by S. R. Sarma)

At the bottom is a section of the ecliptic, with the signs labelled, from right to left, *al-ᶜAqrab* (Scorpio), *al-Qaws* (Sagittarius), *al-Jadī* (Capricorn) and *al-Dalw* (Aquarius). On the ecliptic are marked the lunar mansions with Devanagari numbers, from right to left, 14, 17, 18, 19, 20 and 21. Just above the inscription on the right is a silver point with the label *Rijl Qanṭūrus* (α Centauri). Near the pole is engraved *Quṭb* (?) *Janūbī* (south pole). To its left is a label which is blocked.

Inscription

In the southern hemisphere, above the artic circle, in the two segments occupied by Sagittarius (*al-Qaws*) and Capricorn (*al-Jadī*), is the maker's signature in three lines, which reads:

amal aqall al-ᶜibād ḥāmid ibn muḥammad muqīm ibn ᶜīsā
ibn allāhdād asṭurlābī lāhūrī humāyūnī

taḥrīr fī al-tārīkh shahar 20 rabīᶜ l'awwal sanah 1102.

'The work of the least of the servants [of God], Ḥāmid, son of Muḥammad Muqīm, son of ᶜĪsa, son of Allāhdād of Lahore, the astrolabe maker to [the Emperor] Humāyūn, accomplished on the date 20 of the month *Rabiᶜ al-awwal* of the year 1102 [Hijrī]' (= Thursday, 21 December 1690).

F036 CELESTIAL GLOBE ATTRIBUTABLE TO THE LAHORE WORKSHOP[1165]

Not dated, 17th Century

Diameter 169 mm; weight 1835.7 grams

Chicago, Adler Planetarium (# M-14)

ESS 40



Figure F036.1 – Globe with stand (accession no. M-14)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

[1165] Entry based on Savage-Smith 1985, no. 40, pp. 238-239, and the detailed photos generously provided by the Adler Planetarium.

This celestial globe distinguishes itself by the remarkable clarity of the engraved constellation figures. Animal figures are drawn in the conventional manner as on the other globes, but the serpents Draco, Hydra and Serpens display very fine engraving. Most impressive, however, are the human figures with carefully drawn hair and facial features. Some of these figures show close affinity with those on the Rampur globe which is attributable to Ḍiyā' al-Dīn Muḥammad (F027); on the other hand, there are other figures like Andromeda and Ophiuchus which are definitely unlike any of the figures drawn by Ḍiyā' al-Dīn. Therefore this globe cannot be attributed directly to Ḍiyā' al-Dīn, but to one of his assistants who has his own distinct style but who also occasionally imitates Ḍiyā' al-Dīn's figures. Savage-Smith states that the 'star positions relative to the equinoxes conform to those of the seventeenth century Lahore workshop'. This would support the attribution of this globe to an assistant of the Lahore workshop. But for some unknown reasons this assistant did not draw himself all the figures. As pointed out by Savage-Smith, the three figures of Bootes, Hercules and Corona Borealis are so unattractive that they must have been done by another person.

The stand on which this globe is mounted is also unusual: on the semicircular arc that supports the meridian ring is engraved a geographical gazetteer of 42 localities with their longitudes and latitudes.

The globe is cast as single hollow sphere by the lost wax process; some plugs are visible.

CIRCLES

The equator and ecliptic are divided in 1° and 5°; the former is numbered from 5 to 360 continuously from the vernal equinox onwards, while the latter is numbered from 5 to 30 separately in each zodiac sign. The names of the zodiac signs are engraved along the ecliptic in long flowing script. Six ecliptic latitude circles are traced at right angles to the ecliptic. There are no equatorial tropics or polar circles.

The ecliptic poles in the north and the south are both labelled as *quṭb minṭaqat al-burūj* without specifying the cardinal direction. The north celestial pole is labelled *al-quṭb al-shamālī* and the south celestial pole *quṭb muʿaddil al-nahār janūbī.*

Constellation Figures and Stars

The full set of 48 constellation figures are drawn and the positions of about 1020 stars are marked with inlaid silver nails. At four places (three in Leo and one in Ophiuchus) there are dark circles surrounded by dots, the purpose of which is not known. The names of the constellation figures are engraved with the prefix *kawākib*; in one or two cases without this prefix; a few others like Draco and Leo are not given any title at all. The names of several prominent stars are also engraved.

The figures of animals and birds are drawn in the conventional manner as on other Indo-Persian globes. The figures of the serpents Draco, Hydra and Serpens display very fine engraving, where the bodies are painstakingly filled with innumerable of minute scales; interestingly the shapes of the scales vary in each serpent.

But it is in the depiction of human figures that this globe stands out. The facial features of eyebrows, eyes, ears, noses, mouths and chins are very clearly drawn, but in a distinctly different manner in each figure. In the depiction of these human figures, the engraver pays special attention to the hair on the heads and in the beards which he draws as single strands with parallel lines of different lengths. In the case of Andromeda and Perseus, the hair is parted in the middle and at the top of the line of parting is engraved a diamond-shaped form. In Andromeda, this can be seen as an ornament to decorate the line of parting, but its function is inexplicable in the male person Perseus. In the figure of Cassiopeia, there is no diamond-shaped object, but the hair on both the sides is joined to form a sharp peak. It is not clear what this peak is supposed to indicate. [1166]

The engraver draws in the same manner the hair in the tails of horses in Sagittarius and Centaurus and the hair in the manes of Leo and Lupus and in the leonine figurehead in Ago Navis.

[1166] In the Rampur globe also, the hair on the heads of the twins in the constellation Gemini is drawn in this manner with a sharply pointed peak at the top; see Figure F027.6.



Figure F036.2 – Andromeda, Cassiopeia, Cepheus and Perseus (accession no. M-14)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Andromeda is at the centre of Figure F036.2. Her face is carefully delineated, brows, nose, mouth and chin. The hair is parted in the middle with a large pearl at the top of the line of parting. She is dressed in a long gown that reaches up to her ankles; the gown has long sleeves and a round collar; the lower half is wide. A sash is tied around her waist; the loose end makes a loop and hang down. She wears ear-rings, a tight necklace of beads and a long necklace which is shaped like a crescent with a diamond-shaped locket.

Her arms are stretched out in both directions, not mechanically as on many other globes, but gracefully as if she is performing a dance. The title of the figure is engraved on the right: *kawākib Mar'ah al-Musalsalah,* 'constellation of the chained woman'. The

star on the right of her waist is named *Janb al-Musalsalah,* 'side of the chained [woman]' (β Andromedae) and the star on her right foot *Rijl al-Musalsalah,* 'foot of the chained [woman]' (γ Andromedae).

To the lower right of Andromeda, **Cassiopeia** is seated on an ornate chair, holding with her left hand the back post of the chair; her right hand is pointed towards Andromeda. Her hair is shorter than that of Andromeda, but also parted in the middle. Her facial features are clearly and her breasts are shown as perfect circles. She wears a long dress with long sleeves and a round neck which covers her feet. A sash is tied around her waist; its two loose ends are spread out on her lap. She wears a necklace with a locket. The chair on which she is seated has hour-glass like feet. The seat and the back have ornate designs; the two back posts are topped by trifoliate finials.

The figure is entitled *Kawākib Dhāt al-Kursī,* 'constellation of the one with the chair'. The star on her left hand is given the name *Kaff al-Khaḍīb,* 'dyed hand' (β Cassiopeiae) and that on her knee *Rukbat Dhāt al-Kursī,* 'knee of the one with the chair' (δ Cassiopeiae).

Cepheus is kneeling behind Cassiopeia's chair. His face is shown in full profile with a longish beard; he wears a conic hat with a trifoliate peak. His knee-length tunic has long sleeves and a V-shaped collar; the upper flap closes under his right arm. There is a sash around his waist with loose ends dangling. He wears long breeches decorated with a pattern. He is kneeling behind Cassiopeia's chair with his right hand raised as if he is pleading with her. The title of the figure reads *Kawākib Qīqā'ūs,* 'constellation Cepheus'. The star on his left foot carries the name *al-Rā'ī,* 'the shepherd' (γ Cephei).

Andromeda's rescuer **Perseus** is depicted below the figure of Andromeda. His long hair is parted in the middle, with a large pearl at the top of the line of parting, as in the case of Andromeda. His face is well drawn with drooping moustaches and long beard. Like Cepheus, he is also dressed in a knee-length tunic with a sash and long breeches, with a pattern which is different from that on the boots of Cepheus. With his right hand he holds the severed head of the Ghoul and with the left a sword high above his head; the sword has a long slender blade and an ornate handle. The Ghoul's head is also bearded.

The title of the figure reads *kawākib [Bar]shā'ūs,* 'constellation of Perseus'. The star on the Ghoul's head is named *Rās al-Ghūl,* 'head of the Ghoul' (β Persei); the star

on his right ankle has the name *Mirfaq al-Thurayyā,* 'elbow of *al-Thurayyā*' (α Persei) and the pair of stars on his right foot *ᶜĀtiq al-Thurayyā,* 'shoulder-blade of *al-Thurayyā*' (ος Persei). The two stars on his left wrist are called *Miᶜṣam al-Thurayyā,* 'wrist of *al-Thurayyā*' (hχ Persei). Although these four figures have the conventional postures as in other globes, here the postures of their arms are particularly graceful; it looks as though these four persons are performing a dance. The arrangement of these four figures resembles the same on the Rampur globe, but the facial features are entirely different; Cassiopeia's chair also resembles the same there (cf. Figure F027.12 and Figure F027.14).

The flying horse **Pegasus** is a part of the legend connecting these figures, being the mount on which Perseus rode. Its truncated fore-part, with an ornate wing, is depicted above the figure of Andromeda. There are several named stars in this constellation, entitled *kawākib Faras Aᶜzam,* 'constellation of the larger horse': *Matn al-Faras,* 'side of the horse' (α Pegasi); *Mankib al-Faras,* 'shoulder of the horse' (β Pegasi); *Janāḥ al-Faras,* 'wing of the horse' (γ Pegasi); *Surrat al-Faras,* 'navel of the horse' (δ Pegasi); *Fam al-Faras,* 'mouth of the horse' (ε Pegasi); *Saᶜd al-Humān,* '*saᶜd* (omen) of hero' (ςξ Pegasi); *Saᶜd Bāri,* 'an excellent *saᶜd*' (λμ Pegasi) and *Saᶜd Maṭar,* 'rainy *saᶜd*' (ηο Pegasi).

Next to Pegasus is the figure of **Equuleus**, with the title *al-Qiṭᶜat al-Faras,* 'the part of a horse'. It is followed by the figure of **Delphinus** with the face of a cat or rather that of a humanized lion; it is entitled *Kawākib Dulfīn,* 'constellation of the dolphin'. The star on the tail is named *Dhanab al-Dulfīn,* 'tail of the dophin' (ε Delphini).

To the lower left of Andromeda is the figure of **Triangulum,** drawn as a simple isosceles triangle, with the label *kawākib al-Muthallath,* 'constellation of the triangle', with a star named *Rās al-Muthallath,* 'head of the triangle' (α Trianguli).

On the left-hand side of the image is the graduated scale of the ecliptic which is intersected by the graduated scale of the celestial equator at the point of the vernal equinox. Along the ecliptic are drawn the various figures of the zodiac signs. At the very top is Aquarius which will be described later. Just above the vernal equinox is the figure of **Pisces;** it is represented by two fishes which are joined by a channel of water. One of these is drawn upon the ecliptic above, i.e., to the west of, the vernal equinox with the

label *kawākib al-Ḥūt,* ‘constellation of Pisces’. The second fish is drawn under the right arm of Andromeda. Both the fishes are drawn with multitudes of small scales.

Below the vernal equinox, i.e., to the east of it, at a distance of 26°, is the figure of the first zodiac sign **Aries.** It is depicted as a ram, its front part towards the west, but the head turned backwards to the east; its two curved horns are carefully drawn with all the serrations. The figure is labelled *kawākib Ḥamal,* ‘constellation of Aries’. Three stars are named in this constellation: *al-Nāṭiḥ,* ‘that which butts or gores’ (α Arietis); it is the first lunar mansion; *Muqaddam al-Sharatayn,* ‘anterior of the two signals’ (β Arietis) and *Mu’akkhir al-Sharatayn,* ‘the posterior of the two signals ‘ (γ Arietis). The star on the tail of the ram is called *min al-Buṭayn,* ‘belonging to [the second lunar mansion] *Buṭayn*’; it is probably identical with δ Arietis.

Beyond the graduated scale of the equator is the figure of the sea-monster **Cetus**, its neck crosses the equator and its head is just below the figure of Aries. It is depicted as a large bird with a fish tail and a dog’s head. It is decorated with a chain around the neck. The label reads *kawākib Qayṭus,* ‘constellation of Cetus’. The star on its head is named *Kaff al-Jadhmā’*, ‘cut-off hand [of *al-Thurayyā*]’ (α Ceti); another star in its mouth has the name *Fam al-Qayṭus,* ‘mouth of Cetus’ (γ Ceti); the star on the southern tip of the tail is usually called *Dhanab al-Qayṭus Janūbī,* ‘the southern tail of Cetus’; here it is called by an older Bedouin name *Ḍafdaᶜ al-Ṯānī,* ‘the second frog’; the star on the northern tip of the tail is called here *Dhanab Qayṭus* [*Shamālī*], ‘the [northern] tail of Cetus’ (ι Ceti).



Figure F036.3 – Auriga, Orion and others (accession no. M-14)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

In Figure F036.3, the ecliptic runs through the middle of the image from left to right and the equator is situated below it. The figure of **Auriga** occupies the corner created by the intersection of the ecliptic and the solstitial colure which runs perpendicular to the ecliptic. Auriga is seated with his knees held close to the stomach as if he is riding a horse cart, holding a stylized horse whip in his left hand. His face is in three quarters profile; he is clean-shaven and wears a turban, its the loose end floating in the air behind his head (cf. Figure F027.14). He is draped in a long-sleeved tunic; its upper flap closes under his left arm. The hemline of the tunic is not clearly defined. There is a sash around the waist; the loose ends dangle in a curve. The figure is entitled *kawākib Mumsik al-Aʿinnah,* ‘constellation of he who holds the reins’. The star on his

right shoulder is named *ᶜAyyūq* (α Aurigae) and that on the left shoulder *Mankib Dhī al-ᶜInān,* 'shoulder having the reins' (β Aurigae).

Below him is the figure of **Orion**, straddling the equator, his left arm and the right leg raised high, as if he is flying in the air, with the skirt of his tunic pushed backwards because of the forward motion. He too wears a turban. He is dressed in a tunic; only the flared lower half is clearly defined. His left arm is raised high holding a club-like weapon. His right arm should have been fully covered by the extended sleeve; but the hand is drawn at the end of the sleeve. The label reads *kawākib Jabbār,* 'constellation of the giant'. There are several named stars. The star on his left shoulder is named *Mankib al-Jabbār,* 'shoulder of the giant' (α Orionis). The three stars on his right elbow are given the name *Haqᶜah* ($\lambda\varphi^1\varphi^2$ Orionis), which is the name of the fifth lunar mansion. The three stars marked on his girdle are alled *Minṭaqat al-Jawzā',* 'belt of Orion' (δεζ Orionis). The star on the dagger attached to his girdle is named *Sayf al-Jabbār,* 'sword of the giant' ($c\theta^{2.2}\iota$ Orionis). The stars on each of his feet are named respectively *Rijl al-Yusrā,* 'left foot' (β Orionis) and *Rijl al-Yumnā,* 'right foot' (κ Orionis).

Beneath the feet of Orion is the figure of **Lepus,** labelled *kawākib Arnab,* 'constellation of hare'. Above the figure is engraved *ᶜArs al-Jawzā'*; it should read *ᶜArsh al-Jawzā'*; it means the seat of *al-Jawzā'* and refers to four stars in this constellation (αβγδ Leporis), which are supposed to form the posterior or the throne of the huge female figure of *al-Jawzā'* which occupies this region according Bedouin tradition.

To the west of Lepus is the undulating figure of the river **Eridanus,** labelled *kawākib al-Nahr,* constellation of the river'. To the east is **Canis Major**, entitled *kawākib Kalb Akbar,* 'constellation of the larger dog'; it looks more like a horse with a long mane. The star on its head is named *Shiᶜrā Yamānī,* 'southern *Shiᶜrā*' (α Canis Majoris, Sirius).

Its smaller counterpart, **Canis Minor**, is situated beneath the feet of the twins in Gemini, with the label *kawākib Kalb Aṣghar,* 'constellation of the smaller dog'; the star in it is named *Shiᶜrā Shāmī,* 'northern *Shiᶜrā*' (α Canis Minoris, Procyon).

On either side of Orion are the zodiac figures of Taurus and Gemini drawn on the ecliptic. **Taurus** is labelled *kawākib al-Thawr,* 'constellation of Taurus' and the star near its eye is named *ᶜAyn al-Thawr,* 'eye of the bull' (α Tauri). **Gemini** carries the label *kawākib al- al-Taw'am,* 'constellation of Gemini'. The two stars on the heads of the

twins are named respectively *Rās al-Taw'am al-Muqaddam,* 'head of the foremost twin' (α Geminorum) and *Rās al-Taw'am al-Mu'akkhar*, 'head of the rear twin' (β Geminorum). The two stars on the two feet of the eastern twin are called *min al-Hanᶜah,* 'belonging to [the sixth lunar mansion] *al-Hanᶜah*', (γξ Geminorum).



Figure F036.4 – Autumnal Equinox (accession no. M-14)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

In Figure F036.4, the main constellation figures are Ursa Major, Leo and Hydra, depicted one below the other. The figure of the bear in **Ursa Major** is drawn rather indifferently, but with all the usual named stars. The title, written below the figure, reads *kawākib Dubb Akbar,* 'constellation of the great bear'. The star on the back of the bear is named *Ẓahr al-Dubb,* 'back of the [great] bear' (α Ursae Majoris); the star a little below has the name *Mirāq al-Dubb,* 'loin of the [great] bear' (β Ursae Majoris); the star

to the east of this one is named *Fakhdh Dubb,* 'thigh of the [great] bear' (γ Ursae Majoris) and the star at the base of the tail is given the name *Maghr[iz] al-Dubb,* 'base of the bier' (δ Ursae Majoris). These four stars form a rectangle that was seen as a bier to carry the dead and was given the collective name *al-Naᶜsh,* 'the bier'; this name is also engraved just below the outline of the back.

The three stars on the tail are named respectively as *al-Jawn,* 'the black horse' (ε Ursae Majoris); *al-ᶜAnāq,* 'the goat' (ζ Ursae Majoris); and *al-Qā'id,* 'the leader' (η Ursae Majoris, Alkaid).

Leaving aside the right foreleg, in the paws of the remaining three legs, there are each a pair of star pointers. These were regarded as the marks of the cloven hooves of a deer chased by the dogs of Bootis and were named accordingly. Starting from the east, these names are *al-Qafzah al-Ulā,* 'the first leap' (νξ Ursae Majoris); *al-Qafzah al-Thānī,* 'the second leap' (λμ Ursae Majoris); and *al-Qafzah al-Thālith,* 'the third leap' (ικ Ursae Majoris).

Compared to the bear, the figure of the lion in the constellation **Leo** is depicted more accurately and more majestically with a large head, long mane, and raised tail. The engraver did not add a title to this figure, but named several stars in it: *Qalb al-Asad,* 'heart of the lion' (α Leonis); *Ṣarfah,* 'change of the weather' (β Leonis); *Ẓahr al-Asad,* 'back of the lion' (δ Leonis); *Rās al-Asad al-Shamālī,* 'the northern head of the lion' (μ Leonis); *Rās al-Asad al-Janūbī,* 'the southern head of the lion' (ε Leonis); *Mankhar al-Asad,* 'nose of the lion' (κ Leonis); *Mankib al-Asad,* 'shoulder of the lion' (?).

To the west of Leo is the figure of **Cancer,** bearing the title *kawākib Saraṭān,* 'constellation of Cancer'. The star on the southern claw is named *Ḥammāl Janūbī,* 'southern claw' (α Cancri). The star next to the southern claw carries the name *Min al-Ṭarfah,* 'belonging to the [ninth lunar mansion] *Ṭarfah*' (κ Cancri).

Beneath these two is the powerful figure of **Hydra,** with the title *kawākib al-Shujāᶜ,* 'constellation of the serpent'. The named stars are *Fard al-Shujāᶜ*, 'isolated one of the serpent' (α Hydrae); *Mankhar al-Shujāᶜ*, 'nose of the serpent' (σ Hydrae). Resting on the body of Hydra is **Crater,** depicted as ornate vessel with two handles, entitled *kawākib Bāṭiyah,* 'constellation of the jar'.



Figure F036.5 – Virgo (accession no. M-14)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Virgo wears an ankle-length gown with a sash around the waist; the two ends of the sash fall down straight along the gown. There is a ‘Congress’ cap on her head and a simple necklace with a locket around the neck. Her breasts and nipples are clearly

marked and two wings are drawn elaborately. Her right arm is suspended along the ecliptic. In her left hand she holds an ear of wheat which justifies her traditional name *Sunbulah,* but here the figure is given a more appropriate, but not so frequently used, title: *kawākib ᶜAdhrā,* 'constellation of the virgin'. The star on the right palm is named *Simāk Aᶜzal,* 'unarmed Simāk' (α Virginis).



Figure F036.6 – Hercules, Ophiuchus and others (accession no. M-14)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Figure F036.6 shows Hercules and Ophiuchus, with the large serpent Draco above and another large serpent Serpens below. **Ophiuchus** is depicted as a pleasant young man, clean-shaven, hair parted in the middle, wearing a knee-length tunic, with a wavy hemline. The collar of the tunic is *Y*-shaped, indicated by double lines; the upper flap of the tunic is closed under his right arm. Three parallel lines are drawn on the wrists, and

two parallel lines each on the upper arms and lower arms, indicating probably the folds in the sleeves. There is a sash around the waist from which several loose ends hang down.

Ophiuchus straddles the equator, grasping **Serpens** in both his hands and his bare feet touching the ecliptic. The engraver took great pains in depicting the serpent with its soft under side and the upper side filled with multitudes of tiny scales. The coils are very skillfully drawn. The fierce head of the serpent reaches up to the constellation Corona Borealis, stretching out its tongue which looks like the twig of a plant.

The label treats these two constellations as one and reads *kawākib al-Hawwā wa al-Ḥayyah,* 'constellation of the serpent-bearer and the serpent'. Following the Bedouin tradition, the star on the forehead of Ophiuchus is named *Rās al-Rāᶜī*, 'head of the shepherd' (α Ophiuchi) and that on his shoulder *Kalb al-Rāᶜī,* 'the shepherd's dog' (β Ophiuchi). The star on the neck of the serpent is given the name *ᶜUnuq al-Ḥayyah,* 'neck of the serpent' (α Serpentis).

In contrast to the figure of Ophiuchus, the figures of Hercules and Bootes are very poorly drawn. The physiognomy of the figures, the facial features, the shapes of the hands and feet are extremely crude as in the clumsy human figures on the globes made by Qā'im Muḥammad. As mentioned earlier, these figures could not have been drawn by the same person who drew the other constellation figures. The lower part of **Hercules** is covered by a garment of strange shape. The title reads *kawākib al-Jāthī,* 'constellation of the kneeling man' and the star on his forehead bears the name *Rās al-Jāthī,* 'head of the kneeling man' (α Herculis).

The figure of Bootes is slightly better than that of Hercules. The knee-length tunic, the sash at the waist with the two loose ends are passably drawn, but the face has hardly any resemblance to a human face. The figure is entitled *kawākib al-ᶜAwwā'*, 'constellation of the howler'. The star between his legs is named *Simāk Rāmiḥ,* 'the armed *Simāk*' (α Bootis); there is a star pointer on his right leg; but its name is engraved near his waist: *Mufrad al-Rāmiḥ,* 'solitary [star] of the lancer' (η Bootis).

Between Bootes and Hercules is the carelessly executed figure of **Corona Borealis,** entitled *Kawākib al-Fakkah,* 'constellation of *al-Fakkah*'; the star in it is named *Nayyir al-Fakkah,* 'luminous one of *al-Fakkah*', (α Coronae Borealis).

At the top of the figure is the constellation **Draco;** the soft under side and the tiny scales on the upper side are very skilfully drawn, but there is no title. The star on the head is named *Rās al-Tinnīn,* 'head of the dragon' (γ Draconis) and that on its tongue *al-Rāfiḍ,* 'the wandering camel' (μ Draconis).

Clockwise from Draco are arrayed the constellation figures of Cygnus, Lyra, Sagitta, Delphinus and Aquila. **Cygnus** is drawn with outstretched wings and the legs folded forward, with the title *kawākib al-Tā'ir,* 'constellation al-Tair'. There are two named stars. The star on the beak is named *Minqār al-Dajājah,* 'beak of the fowl' (β Cygni) and star on the bend of its northern leg *Rukbat al-Dajājah,* 'knee of the fowl' ($\omega^{1,2}$ Cygni).

Lyra is depicted like a crown with a trifoliate peak, with the title *kawākib al-Shylyāq,* 'constellation of tortoise'; the star in it is named *Nasr Waqi*^{c}*,* 'falling eagle'.

Sagitta looks like a vase with a long neck and trifoliate top; it is entitled *kawākib Sahm,* 'constellation of arrow'. Delphinus has already been described above.

Aquila is depicted as a bird that is taking off for a flight, with the title *kawākib* ^{c}*Uqāb,* 'constellation of the eagle'. The star in it carries the name *Nasr Ṭā'ir,* 'flying eagle' (α Aquilae).



Figure F036.7 – Sagittarius, Capricorn and Aquarius (accession no. M-14)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Figure F036.7 shows the zodiac figures of Sagittarius, Capricorn and Aquarius drawn upon the ecliptic. **Sagittarius** is half human and half equine. The human upper half is about to shoot an arrow with a bow. He wears a conical hat with trifoliate peak. The figure is entitled *kawākib Qaws,* 'constellation of the bow'. The named stars are *ᶜAyn al-Rāmī,* 'eye of the archer' ($\nu^{1,2}$ Sagittarii); *Fakhd al-Rāmī,* 'thigh of the archer' (?); *Urqūb al-Rāmī,* 'tendon of the archer' ($\beta^{1,2}$ Sagittarii); *Juzz al-Nashshābah,* 'the arrowhead of the wooden arrow' (γ Sagittarii).

Capricorn is half goat and half fish, with the title *kawākib al-Jadī,* 'constellation of the goat'; the star on its tail is named *Dhanab al-Jadī,* 'tail of the goat' (δ Capricorni); the two stars on its horns are called *Saᶜd Dhābiḥ,* 'omen of sacrifice' ($\alpha^{1,2}\beta$ Capricorni); it is the name of the twenty-second lunar mansion.

The figure of **Aquarius** has a close similarity with the same on the Rampur globe (cf. Figure F027.11), including the shape of the vessel from which he pours out water. His face is shown in full profile, the long hair is combed back; the long beard, eyes, noseand mouth are well drawn. He is clothed in a long tunic that reaches up to his ankles, the long sleeves and the wavy hemline are marked by double lines. The upper flap is tied under his left arm. There is a simple sash around the waist. He wears long boots with rather high heels. His right arm is stretched westwards above the body of Capricorn.

The figure is entitled *kawākib Dalw,* 'constellation of the bucket'. The two stars on the eastern shoulder are named *Saᶜd Malik,* 'royal omen' (αo Aquarii). The two stars on the western shoulder are labelled separately as *Saᶜd al-Suᶜūd,* 'omen of good fortune', which is the name of the twenty-fourth lunar mansion. The stars on the hand extended over Capricorn are called *Saᶜd Bulaᶜ* ($\mu\varepsilon$ Aquarii).

The water poured out by Aquarius forms an undulating stream which crosses the ecliptic and reaches up to the mouth of **Piscis Austrinus**, which is depicted exactly as in Figure F027.11 with tiny scales all over the body and two long feelers or tentacles hanging from the mouth. Its title is *kawākib Ḥūt Janūbī,* 'constellation of the southern fish'; the star at its mouth bears the name *Fam al-Ḥūt,* 'mouth of the fish' (α Piscis Austrini).

Between the forelegs of Sagittarius is the figure of **Corona Australis**, entitled *Iklīl Janūbī,* ‘southern crown’ without the prefix *kawākib.* The figure of **Ara**, next to it is labelled *kawākib Mijmarah,* ‘constellation of incense burner’.



Figure F036.8 – Centaurus and Lupus (accession no. M-14)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

The constellation figure of **Centaurus** is well drawn, with particular attention to the hair in his beard, the hair in the tail of the horse and in the mane of Lupus, the wild beast. Centaurus wears a round hat with an ornate rim (this hat occurs on many globes); his tunic is tied under his left arm. The vine twig in his hand is depicted as a twig with three large flowers and two small leaves. The label of the figure reads *kawākib Qanṭūrus,* ‘constellation of Centaurus’; the star of the horse’s hoof is named *Rijl al-Qanṭūrus,* ‘foot of Centaurus’ (α Centauri). The wild beast clutched by its hind legs is depicted as a lion with long mane and title *kawākib Sabᶜ,* ‘constellation of wild beast’.



Figure F036.9 – Argo Navis (accession no. M-14)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

The constellation figure of **Argo Navis** also imitates the same on the Rampur globe (cf. Figure F027.19). But here the leonine figure-head in the front and the open pavilion with an ornate dome resting on four pillars at the back are drawn much better than on the Rampur globe. The title reads *kawākib Safīnah,* 'constellation of the ship'; the star on one of the oars is named *Suhayl* (α Carinae). Below the ship can be seen the ecliptic pole which is named *quṭb minṭaqat al-burūj.*

STAND

The globe is mounted on a stand which consists of a horizon ring supported by four legs which rest on four spherical feet (see Figure F036.1). Above these spherical feet is affixed a thin eight-lobed ring with cross-bars. These cross-bars hold a central pillar which has the shape of a large cone in the lower half; it supports a semicircular

arc which is attached to the underside of the horizon ring at its east and west points. There is a notch at the centre of this arc through which the meridian ring passes.

The horizon ring is divided in 1° and 5° and numbered from 5 to 90, separately in each quadrant, starting from the north and south points and reaching up to the east and west points. The four cardinal points and the four intermediate points are named on the horizon ring. The outer side of the horizon ring is marked with irregular divisions and with the labels *asmā' al-buldān* (names of the cities), *ṭūl* (longitude) and *ʿarḍ* (latitude). These words are engraved also on the underside of the horizon ring; but the purpose of these engravings is not clear.



Figure F036.10 – Graduations on the meridian ring(accession no. M-14)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

A quarter of the meridian ring is divided on one side in 1° and 5° and numbered from 5 to 90, starting at a point named North point (see Figure F036.10). From this point onwards, holes are bored in the meridian ring at 10°, 18°, 27°, 32°, 40°, 54°, 66;30°, 72° and 90°. Holes are also made at points diametrically opposite to these (see Figure F036.1 for the holes and the numbers engraved below them), so that the axis can be adjusted to different terrestrial latitudes.

The most unusual part of this stand is the semi-circular arc attached to the underside of the horizon ring. It is broader at its two ends near the horizon ring and gradually tapers towards the centre. On both sides of this arc are engraved geographical

gazetteers with the names of localities in the upper row and their longitudes and latitudes in the lower row. On the front side are engraved the names and coordinates of 19 localities and on the back the names and coordinates 23 localities, preceded on each side with the arguments *asmā' al-bilād, ṭūl* and *ᶜarḍ.* Savage-Smith copied the 42 place names but not their coordinates; we shall copy the coordinates also as far as they are available in the photos. Strangely there is not a single Indian city among these 42 places, not even Lahore; all of them are from the Greater Iran. It is also not clear what purpose this gazetteer would serve, except as a memorandum.

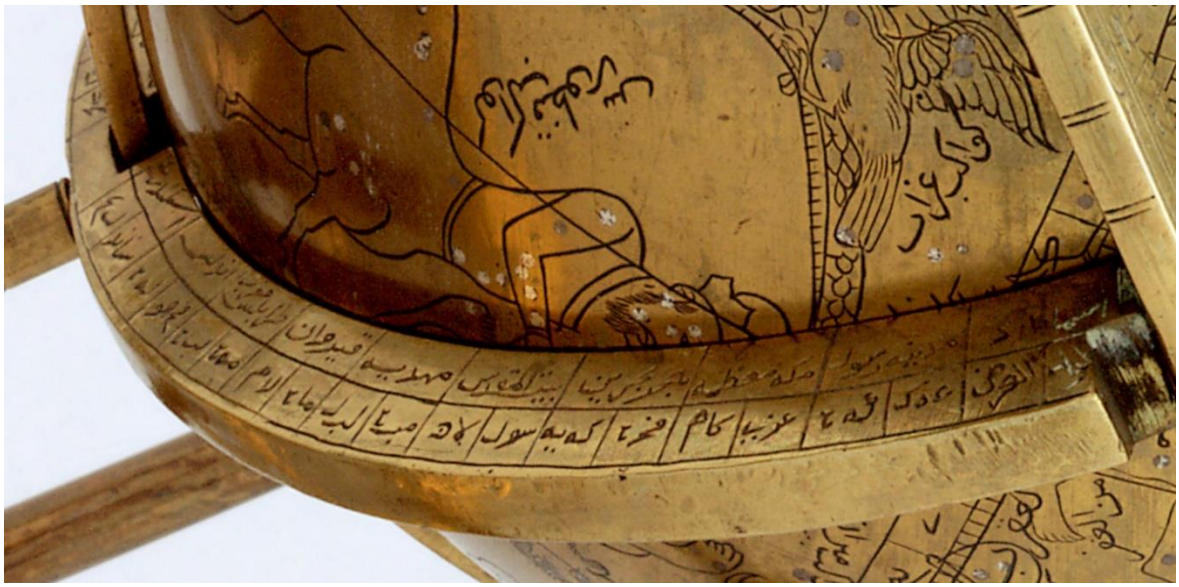


Figure F036.11 – Geographical gazetteer on the front of the semicircular arc (accession no. M-14) Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Table F036-1 Geographical Gazetteer on the front of the semicircular arc

	Asmā' bilād	***al-ṭūl***	***al-ᶜarḍ***
1	Madīnah Rasūl	75;22	25;0
2	Makkah Muᶜaẓẓamah	77;10	21;40
3	Hajar Baḥrayn	83;0	25;15
4	Bayt al-Muqaddas	66;30	31;50
5	Mahdiyyah	92;0	32;30
6	Qayrwān	41;0	31;40
7	Ṭarābulus Maghrib	45;0	32;0

	Asmā' bilād	*al-ṭūl*	*al-ᶜarḍ*
8	Andalus	48;46 (!)	35;0
9	Iskandariya	61;55	30;18
10	Miṣr		
11	Adan		
12	Yaman		
13	Zabīd		
14	Asqalān		
15	Tiberias		
16	Ṭarabulus Shām		
17	Dimashq		
18	Baalbak		
19	Ḥalab		



Figure F036.12 – Geographical gazetteer on the back of the semicircular arc (accession no. M-14)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Table F036-2 Geographical Gazetteer on the back of the semicircular arc

	Asmā' bilād	*al-ṭūl*	*al-ᶜarḍ*
1	Mawṣil		
2	al-Zubayr		
3	Marand		
4	Nakhjawān		
5	Marāgha		
6	Tabrīz		
7	Kūfah		
8	Baghdād	80;4	33;25
9	Baṣra	84;0	30;0
10	ᶜAbādān	84;30	30;0
11	Fīrūzābād	---	---
12	Shīrāz	88;0	29;37
13	Yazd	89;0	32;30
14	Shahrazūr	---	---
15	Nahāwand	---	34;20
16	Abhar	84;30	36;45
17	Hamadān	83;0	35;10
18	ᶜAnarkh?	84;45	34;30
19	Qazwīn	85;0	36;10
20	Iṣfahān	86;40	32;25
21	Qum	85;40	35;45
22	Rayy	86;	35;0
23	Astarābād	89;30	37;--

PROVENANCE

Formerly of the collection of A. W. M. Mensing, Amsterdam; acquired and gifted by Max Adler in 1930.

BIBLIOGRAPHY

Savage-Smith 1985, no. 40, pp. 238-239.

Savage-Smith 1990, p. 25, pl. 2.

Emilie Savage-Smith in Pingree 2009, pp. 228-229

G. INDO-PERSIAN CELESTIAL GLOBES PRODUCED BY OTHERS

INTRODUCTION

MUḤAMMAD ṢĀLIḤ OF THATTA

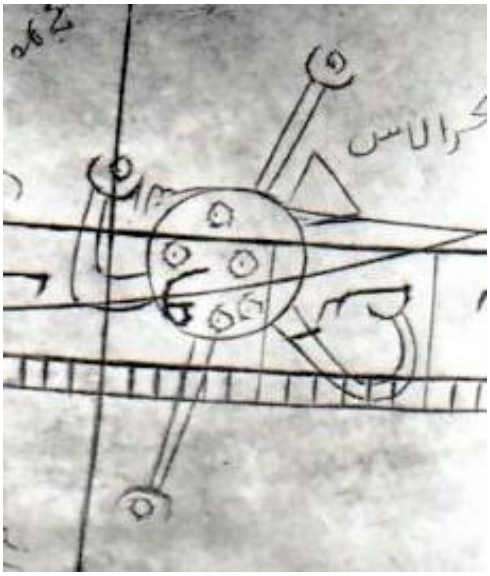
It has already been mentioned that ᶜAlī Kashmīrī who produced the earlier celestial globe in India (G001) was not a member of the Lahore family. Another instrument-maker from outside the Lahore family was Muḥammad Ṣāliḥ of Thatta who made both astrolabes and celestial globes. Four astrolabes signed by him and three others which are attributable to him on stylistic grounds have been described in section B (B008 – B014). But the celestial globes bearing his signature are rather problematic. In early 1992, S. M. Razaullah Ansari and I went for a seminar to Bangalore, where A. M. Kulkarni told us about two celestial globes he had seen in a shop there. The shop readily agreed to our examining and photographing the globes. One of the globes carried the signature of Muḥammad Ṣāliḥ and the year 1072 Hijrī; the other was unsigned and undated, but displayed similar iconography of the constellation figures. We assumed that both these globes were made by Ṣāliḥ. With the enthusiasm of novices, we published our 'discoveries' in 1993.[1167]

Emilie Savage-Smith has, however, shown convincingly that these two globes (and about two dozen more) were not made in the seventeenth century, but are the products of the nineteenth century. The iconography of certain human figures on these globes deviates from the standard iconography of Islamic and, in particular, of the Indo-Persian globes:

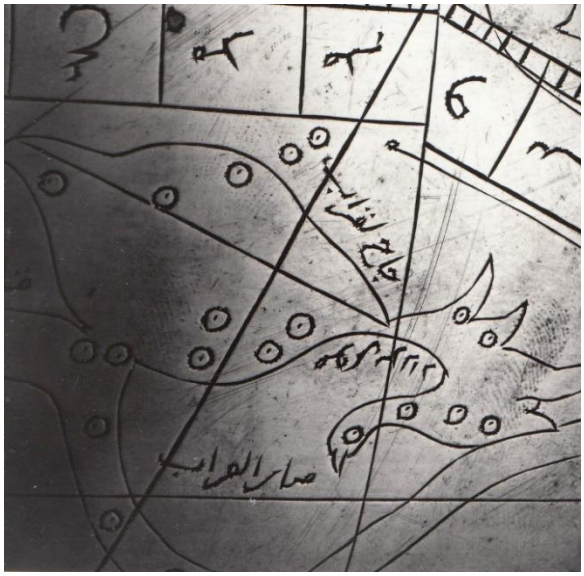
> Cassiopeia is depicted as a woman sitting with her legs drawn up and her ankles crossed, holding an umbrella or parasol over her head. Argo is a square-hulled ship whose masthead is not in the form of an animal head, as is customary, but a man's face, bearded, and turbaned. Also in the southern hemisphere, on the back of the long serpent Hydra, there is a curious version of the constellation Crater, which in this case, resembles a large, wide rimmed cooking-pot covered with a rounded lid.

[1167] Sarma, Ansari & Kulkarni 1993.

Most distinctive of all, however, is the constellation of Auriga, which is given a radically new interpretation. He is shown as a bearded man sitting almost cross-legged, with two small animals held in his arms.[1168]



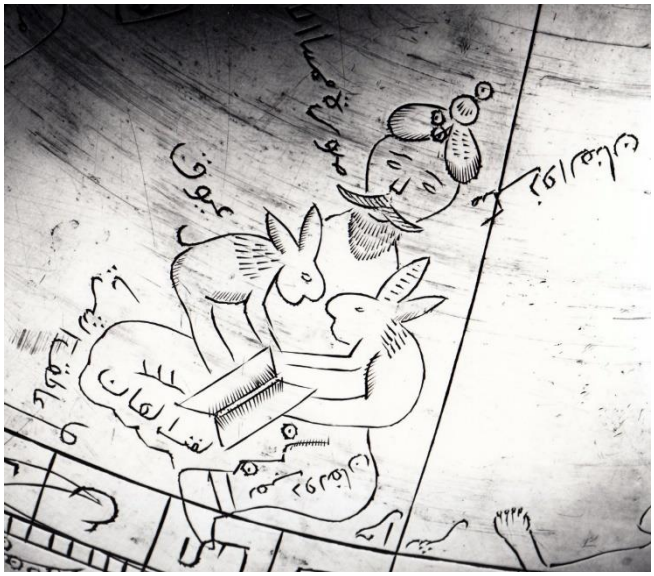
Cancer



Crater



Cassiopeia



Auriga

Figure G1 – Examples of deviant iconography

While the iconography of Cassiopeia and others can be due to misinterpretation or overinterpretation of the mythology of these figures, the new iconography of Auriga displays the impact of early modern European celestial cartography and of the new iconographic models. In Savage-Smith's view, the main source for this deviant

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1168 Maddison & Savage-Smith 1997, part 2, pp. 406-408 (Appendix 1: Modern Indian Globes)

iconography is an illustrated manuscript of a Sanskrit work with the title *Sarva-siddhānta-tattva-cūḍāmaṇi* (the crest-jewel of the essence of all astronomical systems/treatises) which is now preserved in the British Library (Or.5259) and which was composed between 1833 and 1839 and contains the horoscope of Maharaja Ranjit Singh's grandson prince Nau Nihal Singh.

In a forthcoming paper, I propose to show that the horoscope is actually of Lehna Singh Majithia[1169] who was one of the generals of Ranjit Singh and that it was written and illustrated a little before 1854. For the present, it suffices to say that this illustrated manuscript is not the earliest source and not the only source of dissemination in India of the new iconographic models of Europe. A celestial globe made by Muḥammad Faḍl Allāh in 1223/1808 (G005) shows already several features that are found in European globes and in European planispheric maps: here Bootes is depicted with two dogs; some of the human figures are drawn in European style, i.e., with their backs towards the viewer.

Coming back to Muḥammad Ṣāliḥ, I accept Savage-Smith's view that the two globes we saw in Bangalore in 1992 were not made by Ṣāliḥ. These are not included in this catalogue.[1170] What are included are just two globes dated 1070 and 1074 respectively which appear to be genuine products of Ṣāliḥ.

Another globe maker of the seventeenth century is Luṭf Allāh ibn ᶜAbd al-Qādir al-Muḥibb al-Asṭurlābī who made a seamless globe which does not contain constellation figures but has 62 stars marked through inlaid silver points (G004).

Lālah Bulhomal Lāhorī

The tradition of producing celestial globes by the *cire perdue* process continued up to the middle of the nineteenth century and culminated in the globes manufactured

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1169 He was an expert gun maker; he also produced some astronomical instruments; a horizontal sundial (N003) and a column dial (P023) will be described in the relevant sections.

1170 Likewise, several other globes which carry this deviant iconography will be not be included in this catalogue. The unsigned globe we saw at Bangalore came up for auction at Christie's, South Kensington, London on 25 June 1997 (catalogue, lot 19). It is not known what happened to the other globe which carries the signature.

by Lālah Bahlūmal Lāhūrī around the middle of the century at Lahore.[1171] Of all the instruments, the production of celestial globes as single hollow spheres by the lost wax process is a very demanding process, requiring a very high order of technical skill. Bulhomal mastered this technique very well and cast several globes of large dimensions. Mention has already been made of the diverse kinds of instruments produced by Bulhomal, in the introduction to the astrolabes by him in sections B and C. In fact, of all the varieties of instruments he had produced, the celestial globes constitute the largest group with ten extant specimens. Seven of these carry legends in Persian, two in Sanskrit and one in English. Only three of these carry Bulhomal's signature, but the others can easily be attributed to him because they all carry same characteristic features. With this impressive list of large celestial globes cast in the lost wax process, Bulhomal is a major producer of the celestial globes in India, next only to Ḍiyā' al-Dīn Muḥmmad of the Lahore family.

While the Indo-Persian and Sanskrit astrolabes he produced are rather small in size and with less than 10 star pointers on the rete, the celestial globes he cast by the *cire perdue* process are very large— much larger than those of the Allāhdad family whose diameters range between 65 and 188 mm —with diameters measuring between 177.8 and 370 mm; one is said to measure almost half a meter (495.3 mm).

These large-sized globes are mounted on highly distinctive three-legged stands which are once again a characteristic feature of Bulhomal's work. Besides a graduated horizon ring and a graduated meridian ring, these stands consist of a zenith ring and three *S*-shaped legs. The zenith ring comes in two semi-circular parts. The upper part is attached to the upper surface of the horizon ring at right angles to the meridian ring; it then corresponds to the prime vertical and includes the zenith point. The second part is attached below the horizon ring also at right angles to the meridian ring; it contains the nadir point. The two halves of the zenith ring and the three legs are attached to the horizon ring and made fast with winged bolts.

At the apex of the upper half of the zenith ring, there is an ornate crown-like projection; there is also a projection in the lower half at the nadir point which is not so

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[1171] Savage-Smith 1985, pp. 52-56, 235-236, 244, 275-276; Maddison & Savage-Smith 1997, pp. 242-245; Sarma 2015b, pp. 271-278.

flamboyant, but nevertheless decorative. Just as the *kursī* with three perforations is the hallmark of Bulhomal's astrolabes, the crown-like projection in the zenith ring is the hallmark of Bulhomal's celestial globes; and also the three legs which are curved like *S* and rest on round bases with multiple tiers. Often the zenith rings and the legs are embellished with engravings or mouldings.

In the zenith ring, there are rectangular slits at the zenith and nadir points to accommodate the meridian ring. In one half of the meridian ring, i.e., from one pole to the other, the thickness is reduced on the inner side to create a recess, so that a sleeve carrying a graduated arc can slide along the meridian ring. However, this sleeve with the arc survives just in G011; the sleeve without the arc can be seen in G008 and G010.

Now coming to the globes themselves, they are engraved with the usual great circles of equator, ecliptic and the six latitude circles which run perpendicular to the ecliptic. Aside from these, there are six other great circles about which Savage-Smith remarks as follows:

> Balhumal also added to all his globes six meridian circles at right-angles to the equator, along with the ecliptic latitude-measuring circles. Meridian circles are unusual in Islamic globe design, but Bahlumal made them highly idiosyncratic by shifting them six degrees westward so that no meridian represents the equinoctial colure.[1172]

He also draws equatorial tropics and two other pairs of lesser circles at 12° and 20° on either side of the equator. The circles were lightly traced first (obviously by Bulhomal himself) and then engraved over more deeply (probably by assistants).

On the globes he draws the 48 classical constellation figures and marks the positions of 1022 stars with inlaid silver nails. The names of the constellation figures are incised with deeply cut letters, sometimes followed by the serial numbers and sometimes without.

On some globes, the stars within each constellation figure are numbered serially, but not on all the globes. On some globes, some prominent stars are named, on some globes, only the constellations are named.

[1172] Maddison & Savage-Smith 1997, p. 242.

Two constellations receive different names. The figure of Hercules is designated as *Jāthī ᶜAlā Rukbat,* 'the one resting on his knees' instead of the usual name *Jāthī,* 'kneeling man' and Corona Borealis is named *Iklīl,* 'crown' instead of the usual *al-Fakkah* of uncertain meaning.

Bulhomal also makes innovations in the iconography of certain figures. He introduces a charming variation in the figure of Andromeda by placing a flower in her outstretched left hand (Figure G010.5). He adds a wing to the equine half of Sagittarius (Figure G010.7). On one globe, the equine half of Centaurus is decorated with a saddle cloth with an ornate border (Figure G012.3). Cetus is depicted with a bird's head, instead of the usual dog's head (Figure G010.4). These changes are seen only in some of the globes.

Bulhomal fills the constellation figures with very fine engravings. In the constellation figures of Ursa Major, Leo (Figure G010.2), Aries, Taurus (Figure G010.4), Canis Major (Figure G010.10), the outlines of the animals are not drawn with simple lines, but with a series of very small oblique strokes to create the impression of the hairy surface (Figure G010.2 and Figure G010.7).

Even inanimate objects are embellished with ornate outlines, e.g. Lyra, Corona Borealis (Figure G010.3), and Triangulum (Figure G010.4).

The human figures are shown with minimum clothing; generally a short skirt, sometimes with pleats and sometimes without. Women like Andromeda and Virgo are bare-breasted. Men generally have one or two straps running from the waist and going across the shoulders. The most distinguishing feature of men are the mustaches with the ends turned upwards, which reflects the contemporary fashion in the mid-nineteenth century Panjab. The engraver takes great pains to draw the hair of men and women, hair of the head, beards, and even eye-brows. They are all drawn with large eyes whether in profile or in front view.

But the iconography is not uniform on all the globes and there is substantial variation. For example, in G012, the bodies of the animals and snakes, and also the clothing of human figures with innumerable tiny squiggles. On G010, the body of the bear in Ursa Major is filled with myriads of oblique strokes. On another globe, the entire body of the bear in Ursa Major is filled with similar tiny strokes (Figure G010.2).

Other Globe-Makers of the 19th Century

Globes made by a few others in the nineteenth century have come to light. Ghulām Ḥussayn Jaunpūrī, the author of the encyclopaedia *Jāmi-i Bahādur Khānī,* produced a celestial globe in 1231 / 1816 (G006). It is in a private collection at Aligarh. Engraved on it are the full set of 48 constellation figures and about 1020 stars, the co-ordinates of which he claims to have measured afresh.[1173]

The nineteenth century also saw the production of a number of globes with great circles, but without constellations or stars. One such globe was made by/for Mahdi Ḥussain Khān Bahādur in 1279 / 1862 (G016). It is now in the National Museum, New Delhi.

Unsigned Globes

There are extant several globes which carry no signature or date but are evidently produced in India, because these are cast by the *cire perdue* process. These can be grouped into three categories: those with all the constellation figures and about 1020 stars, those without these figures, but with a limited number of stars marked and labelled, and those with only the circles and the names of zodiac signs. In each category, the specimens will be arranged alphabetically by the places where they are preserved.

Copies of Globes

It appears that there was a custom of making copies of certain important instruments. In section B, we have included an astrolabe which is purported to be a copy made at Lahore in 1587 of an astrolabe belonging to Mīrzā Bāysunghur. Similarly, there are two cases of copies being made of celestial globes. Emilie Savage-Smith drew attention to a Kufic celestial globe fabricated by Muḥammad ibn Maḥmūd ibn ᶜAlī al-Tabarī al-Asṭurlābī in Iran in 684/1285-86 and its copy made in India by *cire perdue* process by an unknown instrument maker in the nineteenth century.[1174] The Indian copy is included in this catalogue (G032).

1173 Ansari & Sarma 1999-2000.

1174 Maddison & Savage-Smith 1997, I, no. 123, pp. 212-213 and Savage-Smith 1985, no. 6, pp. 220-221, Fig. 6.

There is yet another case. In 1357/1938-39 a certain Muḥammad Naʿīm al-Dīn Murādābādī fabricated two numbered copies of a globe which was originally made in 1260/1844-45 by Akbar Shāh Muhandis Jahānābādī for the Nawāb of Awadh Muḥammad ʿAlī Shāh. Naʿīm al-Dīn claims that in his copies he made certain improvements on the original. The original has not survived; therefore, it is not possible to see what improvements he made in these two copies. The first copy (G033) is with the Nasser D. Khalili Collection of Islamic Art in London[1175] and the second is in the Lahore Museum (G034).

[1175] Maddison & Savage-Smith 1997, I, no. 138, pp. 172, 239-240.

G001 CELESTIAL GLOBE BY ᶜALĪ KASHMĪRĪ IBN LŪQMĀN, 998 AH (AD 1589-90)[1176]

Diameter ?

London, PC

ESS 10

The is the earliest extant globe to be produced as a single hollow sphere by the *cire perdue* method of casting. There are four small plugs in the southern hemisphere. The stand is not extant. Nothing is known about the maker of this globe ᶜAlī Kashmīrī; no other instrument made by him is extant. His *nisbāh* 'Kashmīrī' indicates that he was from Kashmir, but it is not certain that the globe was produced in Kashmir; no astrolabes or celestial globes produced in Kashmir came to light so far.

Circles

The equator and the ecliptic are represented by single lines on which there are dots at intervals of 2°, but no numbers. The names of the zodiac signs are engraved along the ecliptic in small letters and do not extend to the entire length of each house of the zodiac as in other celestial globes. There are ecliptic latitude circles, but no other circles. Holes are bored at the equatorial poles.

Constellations Figures and Stars

The full set of the 48 constellation figures is drawn and the positions of about 1020 fixed stars are marked with inlaid silver points. The names of the constellations are engraved without the prefix *ṣūrat* or the article *al-*. The equinoxes, the solstitial colure and the equatorial poles are named and the names of some major stars are engraved.

A few constellation figures can be seen in the two photos published by Savage-Smith. Crater (*Bāṭiyah*) and Corona Australis (*Iklīl Janūbī*) have unusual iconography; the former is depicted in the form of the common terracotta water jar named *suṛāhī* in Hindi and Urdu and the latter in the form of a longish cylindrical vase with a narrow opening.

[1176] Entry based on Savage-Smith 1985, no. 10, pp. 223-224, Figs. 11 and 69.

In Savage-Smith 1985, Fig. 69, can be seen the constellation figures of Leo, Virgo and Bootes. The rendition of these figures is rather simple, but far superior to the figures of Qā'im Muḥammad. In the constellation Leo, the star *Ṣarfah* (β Leonis) is placed in the middle of the lion's tail and not at the tip. Virgo is depicted with a bald and round head; a small plant with two leaves appears to grow on the top of the head. Her face is in profile; the two wings are well drawn. She is clothed in an ankle-length dress, with a sash around the waist. The loose ends make a loop and hang down. With her left hand she holds a small trifoliate flower delicately.

Her name *Sunbulah* is engraved on her bosom. The star on her right hand is named *Simāk Aʿzal,* 'unarmed *Simāk*' (α Virginis).

To the north of Virgo is the figure of Bootes, clothed in a knee-length tunic. The neckline and lines on the sleeves are drawn. He wears a turban on his head and a sash around the waist, with the two loose ends hanging down. In his left hand is a straight staff. His name *ʿAwwā* is written on the tunic. Below the hemline of the tunic is the star *Simāk Rāmiḥ,* 'armed *Simāk*' (α Bootis). On his western ankle is a star named *Mufrid Rāmiḥ,* 'solitary [star] of the lancer' (η Bootis).

Inscription

The inscription in Arabic is engraved beneath the figure of Piscis Austrinus:

> 'The one in need of God the Merciful, ʿAlī Kashmīrī ibn Lūqmān, [in] the year 998 corresponding to 34 [of the reign] of Akbar affixed to the globe the observable stars after the calculation of their position (*taqwīm*), and he made it (*ṣanaʿahā*) in a manner useful for the knowledge of all the requirements of astrolabe-makers, as an *aide-memoire* to their craft.'[1177]

Bibliography

Savage-Smith 1985, no. 10, pp. 223-224, Figs. 11 and 69.

[1177] Translation by Savage-Smith 1985, p. 224.

G002⊙ CELESTIAL GLOBE MADE BY MUḤAMMAD ṢĀLIḤ FOR SHAYKH ᶜABD AL-KHĀLIQ, 1070 AH (AD 1659-60)

Diameter 120 mm

New Delhi, Red Fort, Mumtaj Mahal Museum (Reg. no. 40.415, Acc. No. 64)

ESS 25; Répertoire 1



Figure G002.1 – Constellation figure of Ophiuchus (courtesy Anthony J. Turner)

This small globe was made for Shaykh ᶜAbd al-Khāliq. This patron refers to himself on a manuscript copy owned by him as ‘the servant of Shāh Jahān’, but

otherwise nothing is known about him.[1178] The globe is made as a single hollow sphere; holes are bored at both the equatorial and ecliptic poles. The original stand is missing. The globe is covered with thick patina and, therefore, it is difficult to examine and photograph the constellation figures.

Circles

The equator and the ecliptic are represented each with two parallel bands as in the Lahore globes; these are divided in 1° and 5° and numbered in 5s; the equator continuously from 5 to 360 from the vernal equinox onwards and the ecliptic from 5 to 30 separately in each zodiac sign. There are ecliptic latitude circles.

Constellation Figures and Stars

The full set of 48 classical constellation figures is drawn and about 1020 positions of fixed stars are marked with inlaid silver points. The names of the constellations, some major stars, ecliptic latitude circles, the equatorial and ecliptic poles are engraved. Dhama writes: 'The sphere, though made of bronze, has traces of gilt on its surface and shows all the twelve signs of the zodiac in very clear words engraved on it. The names of the signs are *Burj-i Ḥamal* (Aries), *Burj-i Thaur* (Taurus) … .'[1179]

The figure of the constellation Ophiuchus can be seen somewhat clearly. He is clothed in what looks like the modern jogging suit with loose trousers held at the waist by a band or sash and a top with long sleeves and V-neck with lapels. Interestingly, many human figures on the globe G003 are dressed in this manner. Probably Ṣāliḥ was attempting to mythicize the person with such clothing. The headgear of Ophiuchus is also remarkable. While the companion figure of Hercules wears a common turban, Ophiuchus's headgear looks like a series of snake-hoods, as can be seen in certain sculptured images of snake-gods of the Hindu pantheon. He is adorned with a bead necklace.

With both his hands, Ophiuchus is holding the serpent at his back and not in front as generally depicted. The title *ṣūrat al-Ḥawwā* is engraved on his body. The star on his

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1178 Cf. Pingree 1999, p. 76, n. 18; he is not mentioned in Athar Ali 1985.

1179 Dhama 1928-29.

forehead is named *Rās al-Ḥawwā,* ‘the head of Ophiuchus’ (α Ophiuchi, Rasalhague) and the star on his left shoulder *Kalb al-Rāᶜī,* ‘the shepherd’s dog’ (β Ophiuchi).

INSCRIPTION

Near the southern ecliptic pole is the inscription which reads

bi-farmāyish shaykh ᶜabd al-khāliq ᶜamal muḥammad ṣālih tatahwī sanah 1070.

‘By the order of Shaykh ᶜAbd al-Khāliq. The work of Muḥammad Ṣāliḥ of Thatta [in the year] 1070 [Hijrī = AD 1659-60].

BIBLIOGRAPHY

Dhama 1928-29.

Savage-Smith 1985, no. 25, pp. 229-230.

Sarma, Ansari & Kulkarni 1993.

G003⦿ CELESTIAL GLOBE BY MUḤAMMAD ṢĀLIḤ, 1074 AH (AD 1663-64) REWORKED WITH SANSKRIT LEGENDS BY NANDARĀMA, 1824 VS (AD 1767)

Diameter ca. 250 mm; weight of the globe 4.95 kg

London, Nasser D. Khalili Collection of Islamic Art (# SCI 45)

ESS 29



Figure G003.1 – Globe with stand
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 45
Photo courtesy of the Khalili Family Trust © Nour Foundation

Just as the astrolabe made by Ḍiyā' al-Dīn (A093) was thoroughly reworked with Sanskrit legends by Nayanānanda in 1701 (E005), this Indo-Persian celestial globe made by Muḥammad Ṣāliḥ was also reworked with Sanskrit legends by Nandarāma in 1767, but in a more pleasing manner without effacing any of the original inscriptions; he duplicated all the *Abjad* numerals in Devanagari and rendered all the Arabic legends containing the names of the 48 constellation figures and those of several prominent stars into Sanskrit, thus providing us with a small lexicon of astronomical terms in Arabic and Sanskrit.

This entry describes the globe as made originally by Ṣāliḥ; the additions in Sanskrit caused by Nandarāma will be discussed separately under H002. These two entries must be read together.

The globe is cast as a single hollow sphere by the *cire perdue* process; there is one large plug near the north ecliptic pole in the form of the figure of eight. Holes are bored at the equatorial poles for inserting the axis.

Although Muḥammad Ṣāliḥ was a contemporary of Ḍiyā' al-Dīn Muḥammad of the Lahore family, his style of drawing the constellation figures and the nomenclature of certain stars is markedly different from Ḍiyā' al-Dīn's style.

Circles

The equator and the ecliptic are drawn with double bands, the narrower band divided in 1° and the broader band in 5°; on the equator groups of 5° are numbered continuously from 5 to 360 from the vernal equinox onwards; on the ecliptic, these are numbered from 5 to 30, separately in each of the twelve signs. The names of the zodiac signs with the prefix *burj* are engraved in large letters along the ecliptic, but not always at the same distance from the ecliptic and not along the entire length of the zodiac sign as in the Lahore astrolabes. The ecliptic latitude circles (*dā'irah ᶜarḍ*), the equatorial tropics, the solstitial colure (*dā'irah marrah bi-aqṭāb arbaᶜ,* 'the circle passing through the four poles'), the poles of the equator (*quṭb shamālī* and *quṭb janūbī*) and those of the ecliptic (*quṭb falak al-burūj* in the north and *quṭb falak thawābat* in the south) are named. Equinoctial points are labelled as *iᶜtidāl rabīᶜī,* 'vernal equinox' and *iᶜtidāl kharīfī,* 'autumnal equinox'.

The two segments of the solstitial colure between the ecliptic and equator, to be seen between the zodiac houses of Gemini and Cancer on the one hand and between the

houses of Sagittarius and Capricorn on the other, are labelled as *mayl kullī,* ‘complete declination,’ or ‘maximum declination’.



Figure G003.2 – Northern hemisphere
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 45
Photo courtesy of the Khalili Family Trust © Nour Foundation

Constellation Figures and Stars

The 48 classical constellation figures are engraved and the positions of about 1020 stars are marked with inlaid silver points. The names of the constellation figures are engraved with the prefix *ṣūrat.* The zodiac house of Virgo is named *burj sunbulah,* but the figure of Virgo is entitled *ṣūrat ʿadhrā,* ‘figure of virgin’. Interestingly, some stars in the constellations of Auriga, Bootes and Perseus are given long name labels, directly

borrowed from al-Ṣūfī's work, where the different names derived from different traditions are mentioned.[1180]

Constellation figures are engraved lightly; in some cases they have become very faint now. In general, the depiction of the zoomorphic figures is similar to that in the globes made by Ḍiyā' al-Dīn. But the rendition of the anthropomorphic figures is remarkably different in their clothing and in their facial features. The most striking aspect of the clothing is that many male figures (like Perseus, Ophiuchus and others) wear what looks like a modern jogging suit with loose trousers held at the waist by a band or sash and a top with long sleeves and V-neck with lapels. Such outfits are not to be found in contemporary Mughal miniatures. They are products of Ṣāliḥ's imagination, created in order to mythicize the characters. But at the same time, he also introduces variety by drawing a few other figures with short tunics. There is variety in the headgear as well; Auriga, Hercules, Sagittarius and Centaurus wear turbans; Bootes, Ophiuchus and Orion don caps with ornate rims such as the one worn by Centaurus in the Smithsonian globe (see Figure F028.5). Andromeda and Cassiopeia put on narrow boat-shaped caps which resemble those worn in modern times by the members of the Congress Party in India, made famous by the first prime minister Jawahar Lal Nehru. The figures are rather plump, with round faces.

Figure G003.2 shows the northern hemisphere with a large plug on the right. The northern celestial pole at the centre is named *quṭb shamālī* and the northern ecliptic pole *quṭb falak al-burūj.* The figure of the dragon of the constellation Draco is coiled around the ecliptic pole, with the label *ṣūrat al-Tinnīn,* 'figure of the dragon'. A star near its eye is named *Rās al-Tinnīn,* 'head of the dragon' (γ Draconis, Eltanin).

Between the two poles is situated the first constellation **Ursa Minor**, with the label *ṣūrat Dubb Aṣghar,* 'figure of the smaller bear'. The outline of the back and the tail is drawn as an arc of the circle. The star on the front leg of the bear is named *Anwar al-Farqadayn,* '*brighter of the two calves*' (β Ursae Minoris, Kochab) and that on the back *Akhfā al-Farqadayn,* 'more obscure of the two calves' (γ Ursae Minoris). The square formed by these two and two unnamed ones in the middle of the body are collectively

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[1180] I am highly grateful to Dr Flora Vafea for explaining these long labels.

designated as *al-Naᶜsh,* 'the bier' as is usually done in the constellation Ursa Major (e.g. Figure F004.2). The star on the tip of the tail, situated next to the north pole, is called *al-Jadī,* 'the goat' (α Ursae Minoris, Polaris)

On the right is the second constellation **Ursa Major**, represented by a bear with a narrow snout, entitled *ṣūrat Dubb Akbar,* 'figure of the great bear'. It contains several named stars. On the body are the three stars *Ẓahr Dubb al-Akbar,* 'back of the great bear' (α Ursae Majoris, Dubhe), *Mirāq Dubb Akbar,* 'loin of the great bear' (β Ursae Majoris), and *Fakhdh Dubb al-Akbar,* 'thigh of the great bear' (γ Ursae Majoris). The three stars on the tail carry the names *Jawn*, 'black horse' (ε Ursae Majoris), *ᶜAnāq,* 'goat' (ζ Ursae Majoris, Mizar) and *Qā'id,* 'leader' (η Ursae Majoris, Alkaid). The twin stars on the three paws, except the foremost one, are named respectively *al-Qafzah al-Ūlā,* 'the first leap' (νξ Ursae Majoris); *al-Qafzah al-Thānī,* 'the second leap' (λμ Ursae Majoris) and *al-Qafzah al-Thālith,* 'the third leap' (ικ Ursae Majoris).[1181] However, the alternative names derived from the Bedouin concept of a bier (*al-Naᶜsh*) and the three daughters who follow it (*al-Banāt*), are not mentioned in this constellation, although *al-Naᶜsh* is engraved on Ursa Minor.

Besides these three constellation figures, other figures of Auriga, Perseus, Andromeda and Cepheus can be seen arranged roughly clockwise. These will be described at appropriate places below.

Perseus wears loose trousers, held at the waist by a wide belt or sash and a top with long sleeves, V-neck and button in the front. His feet are bare. His face is shown in profile; the head is bald with a few strands of hairs at the back; there is no beard. The ogre's head is heart-shaped with two small circles for eyes. The sword in the left hand of Perseus has an ornate handle and a long slender blade.

[1181] The word *qafzah* is spelt wrongly as *faqrah* by misplacing the diacritical points.



Figure G003.3 – Perseus and Auriga
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 45.
Photo courtesy of the Khalili Family Trust © Nour Foundation.

The name of the figure is engraved on the right hand side of the body as *ṣūrat Parshā'ūs*. The star on his right ankle is named *Mankib al-Thurayyā,* 'shoulder of *al-Thurayyā*' (ξ Persei). There are two stars on the right foot; each of these is named separately as *Māniq al-Thurayyā,* which is an error for *ᶜĀtiq al-Thurayya,* 'shoulder blade of *al-Thurayyā*' (οζ Pegasi). The name of the star above the waist is engraved in two lines as *wa yusmī janb parshā'ūs | wa hū ᶜalā mirfaq yad al-thurayyā al-yumnā,* 'and it is called "the side of Perseus" and it is the elbow of the right hand of *al-Thurayyā,*' (α Persei, Mirfak). The star in the ogre's head is called *Rās al-Ghūl,* 'head of the Ghoul' (β Persei, Algol).

Auriga is depicted in standing posture, holding with both hands a long stick with a forked end; he wears a long tunic with a sash around the waist, its two loose ends dangling in front; the tunic has long sleeves and a V-neck. There is a turban on his head. His face in three-quarters profile with stern looks. The title of the figure is engraved on

the body: *ṣūrat Mumsik al-Aᶜinnah,* 'he who holds the reins'. The large star on his right shoulder is named *ᶜAyyūq* (α Aurigae, Capella). The name of the star on the left shoulder is engraved in three lines and refers to two different traditions: *mankib dhī al-ᶜinān, wa yusmī | hadhah al-thalāthah tawābᶜ al-ᶜayyūq | wa alā' ᶜalām a'yḍā,* 'the shoulder of the one having the reins, and these three [stars] are called "the followers of *al-ᶜayyūq*' and the "marks" as well (β Aurigae).

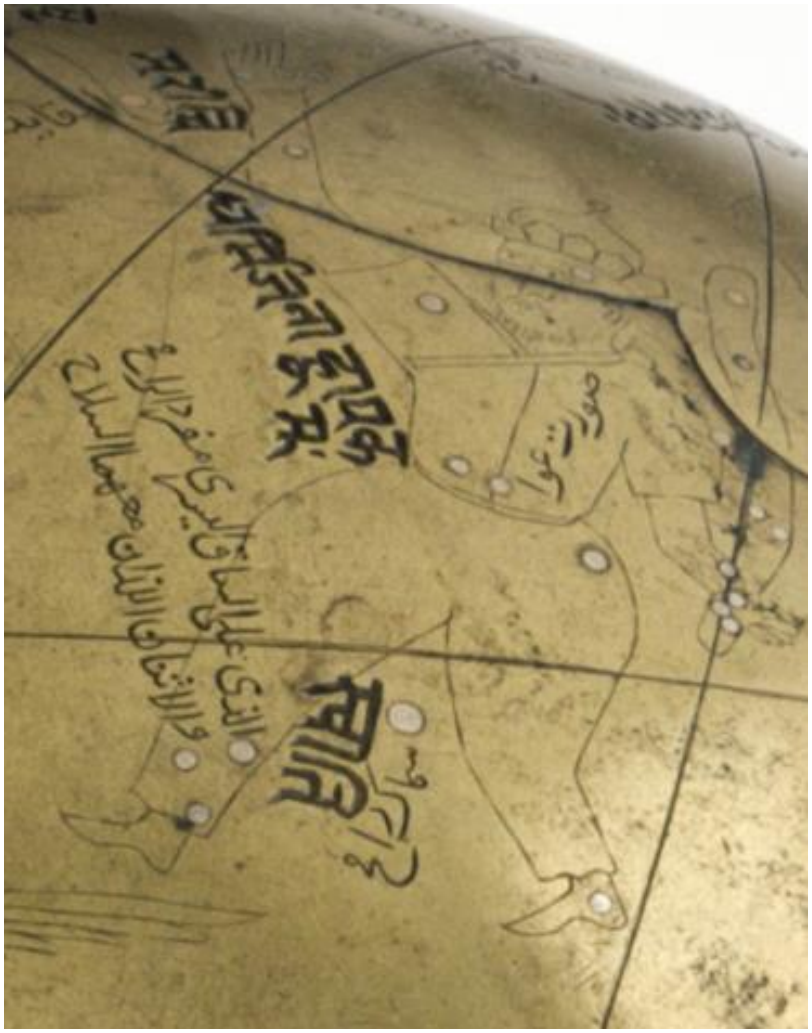


Figure G003.4 – Bootes
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 45
Photo courtesy of the Khalili Family Trust © Nour Foundation

Bootes is represented as a plump figure wearing loose trousers secured at the waist by a thin belt or sash and a top with short sleeves, its flap closed on the right, and elegant shoes. He wears a cap with the raised rim in the form of a series of flower petals and a round bead at the top. Faint mustaches at the corners of the mouth, short beard under the chin; grave looks; his right hand is raised high; the left hand holds a fat crooked stick.

The name of the figure is engraved on the body as *ṣūrat ᶜAwwā',* 'figure of howler'. The large star between the legs is named *Simāk Rāmiḥ,* 'the armed *Simāk*' (α Bootis, Arcturus). The star on the right calf is named: *al-dhī ᶜalā al-sāq al-yusrā mufrad al-Rāmiḥ,* '[the star] that is on the left leg of the one with the lance' (η Bootis, Mufrid). The two stars on the right ankle carry the label: *wa al-Ithānān Muᶜahmā al-Salāḥ*, 'and the two [stars] that [have] weapons with them' (nos. 21-22 in al-Ṣūfī).

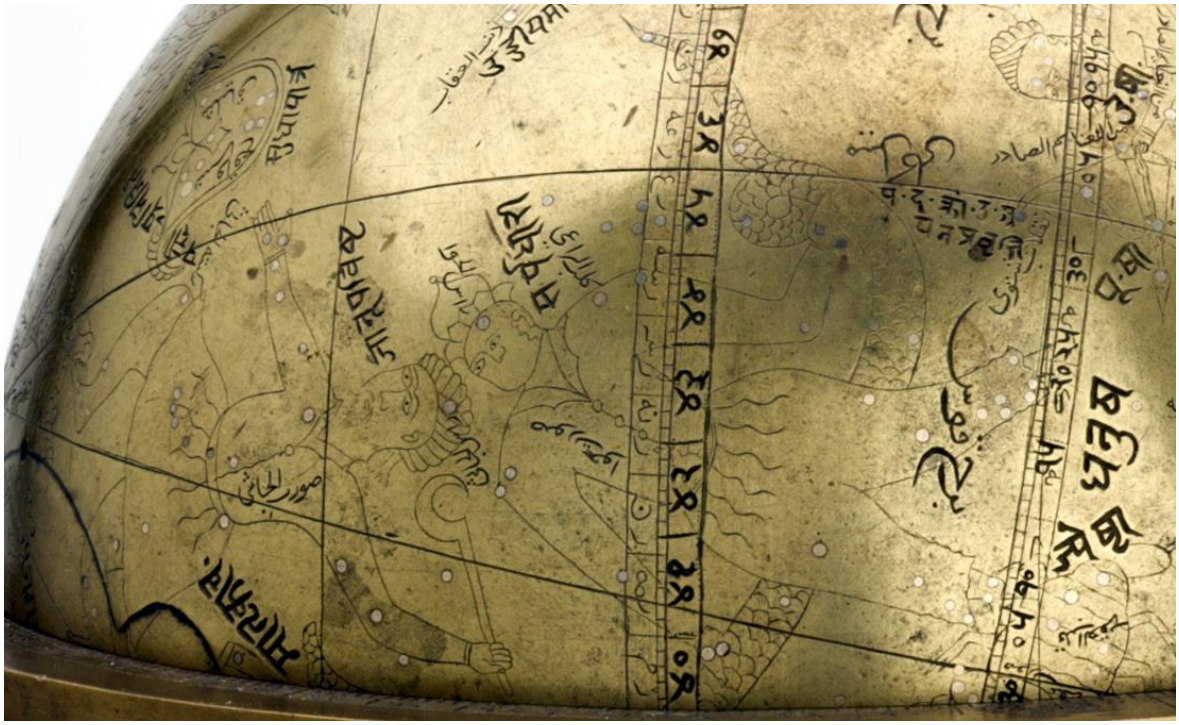


Figure G003.5 – Hercules and Ophiuchus
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 45.
Photo courtesy of the Khalili Family Trust © Nour Foundation

In the Lahore globes, the companion figures of Hercules and Ophiuchus are depicted almost alike, but here they are rendered differently. **Hercules** wears a short tunic tied at the waist by a simple sash, the lower part spreading wide above the knees; the folds in the skirt are indicated by a series of wavy lines; the upper part of the tunic shows long sleeves, V-neck and lapels. His netherwear is not clearly defined. There is an elaborate turban on his head. The face is in three quarters profile with a fuzzy beard. His right knee is bent and both his arms outstretched, a sickle in the left hand. The name engraved on the body as *ṣūrat al-Jāthī,* 'figure of the kneeling man'. A star in the front of the turban is named *Rās al-Jāthī,* 'head of the kneeling man' (α Herculis, Rasalgethi).

Ophiuchus is dressed in a jogging suit, held tightly at the waist by a thin strip of a sash, the folds in the wide trousers shown by a series of wavy lines; top with full sleeves, V-neck and lapels. His feet and hands are not visible; the face is in three-

quarters profile; the eyes, nose, one ear, hair at the back of the head are all drawn well, but the engraver forgot to add the mouth; the chin is clean-shaven, on the head a cap like the one worn by Bootes. He holds the snake behind his back with both hands; the scales on the snake's body are meticulously drawn. The name of the figure is written on the body as *ṣūrat al-Ḥawwā,* 'figure of the snake-charmer'; the star on the forehead is named *Rās al-Ḥawwā,* 'head of the serpent charmer' (α Ophiuchi, Rasalhague) and the star on his left shoulder *Kalb al-Rāʿī,* 'shepherd's dog' (β Ophiuchi).

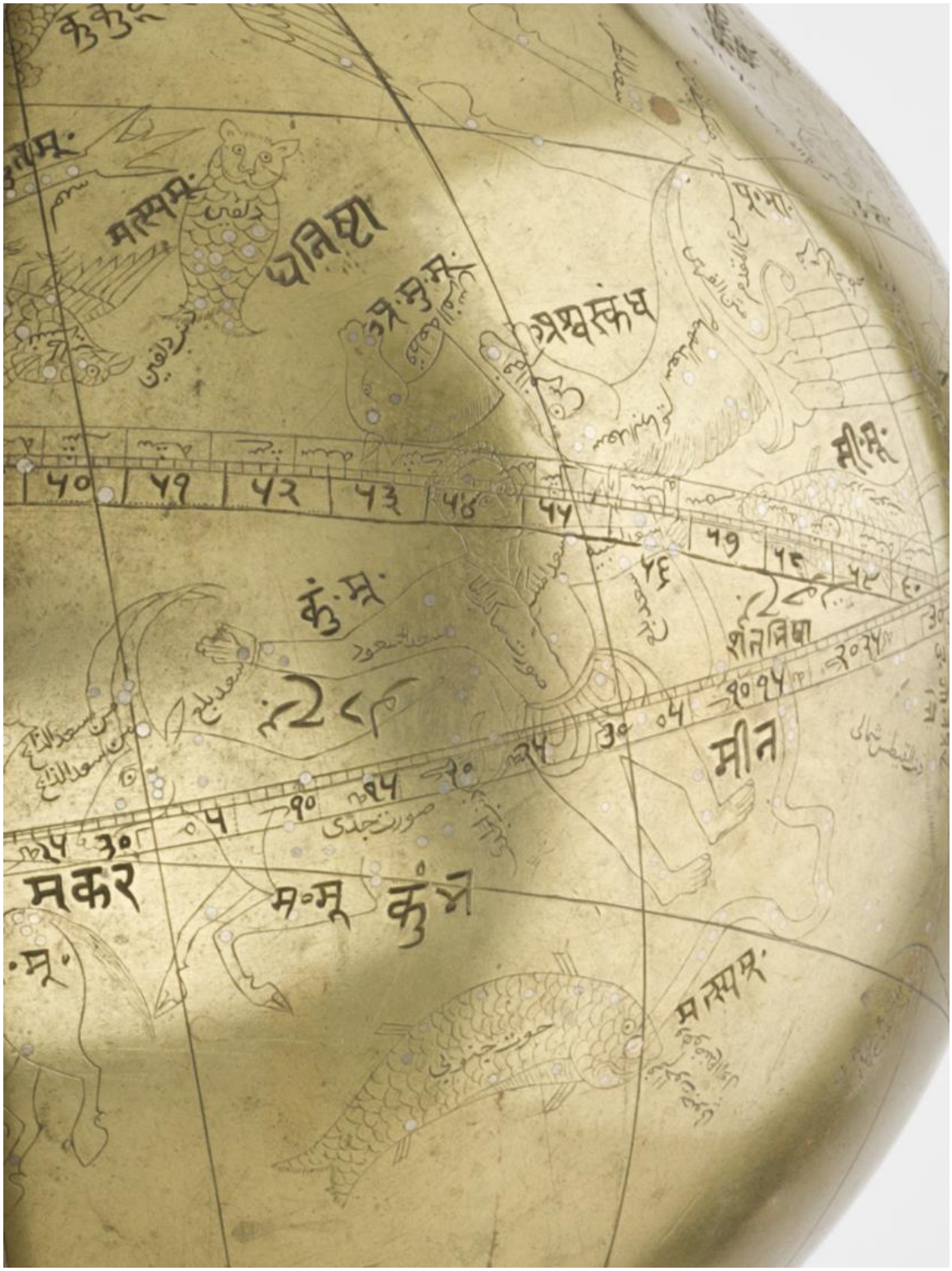


Figure G003.6 – Capricorn, Aquarius and other figures
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 45
Photo courtesy of the Khalili Family Trust © Nour Foundation

Aquarius wears, like the others, a long-sleeved top with V-collar and lapels, but there are no lines on his legs to indicate his netherwear. Below his sash, however, there are drawn two large pouches or purses; on his head is a woven cap with two layers. His

face is in three-quarters profile. Ḍiyā' al-Dīn generally depicts him as an old man; but Ṣāliḥ renders him as a younger person. The title of figure is written as *ṣūrat Sākib al-Mā,* 'figure of the water-pourer'.

The star on his western shoulder is named *Saᶜd al-Suᶜūd,* 'omen of good fortune'; it is the name of the twenty-fourth lunar mansion, applied to two stars on the western shoulder of Aquarius (βξ Aquarii).[1182] A star on his western wrist has the name *Saᶜd Bulaᶜ,* name of the twenty-third lunar mansion and 'refers to two of the three stars in the hand of Aquarius extended over the back of Capricorn' (νε Aquarii). There is also a *Saᶜd Bulaᶜ* on the eastern upper arm. A star on his eastern shoulder is given the name *Saᶜd al-Malik,* 'royal omen' (αο Aquarii).

In the Lahore globes, Aquarius is shown holding a vessel from which water flows down; but there is no vessel here; the stream of water looks like a pipe held by Aquarius in his left hand. The water stream is traced up to the mouth of the southern fish whose body is drawn neatly with scales. The figure is entitled merely as *Ḥūt Janūbī,* 'southern fish' without the prefix *ṣūrat.* The star at its mouth has two names: *Fam al-Ḥūt Janūbī | wa hū Ḍifdaᶜ al-Awwal,* 'mouth of the southern fish, and this is the first frog (α Piscis Austrini).

The figure of the zodiac sign **Capricorn** is drawn below the outstretched western arm of Aquarius. Its front part is that of goat and hind part that of a fish; but the hind part is not clearly defined. The figure has the title *ṣūrat Jadī,* 'figure of the goat'. A star on its tail is named *Dhanab al-Jadī,* 'tail of the goat' (δ Capricorni). Two stars on the horn closer to Aquarius are named *min Saᶜd al-Dhābiḥ,* 'belonging to the [twenty-second lunar mansion] *Saᶜd al-Dhābiḥ*' (α^{1-2} Capricorni and β Capricorni).

Above the scale of the equator are the figures of Delphinus, Equuleus and Pegasus from left to right; their titles are written without the usual prefix *ṣūrat,* simply as *Dālfīn,* 'dolphin', *Qiṭᶜat al-Faras,* 'part of the horse' and *Faras Aᶜẓam,* 'the larger horse'. Delphinus is drawn with a cat's face and the body of a fish. A star at the tail is appropriately named *Dhanab Dālfīn,* 'tail of the dolphin' (ε Delphini). Pegasus is represented by the front half of a winged horse, with the wing drawn very elegantly.

[1182] On these *saᶜd* stars, see Savage-Smith 1985, pp. 130-131, 181-185.

There are several named stars: *Matn al-Faras,* ‘side of the horse’ (α Pegasi); *Mankib al-Faras,* ‘shoulder of the horse’ (β Pegasi); *Surrat al-Faras,* ‘navel of the horse’ (δ Pegasi); *Fam al-Faras,* ‘mouth of the horse’ (ε Pegasi); *Saᶜd al-Humām,* ‘*saᶜd* (omen) of hero’ (ςξ Pegasi); *Saᶜd Bāriᶜ,* ‘an excellent *saᶜd*’ (λμ Pegasi); *Saᶜd Maṭar,* ‘rainy *saᶜd*’ (ηο Pegasi).

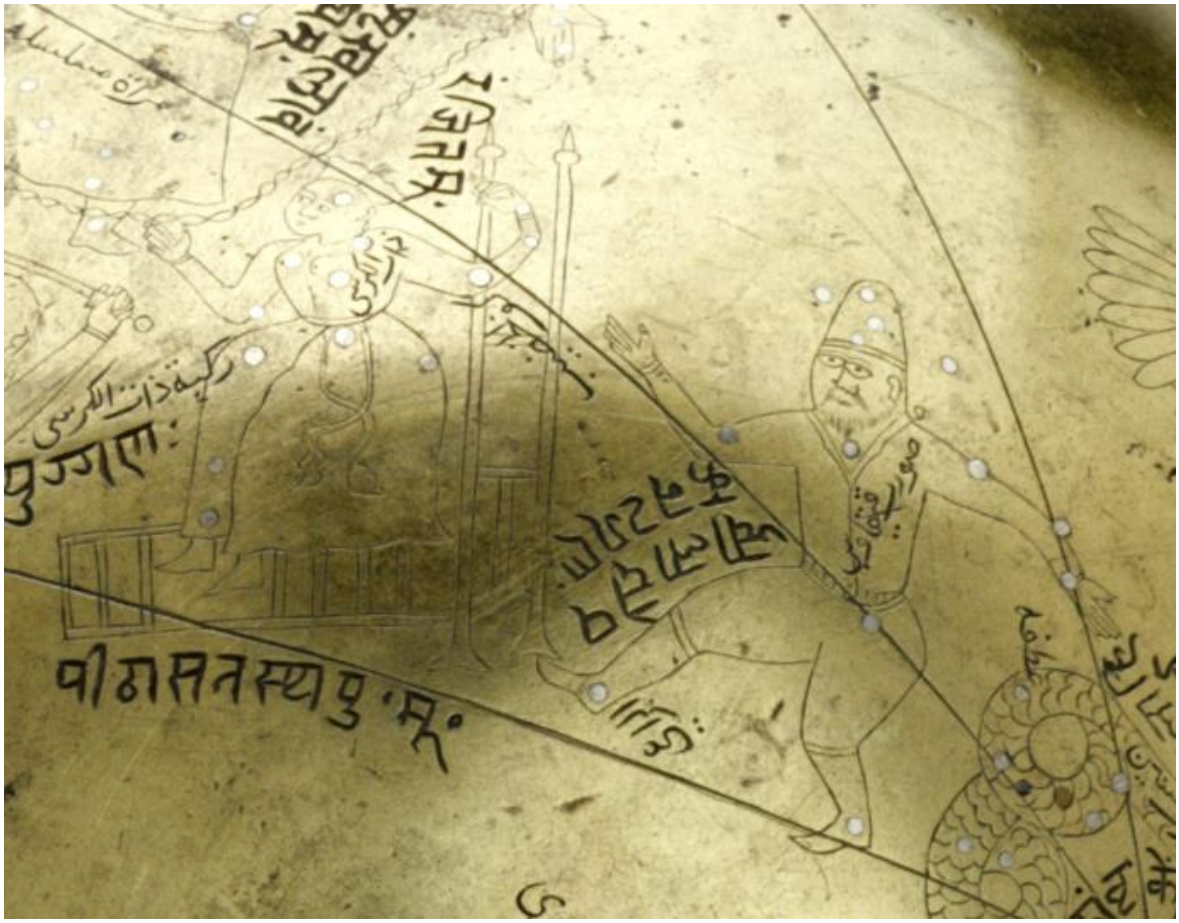


Figure G003.7 – Cassiopeia and Cepheus
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 45
Photo courtesy of the Khalili Family Trust © Nour Foundation

Cepheus also wears a jogging suit, held at the waist by a patterned sash; the trousers reach up to the knees; followed by knee-length boots. The top is with full sleeves, V-neck and lapels. His cap is a simple conical one. His face is in three-quarters profile; mustaches at the corner of the mouth and a short beard under the chin. The name *ṣūrat Qīqā’ūs* is written on the body. On his right heel is a star named *al-Rāᶜī,* ‘the shepherd’ (γ Cephei).

His wife **Cassiopeia** is dressed in a very wide skirt and a top with full sleeves. There is a thin sash around her waist, its two looses ends falling down gracefully and crossing each other. Her face is shown in three-quarters profile, head slightly tilted

upwards, as if to look at her daughter Andromeda; on the head is a boat-shaped ‘Congress’ cap; full breasts are drawn with nipples. With her left hand, she holds the back-post of the chair in a graceful posture; the right arm is stretched forward.

Her name is engraved on the her body, without the usual prefix *ṣūrat,* as *Dhāt al-Kursī,* ‘the one with the chair’. The star on her left elbow is named *Kaff al-Khāḍib,* ‘dyed hand’ (β Cassiopeiae) and the star on her right knee *Rukbat Dhāt al-Kursī,* ‘knee of the one with the chair’ (δ Cassiopeiae).

Her chair is depicted in a strange manner. The back consists of two long posts, having wide feet, ornate ends with sharp tips and a cross-piece. The rest of the chair looks like a rectangular platform with a railing all around with an opening in the front and resembles some of the thrones called *aurang* in Mughal miniatures.[1183] But no feet are drawn in the front on which the platform could rest, nor is the seat indicated where Cassiopeia is resting.



Figure G003.8 – Andromeda
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 45.
Photo courtesy of the Khalili Family Trust © Nour Foundation

[1183] Cf. Verma 1978, pp. 72-74, Pl. LIV, esp. no. 6.

Andromeda is depicted as a corpulent person with stern looks; resembles a nurse in a modern hospital. She is dressed in an ankle-length wide gown, with narrow belt at the waist, long sleeves, V-neck and lapels; full breasts with nipples. Her face is in three-quarters profile. She also wears a 'Congress cap' on her head. Her arms are stretched horizontally in both directions. A long chain goes from one wrist to the other, encircling her entire body.

The name of the constellation is written on the lower part of her skirt, without the usual prefix *ṣūrat,* merely as *Mar'ah Musalsalah,* 'chained woman'. The star on her forehead which she shares with Pegasus is given the name *Surrat al-Faras,* 'navel of the horse' (δ Pegasi). The star on the right side of her waist carries the name *Janb Musalsalah* | *wa yusammā Batn al-Ḥūt*, 'Side of the chained [woman] | and also called belly of the fish' (β Andromedae). The star on her right ankle is named *Rijl al-Musalsalah wa yusammā* | *ᶜAnāq al-arḍ ayḍān,* 'foot of the chained [woman] and called | wild lynx also' (γ Andromedae).



Figure G003.9 – Virgo
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 45.
Photo courtesy of the Khalili Family Trust © Nour Foundation

The zodiac sign **Virgo** is rendered in three-quarters profile with a bald head and a heavy jowl. Her full length gown has an interesting pattern, but all the details are not

visible in the photo. The gown is closed in the front with a series of five round buttons and, as in other figures, V-neck with lapels. The right half of her body is overlapped by the scales of equator and ecliptic; her left wing and left arm can be seen. The title of the constellation is written as *ṣūrat ᶜAdhrā',* 'figure of virgin' and not the usual title *Sunbulah,* 'ear of wheat'. The right hand is not visible, but the star there is named *Simāk Aᶜzal,* 'unarmed *Simāk*' (α Virginis). Five stars on different parts of her body carry the same name *min al-ᶜAwwā',* 'belonging to *al- ᶜAwwā'* (βηγδε Virginis), *ᶜAwwā'* being the name of the thirteenth lunar mansion.[1184]



Figure G003.10 – Centaurus
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 45.
Photo courtesy of the Khalili Family Trust © Nour Foundation

1184 Cf. Savage-Smith 1985, p. 127.

Centaurus is represented as a plump and pleasant person, wearing almost the same type of top as the others, but with a very wide patterned sash and a turban. His face in three-quarters profile. The equine half and the wild beast are well drawn. The olive twigs in his hands look like mere pieces of wood. The label reads *ṣūrat Qanṭūrus,* 'figure of Centaurus'. The star on the hoof of the left foreleg of the horse is named *Rijl Qanṭūrus,* 'foot of Centaurus' (α Centauri). The figure of Lupus is entitled *ṣūrat Sabᶜ,* 'figure of wild beast'.



Figure G003.11 – Southern hemisphere with the signature
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 45.
Photo courtesy of the Khalili Family Trust © Nour Foundation

Figure G003.11 shows the region around the two southern poles. The southern equatorial pole through which the axis passes is named as *Quṭb Janūbī* and the southern ecliptic pole where the six ecliptic latitude circles converge as *Quṭb Falak Thawābat.*[1185] Two of the ecliptic latitude circles are labelled as *dā'irah ᶜarḍ.* The solstitial colure that passes through the two poles is designed as *dā'irah marrah bi-aqṭāb arbaᶜ,* 'circle that passes through four poles'.

On the left hand side is the constellation figure of **Argo Navis**; the ship is depicted in a manner which is entirely different from the figures in the Lahore astrolabes. The bottom of the ship is represented in a realistic manner, but the slanted mast and the pairs of long stripes on the body are rather strange. The title reads *ṣūrat Safīnah,* 'figure of the ship' and the lone star on one of the oars is named *Suhayl* (α, Carinae, Canopus).

STAND

The globe is mounted on a quadruped stand, with spindle legs, on a base formed by two thick crossbars. In the horizon ring there are two notches for the meridian ring to pass through. To its underside of the horizon ring is attached a semicircular arc as a support for the meridian ring. The original meridian ring, however, is missing. The horizon ring is divided in 1° and 6° numbered in 6s from 6 to 90 in Devanagari numerals, separately in each quadrant. The outer band is divided in 30° but not labelled (for the figure, see H002). Savage-Smith opines that the stand was made at the same place where the Sanskrit reworking of the globe was done.[1186] It is probable, but the engraver of the globe and the engraver of the horizon ring are different persons, for the style of the Devanagari numerals 3 and 9 are clearly different on the globe and on the ring.

1185 On the term *thawābat,* Dr Flora Vafea sent me the following note: '"ثوابت" is the plural of "ثابت", an abbreviation of "الكوكب الثابت" (= fixed star). Thus, it means the pole of the circle of fixed stars. I think that this should be the pole of the equator, not the pole of the ecliptic.' But as Figure G003.11 shows clearly, *Quṭb Falak Thawābat* is engraved as the designation of the ecliptic pole, while the pole of equator is named merely as *quṭb janūbī.*

1186 Maddison & Savage-Smith 1997, I, no. 134, p. 234.

INSCRIPTION

The signature is engraved near the southern poles, between two ecliptic latitude circles, thus:

ᶜamal muḥammad ṣāliḥ tatawī sanah 1074

'The work of Muḥammad Ṣāliḥ of Thatta [in] the year 1074 [Hijrī = AD 1663-64].'

PROVENANCE

Formerly in the collection of Alain Brieux, Paris.

BIBLIOGRAPHY

Savage-Smith 1985, No. 29, pp. 231-232, Fig. 18.

Sarma, Ansari & Kulkarni 1993.

Maddison & Savage-Smith 1997, I, No. 134, pp. 234-235.

Anon 1985, p. 86-87.[1187]

[1187] The catalogue reproduces a photo of the globe and the following introduction which is partly incorrect and partly absurd: 'This globe is dated and signed by Muhammad Salih Tatawi, a third generation craftsman from a family of remarkable astrolabists in Lahore [sic!]. The globe was cast in piece, while the stand probably dates from the 18th century. An inscription added in Negari script [sic!] includes a dedication to the shrine Nathdawara and suggests that it was the gift of the astronomer prince Jai Singh.' For the inscription in Devanagari script and its meaning, see REF _Ref479938347 \r \h H002.

G004⊙ CELESTIAL GLOBE BY LUṬF ALLĀH IBN ᶜABD AL-QĀDIR AL-MUḤIBB AL-ASṬURLĀBĪ

Not dated, 17th Century, second half

Diameter 67 mm, height 137 mm

Paris, Institut du Monde Arabe (# AI 86-26)

ESS 67

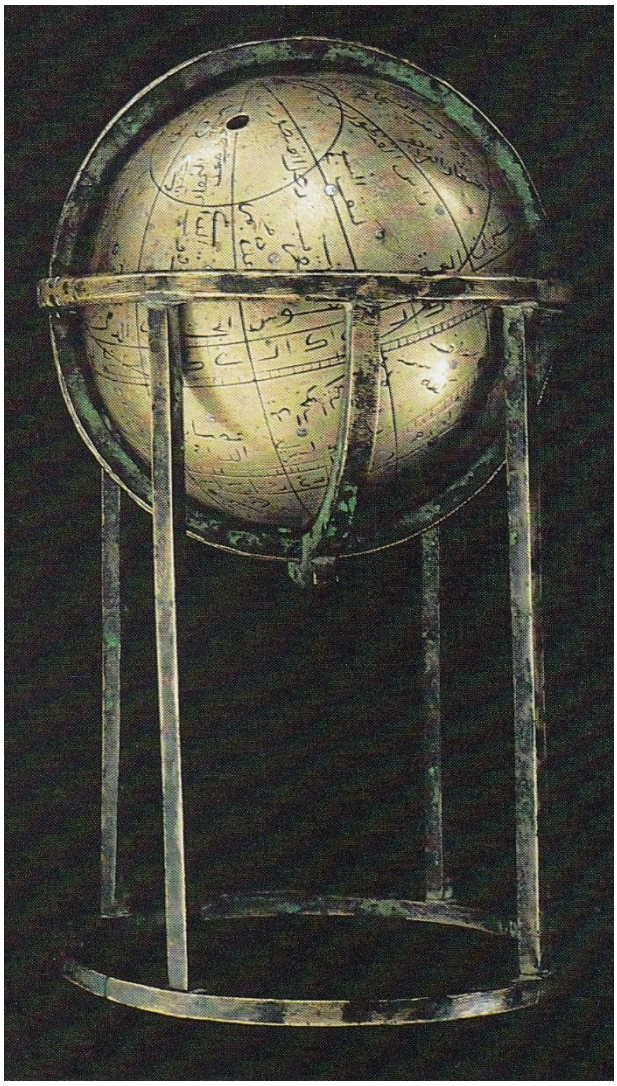


Figure G004.1 – Globe with stand (© Institut du Monde Arabe, Paris)

Luṭf Allāh, the maker of this globe, is the son of ᶜAbd al-Qādir al-Muḥibb; four astrolabes made by him ca. 1621 have been described above (B003 – B006). An astrolabe by Luṭf Allāh's brother Ibn Muḥibb Ḥaqīqa in 1647 is also known (B007). The present celestial globe is the only instrument made by him which is extant. It is not dated; it must have been made sometime in the second half of the seventeenth century.

The globe is cast as a single hollow sphere; there is a large circular plug around the north ecliptic pole. Holes are bored at the equatorial poles.

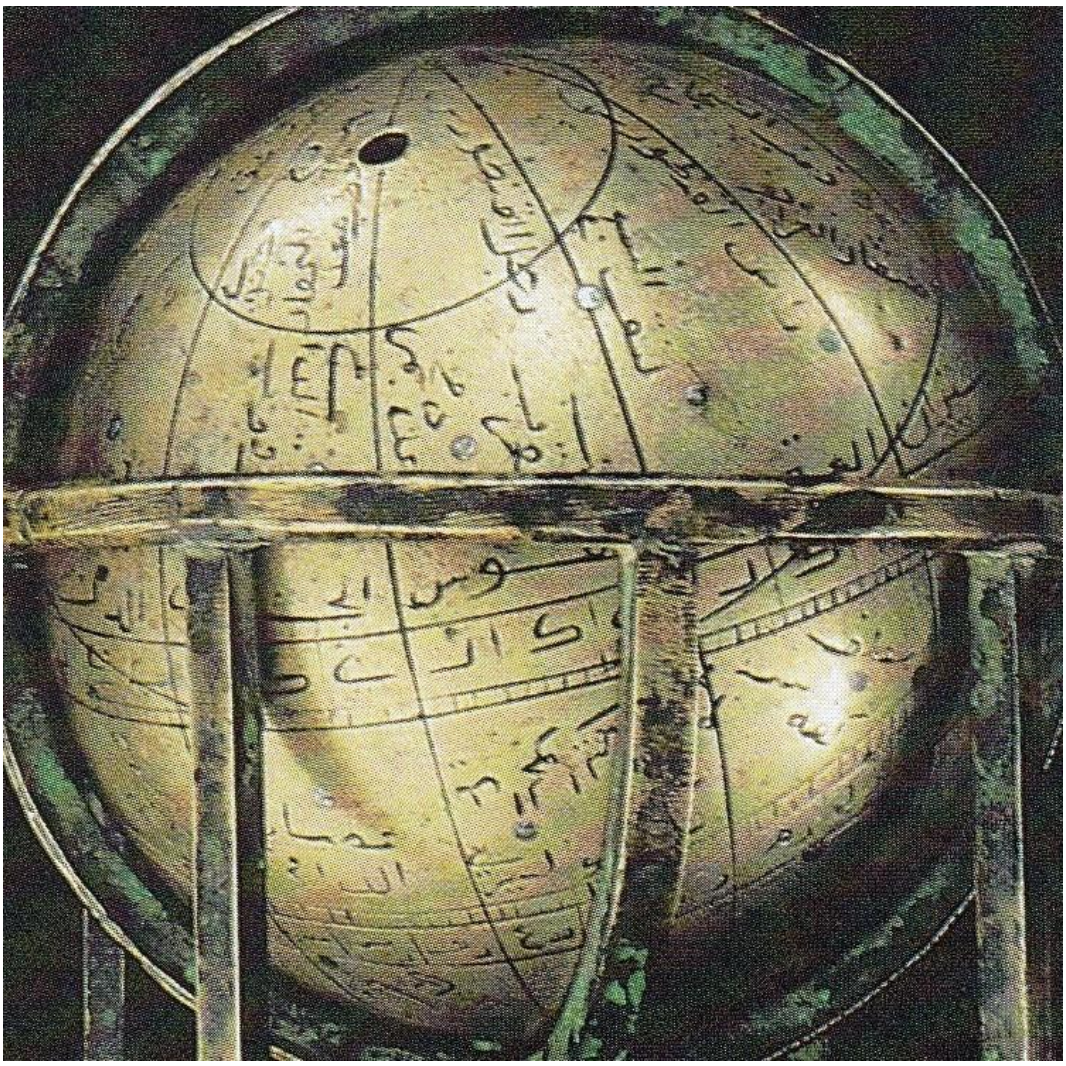


Figure G004.2 – Globe (detail of Figure G004.1)

CIRCLES

The equator and the ecliptic are divided in 2° and 10° and numbered in 10s. The equator is numbered from 10 to 360, starting at the vernal equinox; the ecliptic from 10 to 30 separately in each zodiac sign. The names of the signs are engraved along the ecliptic. There are ecliptic latitude circles, equatorial tropics and equatorial polar circles.

There are no constellation figures. The positions of 62 fixed stars are marked by inlaid silver points; the names of the stars and those of the equatorial and ecliptic poles are engraved.

STAND

The globe is mounted on a quadruped stand with a horizon ring and a meridian ring. Holes are bored in the meridian ring at intervals of 4° so that the globe can be adjusted for different terrestrial latitudes. The axis is missing and the globe sits tightly inside the meridian ring.

INSCRIPTION

The maker's signature is engraved near the northern poles in seven lines:

ṣanᶜah aḍaᶜf al-ᶜibād luṭf allāh ibn ᶜabd al-qādir al-muḥibb al-asṭurlābī. ghafr allāh dhunūbah.

'The work of the weakest of the servants [of God] Luṭf Allāh, son of ᶜAbd al-Qādir al-Muḥibb al-Asṭurlābī. May God forgive his sins.'

PROVENANCE

Formerly in the private collection of Marcel Destombe, Paris.

BIBLIOGRAPHY

Savage-Smith 1985, No. 67, p. 251.
Mouliérac 1989, pp. 84-85.

G005⊙ CELESTIAL GLOBE BY MUḤAMMAD FAḌL ALLĀH, 1223 AH (AD 1808)

Diameter 170 mm

Hyderabad, Salar Jung Museum (# 114/xxxv)



Figure G005.1 – Globe with stand (courtesy Salar Jung Museum)

This is probably the only extant Indo-Persian astronomical instrument produced in southern India. Faḍl Allāh appears to have been an astronomer and instrument maker attached to the court of the Nizam of Hyderabad. His grandfather Muḥammad Mūsā, the astrolabe maker, belonged to Aurangabad; later on, the family must have moved to Hyderabad. No astrolabes or other instruments made by the grandfather have survived; nor of his father; the only extant instrument produced in this family is the present celestial globe.

The inscription states that the star positions on this globe are marked according to the the *Jīz Jadīd Aṣafiyah* compiled by Khwājah Bahādur Ḥussayn Khān Rizwī; this work, also known as the *Jīz-i Nizāmī,* was competed in 1780 at Hyderabad and was dedicated to the Nizam of Hyderabad.[1188] Some of the constellation figures on this globe are drawn in the style of European celestial globes and some show the impact of early modern European iconographic models.

The globe is cast as a single hollow sphere by the lost wax process. There are two circular plugs; a large one with a diameter of 65 mm inside the polar circle in the north and a small one with a diameter of 19 mm near the south celestial pole.

Circles

The equator and the ecliptic are represented by double bands divided in 1° and 6°. The equator is numbered from 6 to 360 continuously from the vernal equinox onwards, while the ecliptic is numbered from 6 to 30 separately in each zodiac signs. The names of the zodiac signs are engraved along the ecliptic. Equatorial tropics, a pair of circles at 12° and 20° and equatorial polar circles are drawn on either side of the equator as dotted lines. Likewise, six meridian circles at right angles to the equator, six ecliptic latitude circles at right angles to the ecliptic and ecliptic polar circles are drawn with dotted lines. The equatorial poles are labelled as *quṭb ᶜālam shamālī* and *quṭb ᶜālam*

[1188] According Abdi 1988, p. 69, the author of this *Zīj*, Khwājā Bahādur Hussayn Khān came to India with his grandparents from Bukhara during the reign of Shāh Jāhan, served Aurangzeb for a while and then moved to Deccan with Nizām ul-Mulk Āsif Jāh who ruled Hyderabad from 1761 to 1803. In the *Jīz* there are frequent quotations from and references to Sanskrit texts on astronomy. See also Ansari 2015, p. 594.

janūbī, the polar circles around them as *madār quṭb ᶜālam*; the ecliptic poles are named *quṭb al-burūj*, and the polar circles around them *madār quṭb al-burūj.*

Constellation Figures and Stars

All the 48 classical constellation figures are engraved along with their titles. The positions of about 1020 stars are indicated with large asterisks and the names of some prominent stars are engraved. The figures of animals and birds are drawn in the conventional manner; but Leo is depicted with the lion's mane and tiger's stripes.



Figure G005.2 – Centaurus and Lepus (photo by S. R. Sarma)

The influence of European iconography is noticeable in certain human figures which are depicted with their backs towards the viewer as on the European globes. For example, Centaurus is shown with the back to the viewer, holding the wild beast by his

right hand and the twig of vine leaves with his left hand (Figure G005.2). He is bare-bodied, except for the turban in the Islamic style. His face is shown in full profile, with faint mustaches and a short beard. The wild beast is depicted with the head of a lion. The title *ṣūrat Qanṭūrus* is engraved above the back of the horse and the star on the hoof of the horse is named *Rijl Qanṭūrus,* 'foot of the centaur' (α Centauri).

Likewise Hercules is shown with his back towards the viewer, with naked buttocks and with long hair falling on his back; mustaches and beard can be discerned on his face. His companion Ophiuchus is depicted in a similar manner, with his bare back and naked buttocks towards the viewer, with the furry serpent wrapped all around him. He is also bearded.



Figure G005.3 – Bootes with two dogs (photo by S. R. Sarma)

Bootes is accompanied by two dogs as in European globes, but he is facing the viewer as in Islamic globes; moreover, the sides are also reversed as in Islamic globes, for he is holding a weapon with his left hand and the dog chains with his right hand. He is clothed in a short tunic with short sleeves; there is a sash around his waist. His thick hair is parted in the middle and combed to both sides. He sports prominent mustaches and a longish beard.

Some figures display rather unusual iconography. Andromeda is seated with her right leg crossed over the left leg; her left arm is outstretched from which the broken chain is dangling; she is dressed in short tunic and tight trousers; her hair is streaming backwards. Compared to her, the figure of Cassiopeia is small and insignificant.

Perseus is delineated with minimal clothing; he holds the ghoul's head by a single strand of hair; the ghoul's head is cheerful and grinning.

Auriga looks like a woman with a Gandhi cap and short tunic; she is squatting with folded legs and holds a small animal on her lap which is either a rabbit or a deer.

STAND

The 270 mm high stand is clearly made after European models, but it is dated 1228, i.e. five years after the globe was made.

The horizon ring is calibrated in single degrees: groups of 6° are numbered in *Abjad* from 12 to 90, separately in each quadrant. Next to these are added common Arabic/Persian numerals continuously, but there is an error in counting.

The horizon ring is supported by two semicircular arcs which pass through a solid cylindrical unit. The meridian ring also passes through this unit rather tightly, but it can be moved so that the inclination of the axis of the globe can be changed according to the local latitude. The axis of the globe is attached at both ends to the meridian ring. The cylindrical unit is supported by three curved legs between which there rests a magnetic compass on a triangular platform. The compass is surrounded by a wind-rose on which is the names of directions are written and also the phrase *khaṭṭ samt qiblah,* 'the line of azimuth of *qibla*'.

On the glass cover above the magnetic compass in written in three lines 1228 | *ḥaydarābād* | *farkhundah ᶜālam,* '1228 AH [AD 1813] | Hyderabad| auspiciousness of the world'.

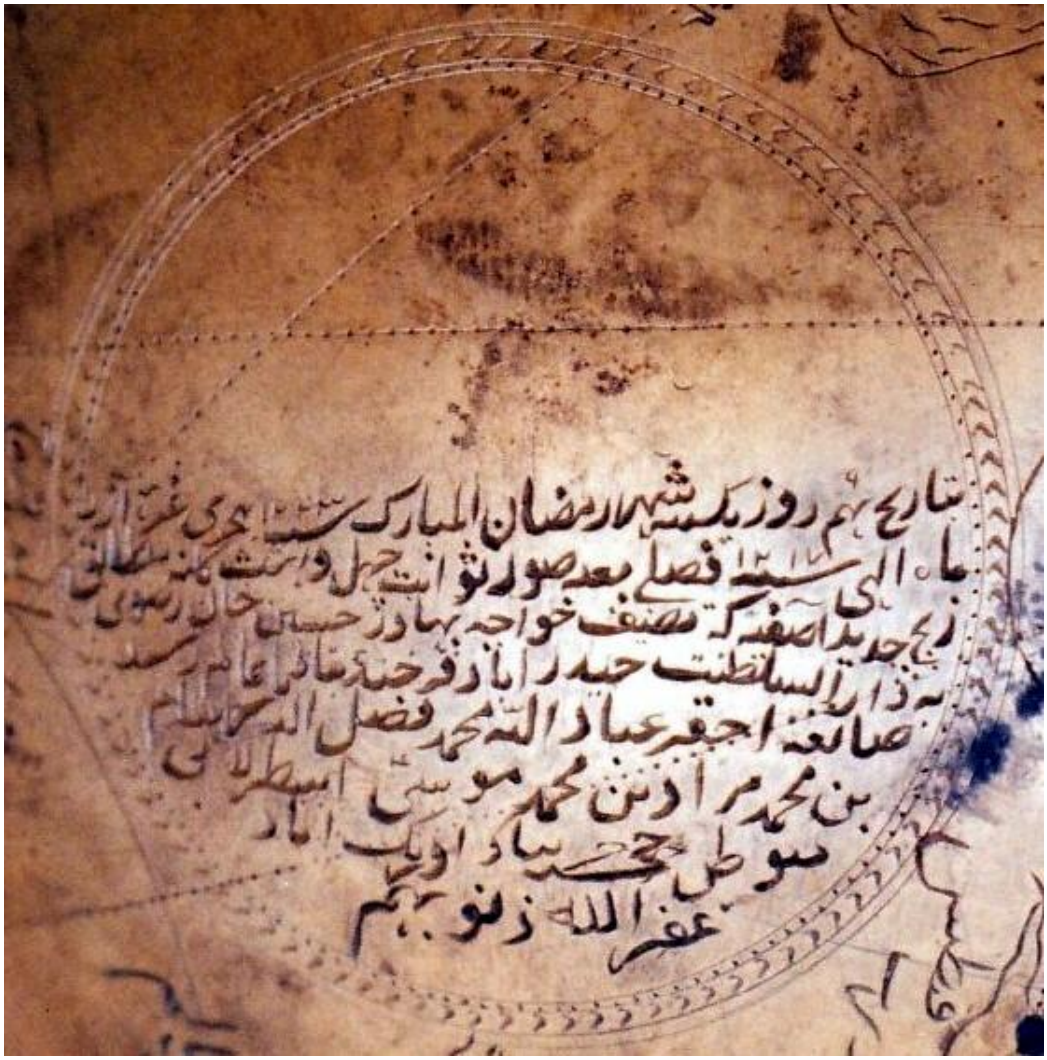


Figure G005.4 – Inscription (photo by S. R. Sarma)

INSCRIPTION

There is a long inscription in the house of Pisces in the southern hemisphere; it is engraved in 8 lines inside a roundel with a decorated border and reads as follows:[1189]

(1) ba-tārīkh nahum rūz yakshanba shahar al-ramaḍān al-mubārak sanah 1223 hijrī ghurrah ādhar

(2) māh ilāhī sanah 1217 faṣalī baʿd ṣuwar thawābit chahal wa hasht kānah muṭābiq

(3) zīj jadīd aṣafiyah keh muṣanif khwājah bahādur ḥussayn khān riḍwī

(4) ba-dār al-salṭanat haydarābad farkhundah bunyād ālam raṣad

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[1189] I am grateful to Mubashir Ul-Haq Abbasi for his help in deciphering and translating this inscription.

(5) ṣānᶜah aḥqar ᶜibād allāh muḥammad faḍl allāh … …

(6) ibn muḥammad murād ibn muḥammad mūsā asṭurlābī

(7) mutawaṭṭin khujastah bunyād awrankābād

(8) gafr allāh dhanūbaham.

(1) 'On the 9th day, Sunday, in the holy Month of Ramadan of the year 1223 Hijrī, [i.e.] the first day (*ghurrah*) of Ādhar,

(2) the divine month (*ādhar māh ilāhī*), of the year 1217 *Faṣlī,* the forty-eight (*chahal wa hasht*) figures (*ṣuwar*) of the fixed stars (*thawābit*) [were drawn] according to

(3) the *Zīj Jadīd Aṣafiyah,* authored by Khwājah Bahādur Hussayn Khān Riḍwī

(4) at the capital city of the kingdom, Hyderabad, the auspicious foundation of the world (*farkhunadah bunyād ᶜālam*);

(5) made by the most contemptible of the servants of God, Muḥammad Faḍl Allāh …,

(6) son of Muḥammad Murād, son of Muḥammad Mūsā Asṭurlābī,

(7) the resident of the blessed foundation (*khujastah bunyād*) Awrangābād.

(8) May God forgive his sins.

Dar al-Salṭanat Ḥaydarābād Farkhundah Buniyād ᶜĀlam appears to be the official title of the city of Hyderabad during the reign of the Asif Jahi dynasty (1724-1948). *Ḥaydarābād Farkhundah ᶜĀlam* is written above the magnetic compass. Moreover, the coins issued at Hyderabad carried the mint name *Ḥaydarābād Farkhundah Bunyād.*[1190] Likewise *Kujasthah Bunyād Awrangābād* appears to be the official title of Aurangabad in this period.

For administrative and fiscal reasons, Akbar introduced a solar calendar in 1584 and named it *Tārīkh-i Ilāhī*, or 'divine calendar'. The years were counted retrospectively from the Nauroz of the year 963 AH (AD 1556), which occurred a few days after Akbar's accession. The names of the months are the same as those in the Persian Yazdjardi solar

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[1190] Perhaps the Persian attribute *Farkhundah Buniyād* is an allusion to Bhāgya-nagar, which is said to be the earlier name of Hyderabad, for *bhāgya* in Sanskrit (prosperity, wealth, good fortune) and *farkhundah* in Persian (auspiciousness) have a similar connotation.

calendar, but carried the prefix *māh ilāhī.* Thus the first month was called *Farwardīn-māh-ilāhī.* Each day of the month had a also different name.[1191] This new calendar served as the official calendar of the Mughal empire for about three quarters of a century from its introduction in 1584.

A regional variant of this calendar is the *Faṣlī* (from the Arabic *faṣl,* 'harvest') calendar; here the months are the same, but the years are not counted from Akbar accession, but continued from 963, which is the *Hijrī* year when the new calendar came into force. That is to say, year 1 in *Ilāhī* calendar is year 963 in *Faṣlī* calendar.[1192] This *Faṣlī* calendar was the official calendar of the Asif Jahi rulers of Hyderabad.

BIBLIOGRAPHY

Sarma 1996a, pp. 27-28, Pl. 15.

1191 Akbarnāma II, pp. 15-24; cf. Sarma 2009c, pp. 139-140.

1192 Sewell & Dikhsit 1896, p. 44.

G006⊙ CELESTIAL GLOBE BY GHULĀM ḤUSSAYN JAWNPŪRĪ, 1231 AH (AD 1816)

Diameter 178 mm

Aligarh, PC



Figure G006.1 – Globe with stand (photo by Ghulam Mujtaba)

Ghulam Hussayn Jawnpūrī (1790-1882) was the court astronomer of the Raja of Tikari (24° 57' N; 84° 53' E) in Bihar and the author of seven books on mathematics and astronomy; these include the astronomical tables entitled *Zij-i Bahādurkhānī* and the encyclopaedia of mathematics and astronomy called *Jāmiᶜ Bahādurkhānī*.[1193] The second chapter of the fifth book of this encyclopaedia deals with the construction and

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[1193] On the astronomical observations made by him, cf. Kapoor 2016.

use of the following twelve astronomical instruments, together with their illustrations: 1. celestial globe, 2. astrolabe, 3. sine quadrant (*ruba*^{c} *mujayyayb*), 4. double ring (*dhāt al-ḥalqatayn*), 5. meridian wall or mural quadrant (*labnah*), 6. Fakhrī sextant (*suds fakhrī*), 7. equinoctial ring (*ḥalqah i*^{c}*tidālī*), 8. *shāmlah ufaqī* (a theodolite-like stand for the telscope), 9. armillary sphere (*dhāt al-ḥalaq*), 10. triquetrum (*dhāt al-shu*^{c}*batayn*), 11. dioptre (*dhāt al-thuqbatayn*), 12. Reflecting telescope.[1194] Ghulām Ḥussayn appears to have constructed all these twelve types of astronomical instruments and used them for instruction and observation, but only the present celestial globe survives.

The globe is cast as a single hollow sphere by the lost wax process; there are circular plugs at the two equatorial poles. The globe and the stand are well crafted, but the quality of engraving and rendering of the constellation figures do not match with Ghulām Ḥussayn's scholarship.

Circles

On the globe, the equator and the ecliptic are marked by double bands of lines: one band is graduated in 1° and in the other band groups of 5° are numbered in *Abjad* notation. The equator is numbered from 5 to 360 continuously from the vernal equinox onwards, while the ecliptic is numbered from 5 to 30 separately in each zodiac sign. The names of the zodiac signs are engraved along the ecliptic. The tropics are marked by single lines. Single lines mark also the ecliptic latitude circles and the equatorial polar circles. However, the circles are not traced properly; the lines are crooked and uneven. The quality of engraving is rather poor.

Constellation Figures and Stars

All the 48 constellation figures are drawn and about 1020 positions of stars are marked with inlaid silver points. Ghulām Ḥussayn states that he had determined the star positions afresh by direct observation at Tekari. The titles of the constellation figures are preceded by the term *sūrat* (spelt صورة).

The constellation figures are not particularly attractive. The human figures are depicted in an indifferent manner. Men and women are shown without any

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[1194] Jawnpūrī 1835, pp. 515-521.

differentiation of sexes. Faces are generally in three-quarters profiles; the hair is indicated by a few vertical strokes; the clothing is minimal. The figures of the snakes are drawn very crudely, so also the figure of the ship in Argo Navis and the chair on which Cassiopeia is seated.



Figure G006.2 – Ursa Major (photo by Ghulam Mujtaba)

Perhaps Jawnpūrī' most successful figure is **Ursa Majoris** where the bear is drawn almost realistically and the all the major stars are named. The title of the figure is written next to the face as *ṣūrat Dubb al-Akbar,* 'figure of the Great Bear'. The star on the back is named *Ẓahr al-Dubb al-Akbar,* 'back of the great bear' (α Ursae Majoris); the star a little below *Mirāq al-Dubb al-Akbar,* 'loin of the bear' (β Ursae Majoris) and that on the thigh *Fakhdh al-Dubb al-Akbar,* 'thigh of the great bear' (γ Ursae Majoris). But the star at the base of the tail is not named *Maghriz al-Dubb al-Akbar,* 'base of the Great Bear' (δ Ursae Majoris) as it should be, but as *al-Naᶜsh,* which is the collective name for all the four stars that form the rectangle on the body (αβγδ Ursae Majoris).

The stars on the tail are named individually as *Jawn,* 'black horse' (ε Ursae Majoris); *ᶜAnāq,* 'goat' (ζ Ursae Majoris) and *Qā'id,* 'leader' (η Ursae Majoris), and their collective name *al-Banāt,* 'the daughters' (εζη Ursae Majoris) is written above the tail.

The pairs of stars on the three paws are engraved as *Qafzah al-Ulā,* ‘first leap’ (νξ Ursae Majoris), *Qafzah al-Thānī,* ‘second leap’ (λμ Ursae Majoris) and *Qafzah al-Thālith,* ‘third leap’ (ικ Ursae Majoris).



Figure G006.3 – Andromeda, Perseus, Cassiopeia and Cepheus (photo by Ghulam Mujtaba)

Figure G006.3 shows four human figures, Andromeda, Perseus, Cassiopeia and Cepheus. They are all clothed in tunics, of which just the lower parts below the sash are shown somewhat distinctly. In the upper half, neither the sleeves, nor the necklines are marked. The sash itself is shown by just two parallel lines. In the case of Cassiopeia, short loose ends are indicated. Cepheus wears a tall conical hat; others are bareheaded. The chair on which Cassiopeia is seated is incomplete; there are just the two tall back-posts and the bases of the two front legs. The seat is not depicted where Cassiopeia’s body should rest.

The figure of Andromeda is entitled *ṣūrat al-Musalsalah,* ‘figure of the chained [woman]’; the star on her forehead is named *Rās al-Musalsalah,* ‘head of the chained [woman]’ (α Andromedae). The title of Perseus is engraved as *ṣūrat Barsā’ūs,* ‘figure of Perseus’; the star on the Ogre’s head is named *Rās al-Ghūl,* ‘head of the Ghoul’ (β

Persei). The figure of Cassiopeia is labelled as *ṣūrat Dhāt al-Kursī,* 'figure of the one with the chair' and the star on her elbow *Kaff al-Khaḍīb,* 'dyed hand' (β Cassiopeia). The figure of Cepheus carries the title *ṣūrat Qīqā'ūs,* 'figure of Cepheus'; the star on his right foot has the name *al-Rā'ī,* 'the shepherd' (γ Cephei).



Figure G006.4 – Ophiuchus (photo by Ghulam Mujtaba)

Figure G006.4 shows the clumsily drawn scales of the equator and ecliptic, and Ophiuchus holding the serpent with both his hands. The serpent and its coils are very crudely drawn. Adjacent to the head of Ophiuchus is the head of Hercules; the scraggy hair on both these heads is drawn in one single sweep. At the bottom on the right is the head of Sagittarius. The figure of Ophiuchus is entitled *ṣūrat al-Ḥawwā,* 'figure of the serpent charmer' and the star on his forehead *Rās al-Ḥawwā,* 'head of the serpent charmer' (α Ophiuchi). Interestingly, the figure of Sagittarius is given the title *ṣūrat al-Rāmī,* 'figure of the archer', and not the usual title *ṣūrat al-Qaws*.



Figure G006.5 – Centaurus (photo by Ghulam Mujtaba)

Centarus is dressed just in a skull-cap; his face is shown in profile. The vine twig in his right hand has a strange shape. With the left hand he appears to be holding the front legs of an animal with the face of a lion. The figure of Centaurus is labelled as *ṣūrat al-Qanṭūrus,* 'figure of Centaurus' and the star on the horse's hoof is named *Rijl al-Qanṭūrus,* 'foot of Centaurus' (α Centauri). **Lupus** carries the label *ṣūrat al-Sabᶜ*, 'figure of the wild beast'. At the lower right corner is the figure of the incense burner **Ara** which is entitled *ṣūrat al-Mijmarah.*



Figure G006.6 – Argo Navis (photo by Ghulam Mujtaba)

The ship in the constellation **Argo Navis** is a crude approximation of a ship. It has a rectangular structure, occupied mostly by a single cabin with a domed roof. At the front is a tall structure which culimiates into a bird's head. A large sail hangs down from the main mast. The title reads *ᶜṣūrat al-Saᶜfīnah.*

STAND

The globe is set up on a stand of 120 mm height. The stand consists of a horizontal ring to which three legs are attached. The legs are curved in the form of inverted letter *S*. The lower tips of the legs rest on circular discs. The horizontal ring is graduated in 1°, and groups of 5° are numbered in *Abjad* notation. The same is the case with the meridian ring. The axis passes through the poles of the equator and is fixed firmly on both sides to the meridian ring. In order to adjust the globe to the local latitude, the meridian ring together with the globe has to be moved within the notches cut in the horizontal ring.

This tripod stand resembles, to a large extent, the tripod stands of the globes made by Ḍiyā' al-Dīn Muḥammad. In his *Jāmiᶜ Bahādurkhānī,* however, Ghulām Ḥussayn illustrates a totally different kind of stand, as shown below.

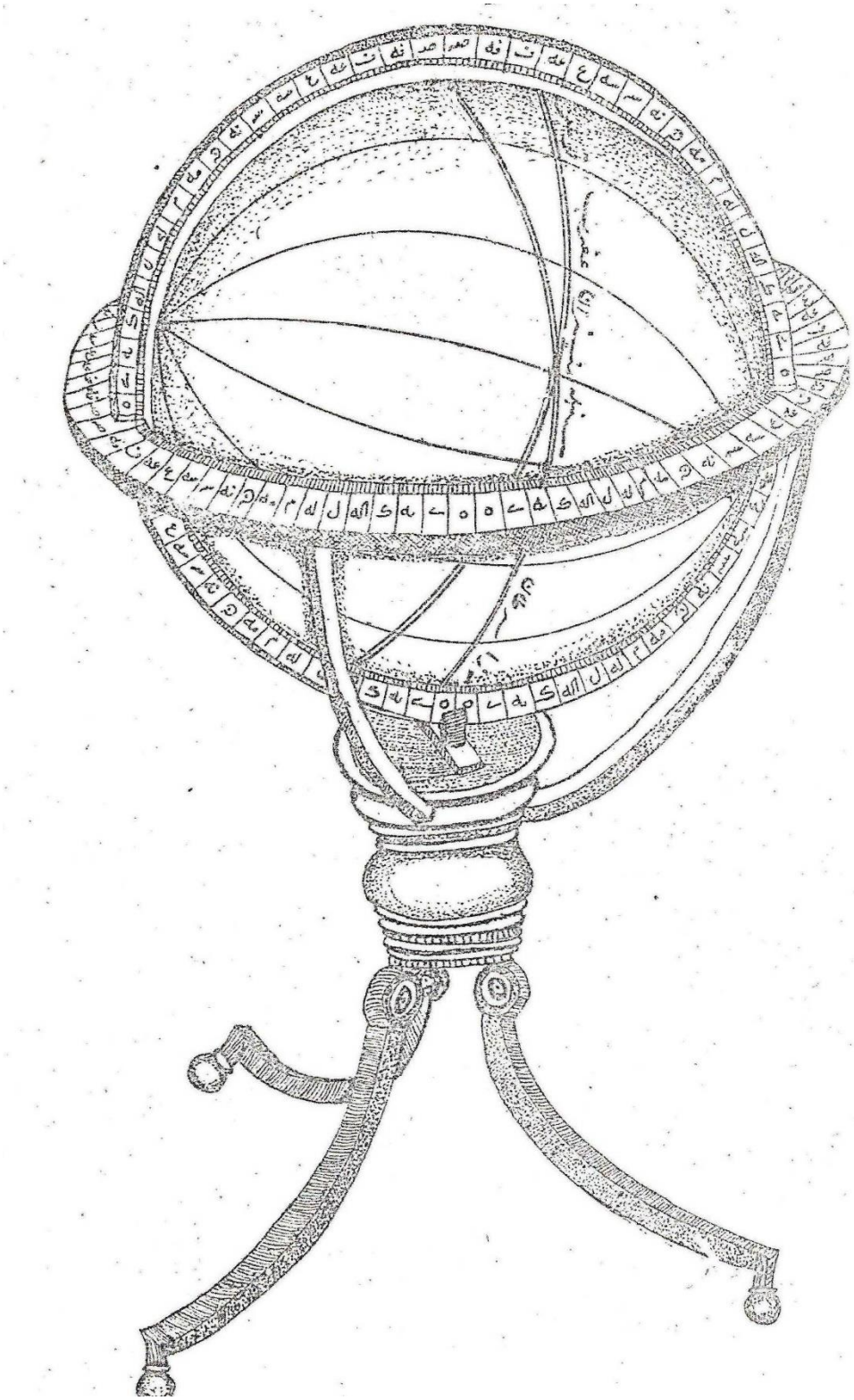


Figure G006.7 – Illustration of the celestial globe in the *Jāmic Bahādurkhānī*

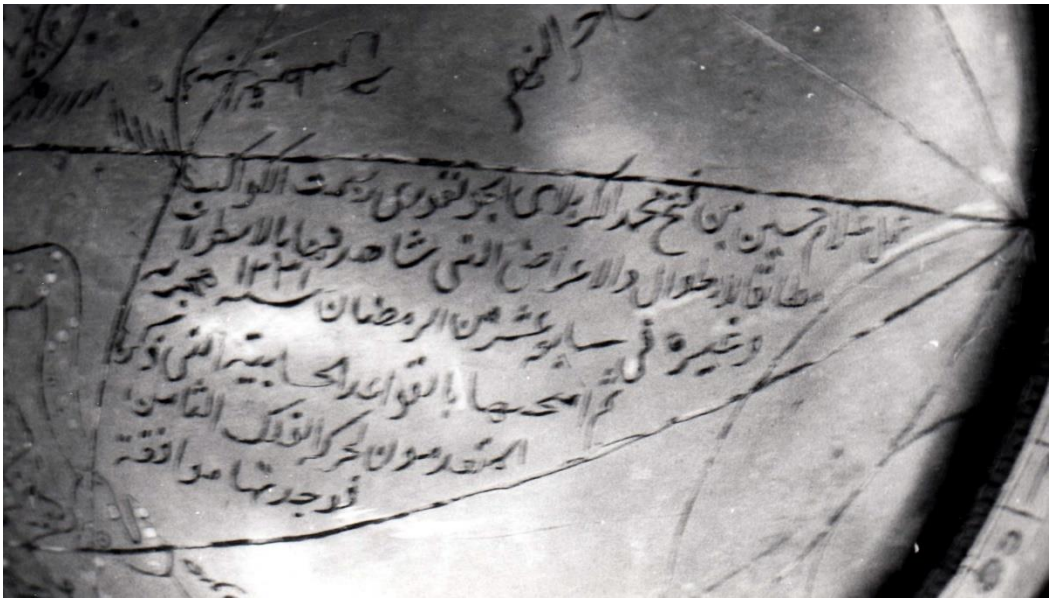


Figure G006.8 – Inscription (photo by Ghulam Mujtaba)

INSCRIPTION

The lower half of the Pisces segment is occupied by an inscription in Arabic in five lines, which translates as follows:

> 'The work (*ʿamal*) of Ghulām Ḥussayn ibn Fateh Muḥammad al-Karbalā'ī al-Jawnpūrī. The stars (*kawākib*) are placed according to the longitudes and latitudes which I had observed with the help of the astrolabe and other [instruments] on the 17th Ramaḍān 1231 Hijrī [= 10 August 1816]. Then I tested it (the celestial globe) on the basis of the mathematical rules (*qawā'id al-hisābiyah*) enunciated by the Ancients (*mutaqaddamīn*) in connection with the eighth sphere and found it to be in accordance with the rules.'[1195]

BIBLIOGRAPHY

Ansari & Sarma 1999-2000

[1195] Translation by Professor S. M. Razaullah Ansari; cf. Ansari & Sarma 1999-2000.

G007 CELESTIAL GLOBE BY MUḤAMMAD KARĪM, 1241 AH (AD 1825-26)[1196]

Diameter 126 mm

London, Victoria and Albert Museum (# M24-1882)

ESS 74

No other instrument by this Karīm has come to light so far; it is not known where he lived and worked. The globe is cast as a singe hollow sphere; there are several plugs including a large square plug near the southern ecliptic pole.

CIRCLES

The equator and ecliptic are divided in 1° and 6°; the equator is numbered continuously from 6 to 360 starting at the vernal equinox; the ecliptic is numbered from 6 to 30 separately in each zodiac sign. The names of zodiac signs are engraved along the ecliptic; also the names of the lunar mansion at intervals of 12;30°. Ecliptic latitude circles are drawn; the solstitial colure is divided in 1° and 6°; the intervals of 6° are indicated by longer lines; these are numbered from 6 to 90, from the ecliptic up to the northern and southern equinoctial poles. There are also ecliptic latitude circles.

CONSTELLATION FIGURES AND STARS

There are no constellation figures. About 80 positions of stars are marked with inlaid silver points and labelled in most cases. The ecliptic poles are also named.

STAND

The stand and rings are missing.

INSCRIPTION

The signature of the globe-maker is engraved inside the southern equatorial polar circle:

ᶜamal muḥammad karīm sanah 1195 yajdijird shamsī
sanah 1241 hijrī

[1196] Entry based on Savage-Smith 1985, No. 74, p. 255.

‘The work of Muḥammad Karīm [in the year] 1195 Yajdijird Solar (*shamsī*) era; [in the year] 1241 Hijrī.’

PROVENANCE

The globe was acquired in India and donated to the Victoria and Albert Museum in 1882.

BIBLIOGRAPHY

Savage-Smith 1985, No. 74, p. 255.

G008⊙ Celestial Globe by Lālah Bulhomal Lāhorī, VS 1899, AH 1258, AD 1842

Diameter 330 mm

London, Science Museum (# 1985-1257)

ESS 33; Répertoire 1



Figure G008.1 – Globe with stand (photo by S. R. Sarma)

This large and ornate globe was created for Nihāl Singh Ahlūwaliya, the Raja of the small princely state of Kapurthala in Panjab, by Lālah Bulhomal Lāhorī, the astronomer (*munajjim*), geometrician (*muhandis*) and astrologer (*hay'atdār*) attached to the court of Kapurthala. For this work he was rewarded by the Raja with the princely sum of 490 gold *Ashrafīs*.

The globe was produced as a single hollow sphere by the lost wax process, with one large plug near the southern poles and several small plugs elsewhere.

CIRCLES

On the globe are drawn the ecliptic and equator in double bands and graduated in 1° and 6°. The groups of 6° are numbered on the equator serially from 1 to 60 from the vernal equinox onwards. On the ecliptic these divisions are numbered from 6 to 30

separately for each sign. The names of the signs are written along the ecliptic. Parallel to the equator are drawn the tropics and two lesser circles at 12° and 20° on either side. There are six ecliptic latitude circles at right angles to the ecliptic and another six great circles at right angles to the equator, the latter commencing at 6° west of the vernal equinox.

Constellation Figures and Stars

In the long inscription, Bulhomal expressly states that he drew the complete set of 48 classical constellation figures and marked the positions of 1022 stars with inlaid silver nails. Next to the constellation figures are engraved their names and serial numbers. The stars in each constellation are numbered serially and some prominent stars are labelled.

Stand

The globe is mounted on an ornate stand consisting of a graduated horizon ring, a graduated meridian ring, a zenith ring in two parts, and three *S*-shaped legs; these are held firm with winged bolts.

The horizon ring is divided in 1° and 6° and numbered in 6s, separately in each quadrant, starting at the east and west points and proceeding on either side to the north and south points. At the four cardinal points, there are rectangular slots to accommodate the meridian ring and the zenith ring. In the meridian ring, the recessed half is divided in 1° and in the other half the intervals of 6° are marked on both faces. The intervals of 6° are numbered in *Abjad* as well as common numerals on the upper face, separately in each quadrant.

At the apex of the zenith ring, there is an ornate triangular projection. At the lower point, around the Nadir, there is also a matching projection. Under both these projections, there are slots to accommodate the passage of the meridian ring. The three curved legs rest on circular bases with multiple tiers. Decorative patterns are engraved on the triangular projection at the apex of the zenith ring, on the three sides of the zenith ring, on the outer edge of the horizon ring and on the three legs.



Figure G008.2 – Inscription (photo by S. R. Sarma)

INSCRIPTION

Near the south equatorial pole is a long inscription in Persian in eight lines which states as follows: [1197]

> 'The celestial globe encompasses the visible nature of the sphere of ecliptic and 10 great circles, among which are the horizon circle [ring], meridian circle [ring], zenith ring (*dā'irat sumūt*) and altitude ring (*dā'irat irtifāᶜ*)— each of these four surrounding the globe itself— and the celestial equator, ecliptic, ecliptic latitude circles (*dawā'ir ᶜurūd*), solstitial colure (*marah bi-*

[1197] The full text of the inscription in Persian and an English translation are given by Savage-Smith 1985, pp. 291, 235. The Persian text and a French translation are given also in Répertoire 1. Here we reproduce the translation as given by Savage-Smith.

aqtāb arbaᶜah), lacking [the circle] of inclination[1198], and declination circles (*dawā'ir muyūl*, meridians); these six circles move with the body of the globe, drawn and designed over 48 constellations—i.e., 21 north, 15 south, and 12 constellations which are along the main part of the zodiac which exists in the middle—and 1022 observable stars which are indicated by silver nails, resulting in a summary of the principles relating to time, place and direction, which are called Three Principles.[1199]

'By order of the exalted benefactor and wealthy (*gunjūr*) Singh Ṣāhib, benefactor of [his] time, unique in [his] lifetime, the end of [his] epoch, Nihāl Singh Ṣāḥib Bahādur Ahluwālīyah, who in all sciences, especially the science of mathematics—which is to say astronomy and geometry—is incomparable and unique in the world, through the efforts of Lālah Bulhomal Lāhūrī, astronomer, geometer, and astrologer, who is one of those attending the honourable Singh Ṣāḥib mentioned before, and who was paid a bonus of 10 *ashrafī* [in addition to] 480 *ashrafī* on completion of the design, an object of special favour, it was made in 1899 in the Vikrama era, corresponding to 1258 H, which is equal to AD 1842. It was placed at the capital Kapūrthalah.'

The inscription is dated in three eras that were in use in India about that time. Vikrama Saṃvat 1899 runs from 11 April 1842 to 30 March 1843 and the Hijrī year 1258 from 11 February 1842 to 30 January 1843. Therefore, the globe was made, or rather completed, some time between 11 April and 31 December 1842.

About the *Ashrafi* coins given to the globe maker, Emilie Savage-Smith states: 'The text speaks of *guldār ashrafī; ashrafī* are gold coins and *guldār* meaning "decorated with flowers" must refer to a coin of a particular floriate design.'[1200] The *Répertoire* also transcribes the expression as *guldār ashrafī* and translates as

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1198 Cf. Savage-Smith 1985, p. 236, endnote: 'It reads simply *ᶜadīm al-mayl* (lacking inclination); the meaning is obscure. Perhaps the maker intends to say that the globe is lacking the equinoctial colure, which is called *dā'irat al-mayl,* thus reading it *ᶜadīm dā'irat al-mayl.*'

1199 In Sanskrit astronomical texts of the type called *Siddhāntas,* the third chapter is usually entitled the chapter on *tri-praśna,* 'the three questions or topics,' these being the determination of the direction (*dik*), place (*deśa*) and time (*kāla*) with the help of the gnomon. Bulhomal is clearly referring to this chapter by the expression 'three principles'.

1200 Savage-Smith 1985, p. 236, endnote.

'fleurissants'. But this is a misreading of the attribute; it should be read *kaldār,* which means 'machine-struck coin' in numismatic parlance.[1201]

Already in the eighteenth century the British East India Company began issuing their own coinage, which included the gold coin which carried the name 'Gold Mohur' in English and *Ashrafī* in Persian. In 1835 the Company standardized the coin with a value equal to 15 silver Rupees and made it the legal tender for all its Indian territories. Since the princely state of Kapurthala did not issue its own coinage, it must have been these 'machine-struck' *Ashrafī* coins of the East India Company which Bulhomal received in 1842.

PROVENANCE

Formerly in the collection of the Maharaja of Kapurthala; offered for sale in Geneva in 1976; acquired by the Science Museum, London, in 1985.

BIBLIOGRAPHY

Savage-Smith 1985, no. 33, pp. 235-236, Fig. 24
Garg 1992.
Sarma 2015b, no. [10], p. 272.

[1201] I am grateful to Dr Sanjay Garg, National Archives of India, New Delhi, for explaining the numismatic connotation of the term *kaldār*.

G009 CELESTIAL GLOBE BY LĀLAH BULHOMAL LĀHORĪ, VS 1899, AH 1258, AD 1842[1202]

Diameter 177.8 mm

Karachi, National Museum of Pakistan (# N.M.1957.1049)

ESS 127



Figure G009.1 – Globe (courtesy Dr Nasim Naqvi)

This globe, produced in the same year 1842 as the previous globe, was meant for the instruction of the son of a certain Khushī Rām. It is not known who this person was, but the name indicates that he was a Hindu, probably belonging to Lahore or Kapurthala in Panjab. It is interesting that a celestial globe with Arabic/Persian legends was employed for teaching astronomy to a Hindu boy in the mid-nineteenth century Panjab.

[1202] Entry based on photos kindly sent by Dr Nasim Naqvi and material and photos generously provided by Mubashir Ul-Haq Abbasi.

Unfortunately, however, the globe is heavily corroded; the silver nails marking the star positions have disintegrated and many of the engravings became indistinct.

Circles

As in other globes, here also the equator and the ecliptic are divided in 1° and 6°; the intervals of 6° are numbered on the equator serially from 1 to 60, starting from the vernal equinox, but on the ecliptic these are numbered from 6 to 30 separately in each sign. The names of the signs are engraved along the ecliptic. Parallel to the equator are drawn the tropics, polar circles and two lesser circles at 12° and 20° on either side. There are six ecliptic latitude circles at right angles to the ecliptic and six great circles at right angles to the equator, the latter commencing at 6° west of the vernal equinox.

Constellation Figures and Stars

In the long inscription, Bulhomal expressly states that he drew the complete set of 48 classical constellation figures and marked the positions of 1022 stars with inlaid silver nails. Next to the constellation figures are engraved their names and serial numbers. The stars in each constellation are numbered serially and some prominent stars are labelled.

The male figures are generally dressed in short tunics, but there is some variation in details: some have V-necks and some round necks; in some the upper flap closes in the front, in some on the right; but in all the collars are decorated with geometrical patterns. All wear a sash around the waist; here also the two loose ends are drawn differently in each case. Similar variations occur in the headgear and in the beards. All wear armlets and bracelets.



Figure G009.2 – Perseus and Auriga (detail of Figure G009.1)

Auriga is dressed in a short tunic which terminates above the knees. The tunic has a V-neck and the collar is decorated with a geometrical pattern. Similar pattern is repeated on the arms and wrists as well, indicating armlets and bracelets. A sash is wrapped around the waist; the loose ends fall down together as one piece. He dons an elegant turban. The figure is entitled *Mumsik al-Aᶜinnah,* 'he who holds the reins', followed by the serial number 12. Three stars are named in this constellation: the star on his right shoulder is named *ᶜAyyūq* (α Aurigae, Capella), the star on the left shoulder *Mankib Dhī al-ᶜInān,* 'the shoulder having the reins' (β Aurigae, Menkalinan) and the star on his ankle which is common to a horn of Taurus is given the name *Kiᶜāb Dhī al-ᶜInān,* 'ankle having the reins' (γ Aurigae = β Tauri).

Perseus also wears a short tunic; a sash is wrapped around his waist, the two loose ends fall down in the form of the inverted letter V. He wears armlets and bracelets, but no turban. His hair is depicted with many closely drawn lines; his eyebrows, eyes, nose and mouth are clearly drawn. The same care is shown in the ghoul's head as well, which is depicted with straight and long mustaches and well-shaped beard.

The title of the figure cannot be deciphered. The star on the shin-bone of his right leg is named *Mankib al-Thurayyā,* 'shoulder of *al-Thurayyā'* (ξ Persei) and the two stars on the right foot are labelled as *ᶜĀtiq al-Thurayyā,* 'shoulder-blade of *al-Thurayyā*' (ο

Persei). The star on the ghoul's head is labelled as *Rās al-Ghūl,* 'head of the ghoul' (β Persei, Algol).

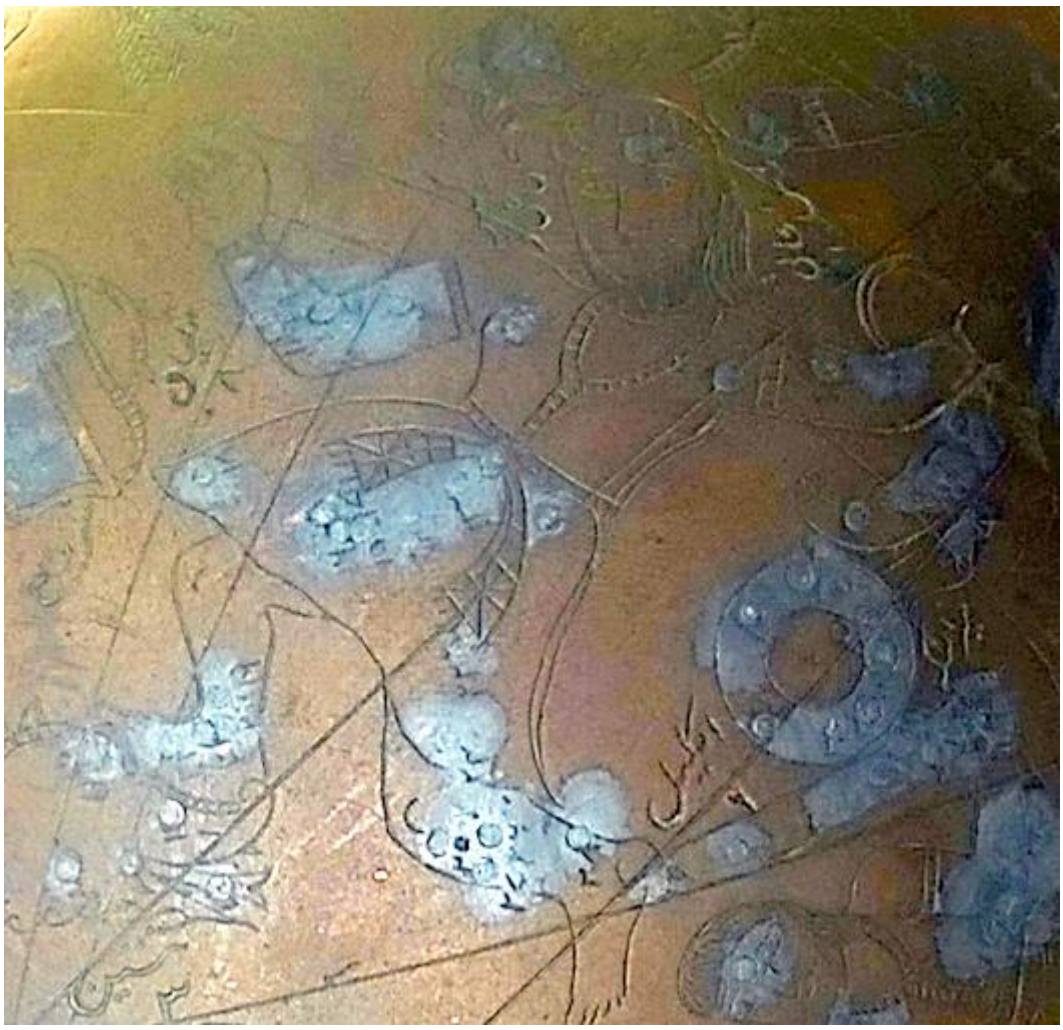


Figure G009.3 – Hercules (photo by Mubashir Ul-Haq Abbasi)

Hercules is dressed in a short tunic with a round neck; the upper flap closes in the front, the lower half is elegantly flared. A narrow sash is wrapped around his waist; the two loose ends are decorated with geometrical patterns. He is adorned with armlets and bracelets. He wears a simple turban; his long hair can be seen to the left of his bearded face. He holds a curved sickle in his left hand. The title cannot be deciphered; but the star on his forehead is named *Rās al-Jāthī,* 'head of the kneeling man' (α Herculis, Rasalgethi).

The figure of **Lyra**, to his right is labelled *Shulyāq 8,* 'tortoise'. The figure of **Corona Borealis** on his right is given the unusual name *Iklīl 6,* 'crown', and not the usual *al-Fakkah.* But the star in this constellation is named in the usual manner as *Nayyir al-Fakkah,* 'luminous one of *al-Fakkah'* (α Coronae Borealis, Alphecca).

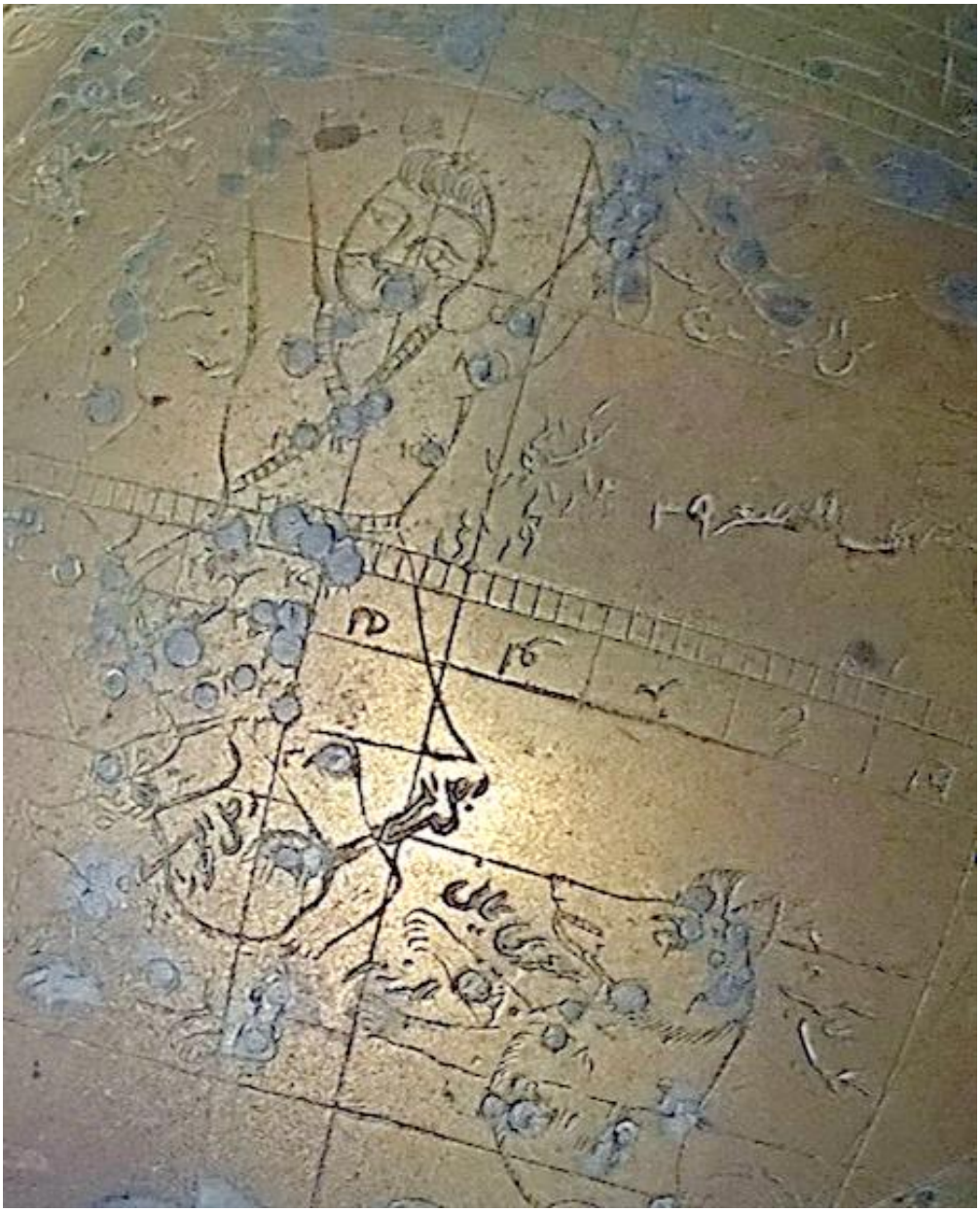


Figure G009.4 – Orion and Canis Major (photo by Mubashir Ul-Haq Abbasi)

Orion's tunic is longer and reaches up to his ankles. The collar is decorated with a geometrical pattern; the upper flap closes on his right. There is a sash around the waist, but no loose ends hanging down. He wears no headgear; his hair is neatly combed back. He holds a weapon in his left hand which is not clearly defined. The sleeve on his right arm is elongated as on other globes. There are several named stars in this figure.

The figure of the hare is drawn immediately below the feet of Orion as if he is standing on it. It looks more like a piglet than a hare.

To his lower left is the fierce figure of Canis Major with the label *Kalb al-Akbar 38,* 'greater dog'. The large star on its chin is named *Shiʿrā Yamānī,* 'the southern *Shiʿrā*'

(α Canis Majoris, Sirius). The outline of its body is drawn with short oblique strokes to suggest hairy nature of the body.

INSCRIPTION

A long inscription in 8 lines is engraved near the southern poles in the houses of Capricorn, Aquarius and Pisces. The first part consisting of the first five lines and the beginning of the sixth line is exactly the same as on globe G008. The rest is the new operative part. For the first part, we reproduce the translation by Emilie Savage-Smith from G008 with slight modifications; the translation of the operative part is by Mubashir Ul-Haq Abbasi.



Figure G009.5 – Inscription (photo by Mubashir Ul-Haq Abbasi)

1. ‘The celestial globe (*kurah raṣadī*) encompasses the visible nature of the sphere of ecliptic and 10 great circles, among which are
2. ‘the horizon circle (i.e. ring) (*dā’irat ufq*), meridian circle (i.e. ring) (*dā’irat nisf al-nahār*), zenith circle (i.e. ring) (*dā’irat sumūt*) and altitude circle (i.e. ring) (*dā’irat irtifāᶜ*)—each of these four surrounding the globe itself— and the celestial equator (*dā’irat muᶜaddil al-nahār*),
3. ‘the ecliptic (*dā’irat minṭaqat al-burūz*), ecliptic latitude circles (*dawā’ir ᶜurūd*), solstitial colure (*marah bi-aqtāb arbaᶜah*), lacking [the circle] of inclination (i.e. lacking the equinoctial colure?), and declination circles (*dawā’ir muyūl*, meridians); these six circles move with the body
4. ‘of the globe, [which is] drawn and designed over 48 constellation figures (*taṣvīr*)—i.e., 21 north, 15 south, and 12 constellations
5. ‘which are along the main part of the zodiac which exists in the middle—and 1022 observable stars (*kawkab marṣūdah*) which are indicated by silver nails, resulting in a summary of the principles (*iḥkām*) relating to time (*jamānī*), place (*makānī*) and direction (*jahātī*),
6. ‘which are called Three Principles (*iḥkām thallathah*),’[1203]

   ‘through the efforts (*bi-tajwīz*) of Lālah Bulhomal Lāhūrī, astronomer / astrologer (*munajjim*), geometer / engineer (*muhandis*), and astrologer / astronomer (*hia’tdān*),

   for the instruction (*taᶜlīm*) and excercise (*taᶜmīl*) of the ‘light of the eyes’ (*nūr al-abṣār*) (i.e. the son) of Khushī Rām, at the capital of the Sultanate (*dār salṭanat*),
7. ‘Lahore, in the Saṃvat [year] one thousand eight hundred and ninety nine of Vikramāditya, corresponding to (*muwāfiq*) [the year] one thousand fifty eight Hijrī, which is equal to (*muwāfiq*) [the year] one thousand, eight hundred
8. ‘and forty two Christian era, was made.’

[1203] In Sanskrit astronomical texts of the type called *Siddhāntas,* the third chapter is usually entitled the chapter on *tri-praśna,* ‘the three questions or topics,’ these being the determination of the direction (*dik*), place (*deśa*) and time (*kāla*) with the help of the gnomon. Bulhomal is clearly referring to this chapter by the expression ‘three principles’.

BIBLIOGRAPHY

Savage-Smith 1985, no. 127, pp. 275-276.

Sarma 2015b, no. [11], pp. 272-273.

G010 CELESTIAL GLOBE ATTRIBUTABLE TO LĀLAH BULHOMAL LĀHORĪ[1204]

Not dated, mid-19th century

Diameter 370 mm

London, Nasser D. Khalili Collection of Islamic Art (# SCI 285)



Figure G010.1 – Globe with stand
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 285
Photo courtesy of the Khalili Family Trust © Nour Foundation

[1204] Entry based on Maddison & Savage-Smith 1997, I, no. 140. pp. 242-243, and the detailed photos generously provided by Nahla Nassar, the Registrar of the Nasser D. Khalili Collection of Islamic Art, London.

This globe is neither signed, nor dated. Even so, the characteristic stand and the engravings on the globe make it unmistakably certain that it was created by none other than Bulhomal Lāhorī. The globe is cast as a single hollow sphere by the *cire perdue* method. There are two large plugs at the tail of Cygnus in the north and at the lower part of Argo Navis in the south (Figure G010.8). A rectangular copper plug can be seen at the waist of Hercules (Figure G010.3) and several other smaller plugs of copper at different places.

There occurred a serious error in engraving. The work on this large globe began first with what is now the south pole. With this as the north celestial pole, the equator, the ecliptic and other circles were drawn. The equator and the ecliptic were divided in 1° and 6°. The intervals of 6° were numbered in *Abjad* notation in such a manner that the tops of the letters were towards this north pole. On the equator these intervals were numbered serially from 1 to 60, starting at the first meridian to the east of the vernal equinox. On the ecliptic, these are numbered from 6 to 30 separately in each zodiac sign. The names of the zodiac houses were written by inlaid silver, again in such a manner that the tops of the letters are towards the north pole. Then the first constellation figure of the Ursa Minor was engraved.

After all this was done, for some incomprehensible reason, the sphere was inverted and the other pole was taken as the north pole. Therefore corrections had to made in the markings on the ecliptic and equator. On the equator the intervals of 6° were renumbered so that the numbers now proceed eastwards from left to right. The new numbers were engraved next to or upon the old numbers, with the result that now each cell bears one *Abjad* number which is straight and another which is upside down. The names of zodiac houses written with inlaid silver were rubbed off and new labels are engraved with the correct orientation. No changes are made on the equator: the serial numbers there are now upside down and proceed from right to left, i.e., westwards. The constellation figure of Ursa Minor drawn previously before the poles were changed is retained and a new figure of Ursa Minor is drawn near the new northern poles. Savage-Smith attests that, in spite of these changes, ‘the workmanship on the globe is of high quality and the precision of the instrument is excellent for this period of instrument making.’

Interestingly, an inscription on the zenith ring carries the name of Jotishi Dharm Chand as the owner of the globe; he was himself an instrument maker known through ten extant instruments which will be discussed elsewhere in this catalogue.

Circles

The equator and ecliptic are divided in 1° and 6° and labelled in the manner explained above. Six great circles at right angles to the ecliptic and another six at right angles to the equator are traced; the former for measuring the ecliptic latitudes and the latter as meridians. But these meridian circles commence at 6° west of the vernal equinox.

There are equatorial tropics, another pair of circles parallel to the equator on either side at 12° and 20°, and polar circles.

Constellation Figures and Stars

The complete set of 48 Ptolemaic constellation figures are drawn and about 1022 positions of stars are marked with inlaid silver points. The names of the constellation figures are engraved together with their serial numbers. The stars in each constellation figure are numbered serially. Both these sets of numbers are in common Arabic/Persian numerals. But major stars are not named. The constellation figures are drawn with somewhat fainter lines, but the labels are incised with deeper strokes.

Bulhomal fills the constellation figures with very fine engravings. In the constellation figures of Ursa Major, Leo (Figure G010.2), Aries, Taurus (Figure G010.4), and Canis Major (Figure G010.10), the outlines of the animals are not drawn with simple lines, but with a series of very small oblique strokes to create the impression of the hairy surface. Moreover, the entire body of the bear in Ursa Major (Figure G010.2) is filled with similar tiny strokes. Even inanimate objects are embellished with ornate outlines, e.g. Lyra, Corona Borealis (Figure G010.3) and Triangulum (Figure G010.4).

The human figures are shown with minimum clothing; generally a short skirt, sometimes with pleats and sometimes without. Women like Andromeda and Virgo are bare-breasted. Men generally have one or two straps attached to the sash at the waist and going across the shoulders. The most distinguishing feature of men are the mustaches with the ends turned upwards, which reflects the contemporary fashion in the

mid-nineteenth century Panjab. Men wear long hair which falls down to the left of their faces. The engraver takes great pains to draw the hair on the head, of the beards, and even of the eye-brows. The men and women are drawn with large eyes, whether in profile or in front view.



Figure G010.2 – Ursa Major and other figures
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 285
Photo courtesy of the Khalili Family Trust © Nour Foundation

Figure G010.2 shows, besides Ursa Major and Leo, also a part of the figure of **Virgo**. Her face is in full profile; there are no lines to indicate her clothing; the available photo shows her full breasts, the northern wing, and interestingly both hands. While it is customary to depict her right arm vertically along the scale of the equator and to place the star α Virginis on the right palm, here the right arm is pointing northwards like the left arm. The available photo does not show where the star α Virginis is placed.

This figure also shows faintly the constellation figure of **Bootes**, with slightly bent knees, the right arm raised high and the left hand holding a strange object consisting of a series of heart-shaped pieces. He is clothed in a short skirt with many folds, held at the waist by a belt. His legs are bare; the upper part of the body is bare, but for two straps in the form of the letter X, like a pair of braces from the belt across both shoulders. The belt, the suspenders, the series of heart-shaped pieces are drawn with double lines

with dots between them. His beard is drawn with a series of vertical lines; his mustaches are straight with the ends turned upwards. The title of the figure is written as *ᶜAwwā 5.*

Hercules is an improved version of Bootes. He is also clothed in just a short skirt, of triangular shape with double outlines. There is only one suspender, crossing his torso from right end of the waist to the left shoulder. At the middle of the suspender is what looks like a hairy cross; is it supposed to indicate the hair on the chest? A scarf is tied to the suspender at the point where it crosses the cross; the scarf flutters to the left.

Great care is taken to delineate his face. His head is covered with a triangular cap with a small feather at the top; his long hair can be seen on the left of the face. His large eyes, nose and mouth are nicely drawn. In the eyebrows and in the upturned mustaches, every single hair is drawn very meticulously. His beard is parted in the middle and combed to form two separate triangles. He is adorned with armlets and bracelets.

Both his legs are bent in a kneeling posture and both his hands are raised. The left hand holds a weapon shaped like the elephant's goad. The title of the figure is written in large letters, cut deeply to the left of his head: *Jāthī ᶜAlā Rukbat,* 'he who is resting on his knees' followed by the serial number 7.

His companion, **Ophiuchus** offers a contrast in hair styles. The hair on his head is short, combed down onto the forehead; the beard is short, parted in the middle and combed sideways; other facial features, eye-brows, eyes, nose, mouth and mustaches are almost the same. The figure is entitle *Ḥawwā 13.*

Beneath the right foot of Hercules is the head of the dragon **Draco**, labelled *Tinnīn 3*. To his right is the constellation **Lyra**, entitled *Shulyā 8,* and to the left is **Corona Borealis**, with the title *Iklīl 6.* The outlines of these three figures are drawn with double lines with dots between them.

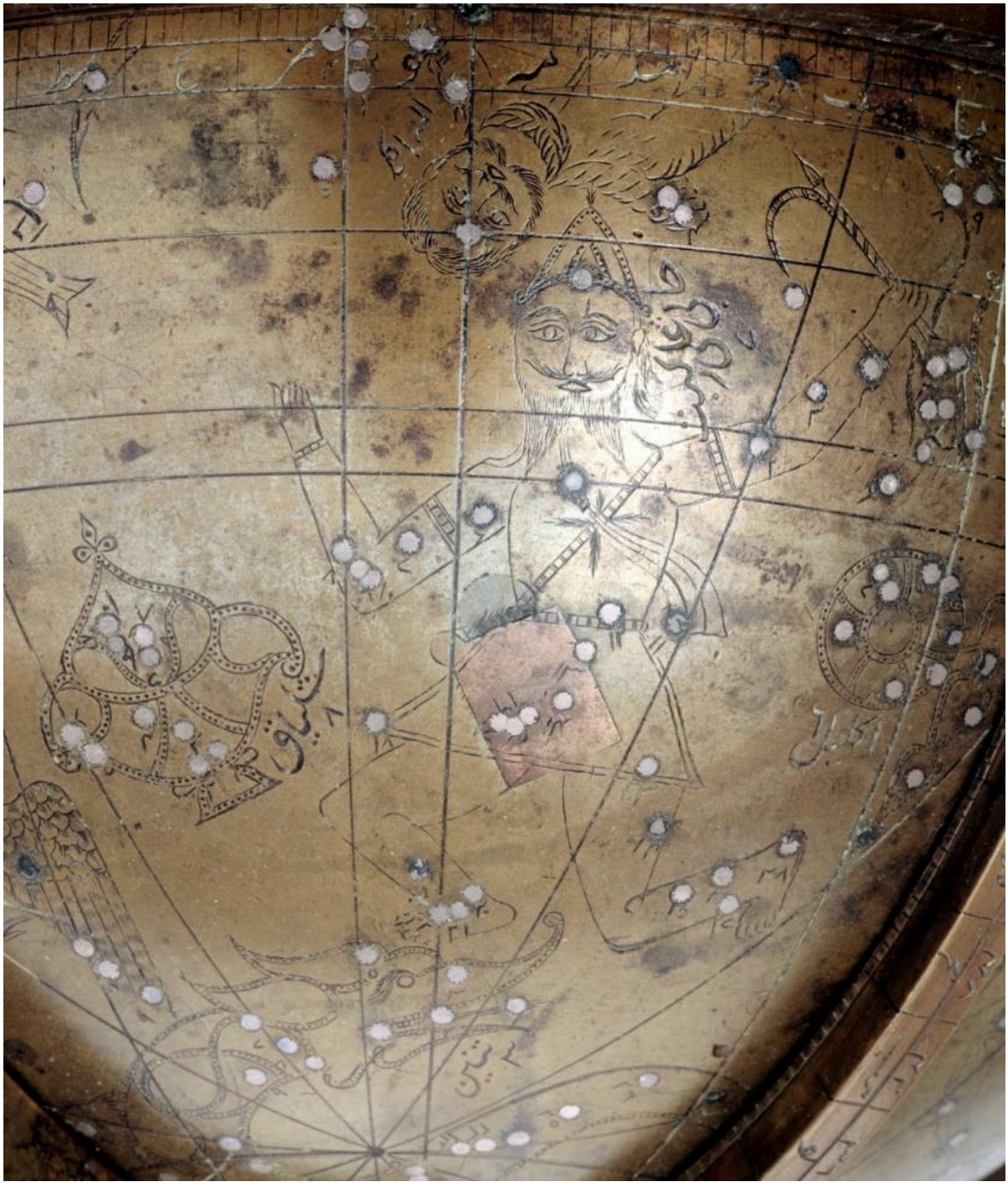


Figure G010.3 – Hercules.
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 285
Photo courtesy of the Khalili Family Trust © Nour Foundation



Figure G010.4 – Andromeda, Cassiopeia and Perseus
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 285
Photo courtesy of the Khalili Family Trust © Nour Foundation

Figure G010.4 shows Andromeda, Cassiopeia and Perseus above the ecliptic, and Aries and Taurus on the ecliptic. In the figure of **Perseus,** there are no lines to indicate his clothing, except a sash around his waist, the two loose ends of which hang down. With the right hand he holds the head of the ghoul and with the left hand a curved sword. A turban is faintly indicated on the head; his long hair falls down to the left of the face. His beard is thick and the ends of the slender mustaches are turned upwards. The figure carries the title *Barshā'ūsh,* followed by the serial number 11.

On the ecliptic scale are drawn the zodiac sign **Aries** (title *Ḥamal 22*) and **Taurus** (*Thawr 23*). Below Aries can be seen the head of **Cetus**; it is depicted as a bird's head instead of the traditional dog's head. The label next to it reads *Qayṭus 34*.

To the north of Perseus is the figure of **Andromeda**. She is clothed in a short pleated skirt; the upper clothing is not clearly drawn. Below the bare breasts, she seems to be wearing some bodice; she is decorated with armlets and bracelets. A chain is tied to her feet. In a charming variation, the engraver places a flower in her left hand. The title, engraved above left arm reads *al-Mar'ah al-Musalsalah 20.*

Under Andromeda's right arm is drawn the eastern fish of the constellation **Pisces**, with an ornate collar. To Andromeda's lower right is the figure of **Triangulum**, drawn with decorative outlines and with the label *Muthallath 21.*



Figure G010.5 – Andromeda holding a flower (detail)
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 285
Photo courtesy of the Khalili Family Trust © Nour Foundation



Figure G010.6 – Gemini and Cancer
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 285
Photo courtesy of the Khalili Family Trust © Nour Foundation

Figure G010.6 shows the zodiac signs Gemini and Cancer. **Gemini** is represented, following the Sanskrit convention, as a man and a woman; the male figure on the west is shown with hair, beard and mustaches; the female figure on the east is endowed with a belt around the waist. The title reads *Jawzā' 24.*

This figure is followed by the most artistic rendition of the crab which represents the zodiac sign **Cancer**. The claws and legs of the crab are formed into arabesque patterns on either side of the heart-shaped body. The figure is labelled as *Saraṭān 25.*

On the ecliptic scale can be seen the two styles of numbering of the intervals of 6°, one proceeding from the left to the right and the other in the opposite direction.



Figure G010.7 – Sagittarius
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 285
Photo courtesy of the Khalili Family Trust © Nour Foundation

The rendition of the zodiac sign **Sagittarius** as a winged horse with a human head is the most original on this globe. This iconography is obviously derived from that of *al-Burāq,* 'the lightning', the celestial steed which carried Prophet Muḥammad to the heaven. The wing is drawn in the same manner as the wing of Virgo; on the human head is a crown with three peaks; to the crown are attached two long feathers which encompass the various stars in this region. This rendition is more natural than the strange attachments that are found on the Lahore globes. The label reads *Qaws 30.*

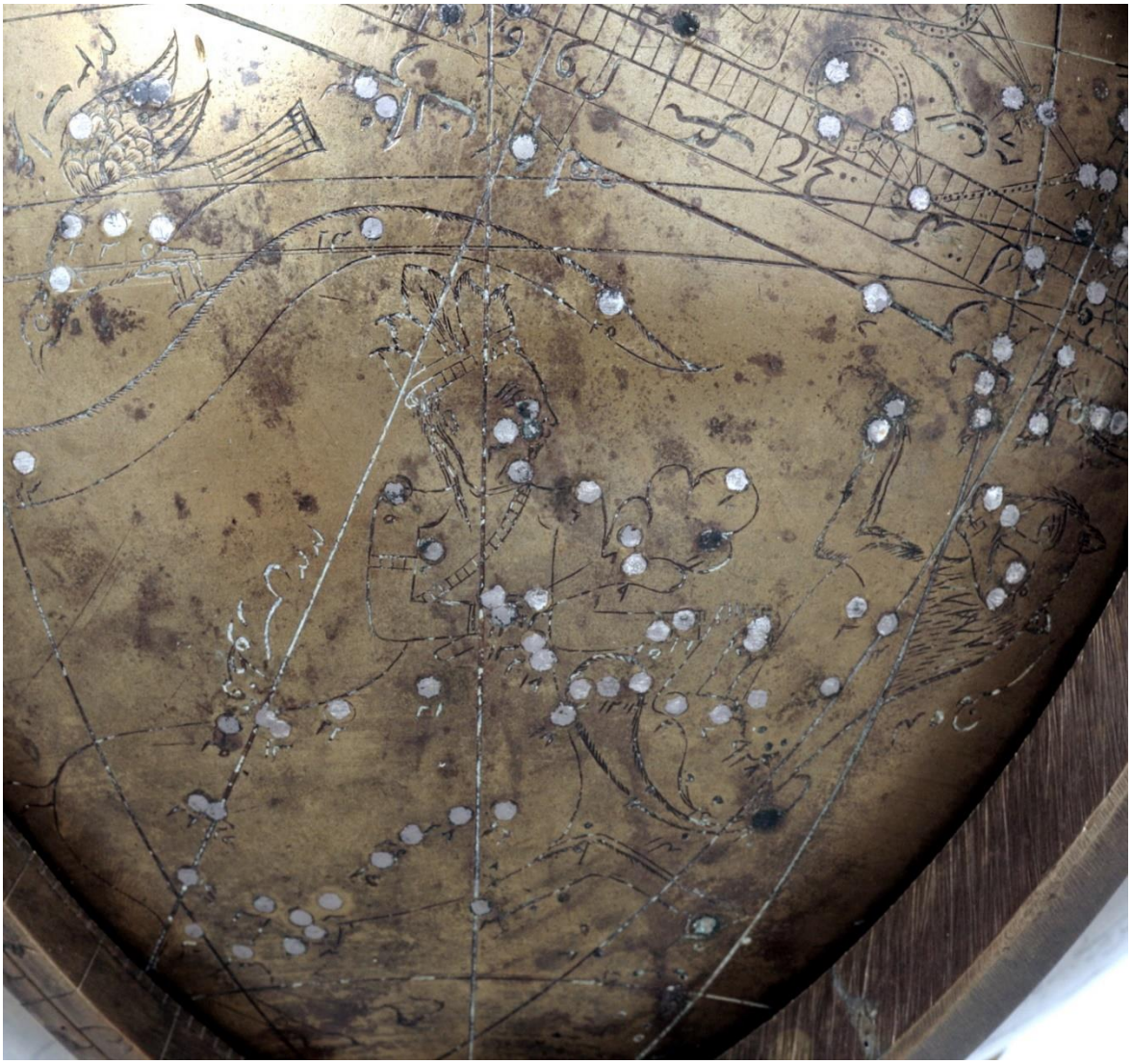


Figure G010.8 – Centaurus
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 285
Photo courtesy of the Khalili Family Trust © Nour Foundation

The other hybrid figure **Centaurus** is also endowed with a crown with five peaks. There is an armlet on the right arm and a strap crosses his upper body and goes over the left shoulder. The face is in profile, his long hair falls on his shoulder. The olive twig in his hand is interpreted as a twig with a cluster of leaves. The title *Qantūrus 44* is engraved to the left of the figure. **Lupus** is depicted with a lion's face and mane and is labelled *Sabᶜ 45.*

Above the head of Centaurus can be seen the tail of the serpent **Hydra**; **Corvus**, in flight, appears to be alighting on the snake's body (label *Ghurāb 43*).



Figure G010.9 – Argo Navis
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 285
Photo courtesy of the Khalili Family Trust © Nour Foundation

The ship in the southern constellation **Argo Navis** is depicted as a grand edifice. The lower deck consists of a series of cabins with arched windows. The huge leonine figure-head of the Lahore globes is replaced here by a multistoried structure and a yet taller tower, both with ornate cabins at the top. There are trifoliate finials above both cabins. There are four masts, the second being the main mast to which is attached a sail; at the top of the third mast flies a double pennant. Chains run from the top of the main mast to both sides.

To the west of the ship is the figure of **Canis Major** entitled *Kalb Akbar 38.*



Figure G010.10 – The crown of the zenith ring (detail of Figure G010.1)

STAND

The highly ornate stand consists of a graduated horizon ring, a graduated meridian ring, a zenith ring in two parts, and three *S*-shaped legs. The two parts of the zenith ring and the three legs are attached to the horizon ring and made fast by means of winged bolts.

The horizon ring is divided in 1° and 6° and numbered in 6s in the *Abjad* notation and also in common Arabic/Persian numerals, separately in each quadrant, starting at the east and west points and proceeding on either side to the north and south points. At the four cardinal points, there are rectangular slots to allow the meridian ring and the zenith ring. In the meridian ring, the recessed half is divided in 1° and in the other half intervals of 6° are marked on both faces. The intervals of 6° are numbered in *Abjad* as well as common numerals on the upper face, separately in each quadrant.

At the apex of the zenith ring, there is an ornate triangular projection, elegantly reticulated almost like the *kursī* in Muḥammad Muqīm's astrolabe of 1624 (A021). At the lower point, around the Nadir, there is also a projection, but of a simpler design. Under both these projections, there are slots to accommodate the passage of the meridian ring.

The meridian ring is divided in 1° and 6° on both side faces. On the upper face, the intervals of 6° are numbered in *Abjad* letters and common Arabic/Persian numerals.

The thickness of the meridian ring is reduced in half, from one pole to the other, so that there is a recess between the ring and the globe. This recess allows a sleeve of 6° to slide along the meridian ring. There ought to be a graduated arc of 90° attached to this sleeve, but it is missing.

The three curved legs are the most beautiful of all similar legs in the stands created by Bulhomal. These are decorated here with fluted columns and tulips. They are interrupted in the middle by a pair of tulips joined base to base. They rest on circular bases with multiple tiers at the top of which there are once again tulips

The inner diameter of the horizon ring measures 220 mm; outer diameter 265 mm; height of the stand 168 mm; weight of the globe with the meridian ring 2.95 kg; with the stand and zenith ring 3.7 kg.

INSCRIPTION

On one face of the zenith ring, just below the triangular projection, on either side of the slot through which the meridian ring passes, is an inscription which reads

īn kurah falkī jotishī dharm chand

'This celestial globe [belongs to] Jotishī Dharm Chand.'

Dharm Chand himself was an instrument maker known through ten extant specimens of different types; he was a contemporary and possibly an associate of Bulhomal.[1205]

BIBLIOGRAPHY

Maddison & Savage-Smith 1997, I, no.140. p. 242, Fig. on p. 243.
Sarma 2015b, no. [13], p. 273.

[1205] Sarma 2003, pp. 78-84; Sarma 2008d, pp. 29-32; Sarma 2015b, nos. [29]-[38], pp. 287-294.

G011 CELESTIAL GLOBE WITH LEGENDS IN ENGLISH ATTRIBUTABLE TO LĀLAH BULHOMAL LĀHORĪ[1206]

Not dated, mid-19th Century

Diameter 360 mm

London, Nasser D. Khalili Collection of Islamic Art (# SCI 44)



Figure G011.1 – Globe with stand
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 44
Photo courtesy of the Khalili Family Trust © Nour Foundation

[1206] Entry based on Maddison & Savage-Smith 1997, I, no, 141, pp. 242-243, 245, and the detailed photos generously provided by Nahla Nassar, the Registrar of the Nasser D. Khalili Collection of Islamic Art, London.

This globe shares all the characteristic features of the globe which has been just described above (G010) and is of about the same size. But here an attempt was made to give English names to the constellation figures and to the celestial poles and to number the various scales with 'English' numerals. [1207] However, the engravings were not completed and the work was discontinued midway.[1208] Emilie Savage-Smith thinks that the globe was made for an English-speaking patron,[1209] but it could also have been made just to show off the maker's proficiency in English. Bulhomal's contemporary Joshi Dharm Chand also produced two specimens of a perpetual calendar in English,[1210] in addition to three pieces in Persian.

Circles

The equator and the ecliptic are divided in 1° and 6°. The intervals of 6° are numbered serially from 1 to 60 on the equator, and from 6 to 30 separately in each zodiac sign on the ecliptic. The names of the zodiac signs are written along the ecliptic. Great circles perpendicular to both the equator and the ecliptic are drawn in the same manner as in the previous astrolabe G010; also the equatorial tropics and parallels to the equator at 12° and 20° on either side.

Constellation Figures and Stars

The full set of the 48 constellation figures is engraved, but not all of them are named. Of the 21 northern constellations, 18 are named in English, some with unusual or incorrect names: Pegasus is named 'Painter's Horse', Equuleus 'Pegasus', Triangulum 'TriangulumMin' and Cygnus 'Cerberus'. The names of the 12 zodiac

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1207 Savage-Smith calls these numerals 'Western' or 'European' numerals; historians of mathematics designate them as 'Hindu-Arabic' numerals; in common parlance, these are referred to as 'Arabic' numerals to distinguish them from Roman numerals. In the milieu of Bulhomal and Dharm Chand in the nineteenth-century India, they must have been called 'English' numerals; even now in non-academic contexts in India, they are called 'English' numerals to distinguish them from numerals of the various regional languages.

1208 Maddison & Savage-Smith 1997, I, p. 243: 'At the eighth zodiacal constellation, Scorpio, the numbering of the stars with European numerals ceases. The outline of Scorpio seems incomplete as do some other constellation outlines. A slight error, a gouge made near Capricorn and Aquarius, may account for it being unfinished. It seems that more than one artisan may have worked on the engraving of the constellations.'

1209 Maddison & Savage-Smith 1997, I, p. 242.

1210 Sarma 2015b, nos. [32] and [33], pp. 290-292.

houses are written along the equator, but the related figures are not named. Of the 15 southern constellations, only 10 are given names, but again some of these are not correct: the names of Orion and Lepus are interchanged and Eridanus is labelled as Hydrus.

The positions of about 1020 stars are marked with inlaid silver nails. The stars within each constellation are numbered serially; but there is inconsistency here as well. Stars are numbered with European numerals up to Libra; thereafter the numbering ceases.

Up to Libra, the figures are drawn more or less in the same manner as in G010; but from Scorpio onwards, the figures look incomplete. For example, in Sagittarius, the bare outlines of the figure are drawn, but neither the crown is completed, nor are the wings drawn as in Figure G010.6.



Figure G011.2 – Perseus, Cassiopeia, Cepheus and others
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 44
Photo courtesy of the Khalili Family Trust © Nour Foundation

Figure G011.2 offers a view of the northern hemisphere, framed by the zenith ring. The sides of the zenith ring are embellished by floral engravings, the triangular crown on its apex is also decorated with a pattern of leaves. Just above the horizon ring are the figures of Perseus, Cassiopeia, Cepheus, Cygnus, Lyra and Aquila, ranged from left to right.

Perseus is depicted with a shaven head, straight mustaches and a long beard; he holds a curved sword with an ornate handle. No lines are drawn to indicate his clothing. He looks completely naked, covered just by the serial numbers of the stars, as it were. Next to him is **Cassiopeia**; her face is delineated well with all the details. **Cepheus** wears a crown with three long projections. He has a full beard; his mustaches are straight without any curve. The next figure, **Cygnus**, is drawn with a fan-like tail, outstretched wings, and a plume on the head, almost in the same manner as in the Lahore globes; some 17 star pointers are numbered in this constellation; but the constellation itself is labelled erroneously as Cerberus. Lyra is depicted as in G010. Andromeda is to be seen in the upper register to the left. She is clothed in a short skirt, but the upper part of her body is bare. Her two feet are chained and the two arms are stretched out in two directions. What is of interest in this rendition is that her left hand, to be seen on the other side of meridian ring, holds some kind of a flower.

At the top centre is Pegasus, misnamed ‘Painter’s Horse’, followed by Equuleus, also misnamed ‘Pegasus’, Delphinus, Sagitta and Aquila.



Figure G011.3 – Perseus and Cassiopeia (detail)
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 44
Photo courtesy of the Khalili Family Trust © Nour Foundation

As mentioned above, work stopped after the constellation figure of Scorpio. For example, in Figure G011.4 can be seen the unfinished figure of **Sagittarius**. Here the bare outlines of the equine body and the human head with the crown are drawn, but details like the hand and wing (which can be seen in Figure G010.6) have not been added. There are star pointers with silver inlay, but these are not numbered. Nor is the figure given the title.



Figure G011.4 – Sagittarius and other figures
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 44
Photo courtesy of the Khalili Family Trust © Nour Foundation

Likewise Corona Australis is not labelled, but its serial number 47 is engraved in common Arabic/Persian numerals. In the figure of Ara, however, there is the title in English letters and the serial number 46 in common Arabic/Persian numerals.

Stand

The rings and the 158 mm high stand are nearly the same as in the previous globe G010. The horizon ring is divided in 1° and 6° and numbered in 6s in 'English' numerals, separately in each quadrant, starting at the east and west points and proceeding on either side to the north and south points. At the four cardinal points, there are rectangular slots to allow the median ring and the zenith ring.

The meridian ring is divided in 1° and 6° on the two faces on the sides, and the intervals of 6° are numbered in 'English' numerals. There is a groove on the upper face. In one half of the meridian ring, the thickness is reduced on the inner side so that a sleeve of 10°can slide along the semicircle. To the sleeve is attached an arc of 90° which is rotatable. This arc is also divided in 1° on the sloping face and the intervals of 6° are numbered from 6 to 90 on the upper face. The numbering starts at the end of the arc and ends at the sleeve. The artisan who engraved these 'English' numerals had difficulty in

the placing the digits correctly as can be seen in Figure G011.1: 24 is engraved as 42; 36 was first engraved as 63 and then corrected; there are similar corrections elsewhere also. However, this is the only extant globe where this arc survives.

At the apex of the zenith there an ornate triangular projection at the top of which as an oval ring is pivoted. There is also a matching projection at the lower point of the zenith ring. All the three faces of the zenith ring are decorated with floral patterns; the two faces on the sides have same design with floral patterns interspersed with patterns of dots while the upper face is engraved with a different floral pattern. The triangular projection at the apex is also embellished with engravings.

The three curved legs are embellished with the design of double tulips and rest on circular bases with multiple tiers. But the winged bolts are missing in this stand.

PROVENANCE

Christie's, London, auction of 29 September 1988, lot no. 15.

BIBLIOGRAPHY

Maddison & Savage-Smith 1997, pp. 242-243; Fig. on p. 245.
Sarma 2015b, no. [19], p. 278.

G012⊙ CELESTIAL GLOBE ATTRIBUTABLE TO LĀLAH BULHOMAL LĀHORĪ

Not dated, mid-19th Century

Diameter 214 mm

New Delhi, National Museum (# 56.155/1)



Figure G012.1 – Globe with stand (photo by S. R. Sarma)

This globe and stand appear to have been made of copper. The globe is cast as a single hollow sphere by the *cire perdue* method. Constellation figures are drawn lightly with shallow lines; therefore, it was difficult to photograph them.

CIRCLES

The equator is graduated in 1° and 6° and the divisions of 6° are numbered serially from 1 to 60, starting from the vernal equinox, both in the *Abjad* notation and in common

Arabic/Persian numerals. The ecliptic, however, is divided in 1° and 5° and numbered in the *Abjad* as well as in common Arabic/Persian numerals from 5 to 30 separately in each zodiac sign. The names of the signs are written along the ecliptic. Six great circles are traced at right angles to the ecliptic and another six great circles perpendicular to the equator, in the latter case, starting at 6° west of the Vernal equinox. Parallel to the equator are drawn the tropics and circles at 12° and 20° on either side. There are no polar circles.

Constellation Figures and Stars

The full set of the 48 constellation figures is engraved together with their names and serial numbers, where great care is shown in depicting the details such as hair, beards and textile patterns on the clothing. The positions of about 1022 fixed stars are indicated by inlaid silver nails.

There is a new feature on this globe in the delineation of the constellation figures: the bodies of zoomorphic figures and the garments of the human figures are filled with innumerable squiggles. Figure G012.2 will give a fair idea how the constellation figures are drawn on this globe. Here one can see Ophiuchus holding the serpent in both his hands. The body of the snake is filled with squiggles. Ophiuchus is dressed in a short tunic with short sleeves and tight-fitting trousers. Both these garments are filled with countless squiggles. Part of his face can be seen above the horizontal ring. He wears an elaborate crown on his head. But his companion Hercules is bare-headed. Notice how meticulously the scorpion's tail is depicted below the figure of Ophiuchus.

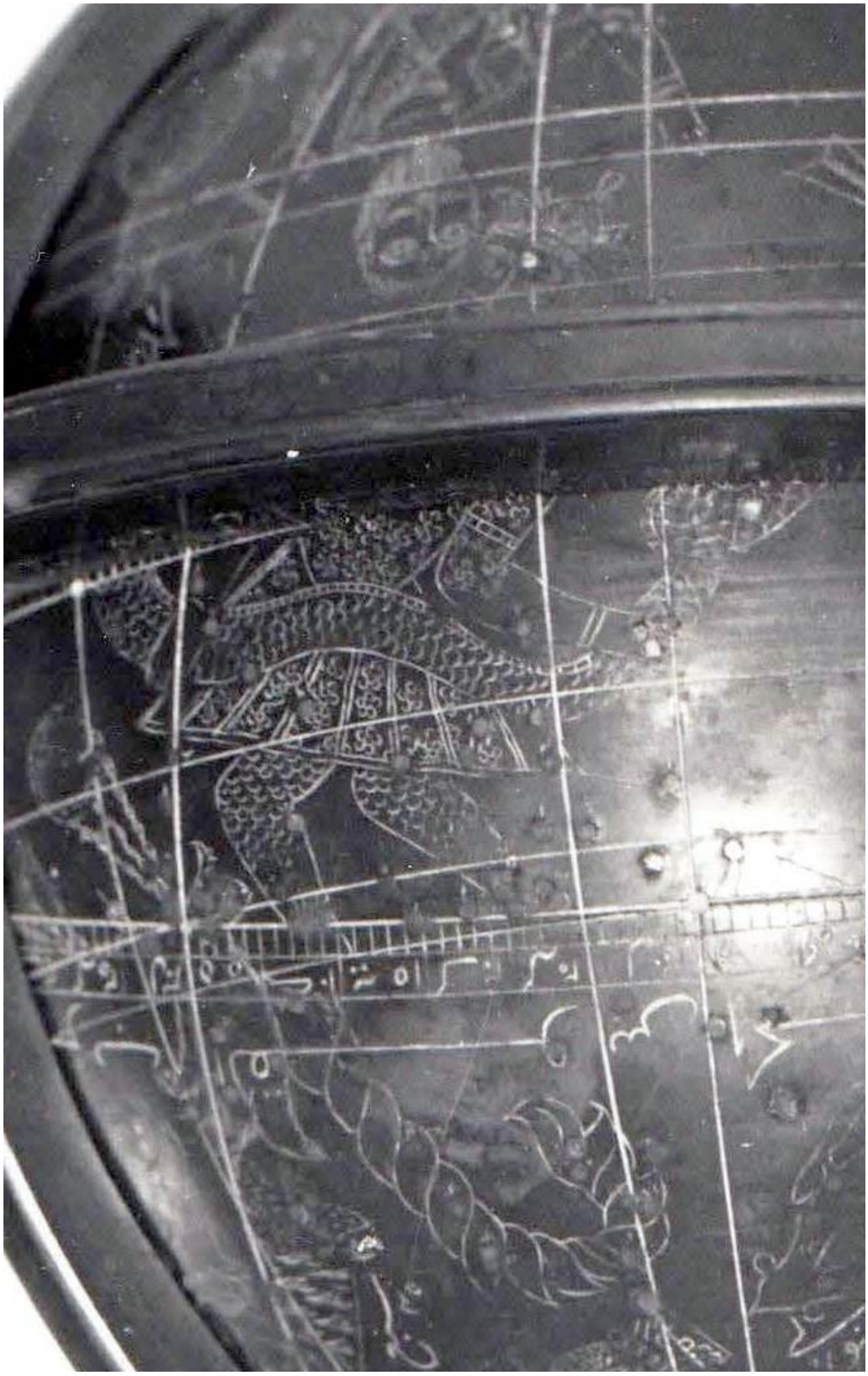


Figure G012.2 – Ophiuchus (courtesy Anthony J. Turner)



Figure G012.3 – Centaurus (courtesy Anthony J. Turner)

Figure G012.3 shows the lower face of the horizon ring which is also graduated in 1° and 6° and numbered in *Abjad* and common Arabic/Persian numerals; the meridian ring is also similarly graduated and numbered. At the upper left can be seen the long skirt and feet of Virgo. The skirt is filled with squiggles like the clothing of Ophiuchus which can be seen on the right. Below the ecliptic scale are the figures of Corvus and Hydra, both filled with small squiggles. Occupying the centre is the figure of Centaurus. The equine half is adorned with a saddle cloth with decorated borders, on which is written the title of the figure *Qanṭūrus 44*. This is the first time this figure is so rendered.

The engraver pays great attention also in drawing the beard of Centaurus here and of Hercules in the earlier figure.



Figure G012.4 – Andromeda (photo by S. R. Sarma)

Andromeda is endowed with a triple crown. Her gown as well as the body of the fish under her right arm are filled with many squiggles. Her face is framed by long hair, where each strand of hair is painstakingly drawn.



Figure G012.5 – Stand without the meridian ring (photo by S. R. Sarma)

STAND

This celestial globe is mounted on a 190 mm high stand which is similar to the other stands made by Bulhomal, but there are no decorative engravings on the rings or on the legs. Even without such embellishments, the stand looks elegant. The diameter of the horizon ring is 220 mm and the thickness 11 mm. The horizon ring and the meridian ring are graduated in 1° and 6° and labelled on both sides in the *Abjad* notation as well as in common Arabic/Persian numerals from 6° and 90° separately in each quadrant. In one half of the meridian ring, the thickness is reduced on the inner side to

create a recess, so that a sleeve carrying an arc can slide along the meridian ring. But the sleeve and the arc are missing. The ornate crown of the zenith ring is topped by a lotus-shaped finial. There are 8 winged bolts to hold firm the assembled parts.

BIBLIOGRAPHY

Sarma 2015b, no. [14], p. 273.

G013 CELESTIAL GLOBE ATTRIBUTABLE TO LĀLAH BULHOMAL LĀHORĪ[1211]

Not dated, mid-19th Century

Diameter ca. 190 mm

Srinagar, Sir Pratap Singh Museum



Figure G013.1 – Globe with stand (photo by Nazir Ahmad Doshab)

The globe appears to have been cast as a single hollow sphere by the *cire perdue* process. No plugs are visible. There are no constellation figures on this globe; the positions of some prominent stars are marked with inlaid silver nails.

[1211] Entry based on the photos and measurements kindly provided by Mr Nazir Ahmad Doshab, Central Asian Museum of the University of Kashmir, Srinagar.

Circles

The equator and the ecliptic are divided in 1° and 6°. The equator is numbered from 6 to 360 continuously from the vernal equinox. The ecliptic is numbered from 6 to 30 separately in each zodiac sign. The names of the zodiac signs are engraved along the ecliptic. Interestingly, these names are followed by their serial numbers in Devanagari script. Seven names can be seen in the available photos, viz. *al-Asad 5, al-Sunbulah 6, al-Mīzān 7, al-ᶜAqrab 8*, *al-Jadī 10, al-Dalw 11, al-Ḥūt 12.* Parallel to the equator are drawn the tropics, polar circles and two lesser circles at 12° and 20° on either side as in other globes. Six ecliptic latitude circles cut the ecliptic at right angles. But unlike in other globes by Bulhomal, there are no meridian circles here.

Constellation Figures and Stars

No constellation figures are drawn on this globe, but the positions of certain stars are marked by inlaid silver points with the names engraved next to the silver points. In the available photos, the following stars can be seen. These are listed below in the order of increasing longitude, starting from the vernal equinox.

Table G013-1 Named stars on the globe

	Star name as engraved	Identification
1	*Dhanab al-Qayṭus J[anūbī]*	β Ceti
2	*Shiᶜrā Yamānī*	α Canis Majoris
3	*Suhayl*	α Carinae
4	*Rijl al-Jawzā' al-Yusrā*	β Orionis
5	*Rijl al-Jawzā' al-Yumnā*	κ Orionis
6	*Rās al-Taw'am al-Muqaddam*	α Geminorum
7	*Fard al-Shujāᶜ*	α Hydrae
8	*Qalb al-Asad*	α Leonis
9	*Ẓahr al-Asad*	δ Leonis
10	*Ṣarfah*	β Leonis

	Star name as engraved	Identification
11	*Janāḥ al-Ghurāb*	γ Corvi
12	*Simāk Aᶜzal*	α Virginis
13	*Kiffah J[anūbī]*	α Librae
14	*Kiffah Sh[amālī]*	β Librae
15	*Qarn al-Jadī*	α Capricorni
16	*Dhanab al-Jadī*	δ Capricorni
17	*Mankib Sākib al-Mā'*	α Aquarii
18	*Sāq Sākib al-Mā'*	δ Aquarii
19	*Dhanab al-Qayṭus Sh[amālī]*	ι Ceti

STAND

The globe is mounted on a three-legged stand, which is very similar to the stands in the celestial globes made by Bulhomal of Lahore. The stand, 185 mm high, consists of an ornate horizontal ring with a diameter of 195 mm, a meridian ring and a zenith ring without a crown. Both the horizontal and meridian rings are graduated in 1° and 6° and labelled in *Abjad* notation. An axis passing through the two celestial poles on the globe is pivoted to the meridian ring in the stand. The curved legs are decorated with a leaf pattern.



Figure G013.2 – Another view of the globe (photo by Nazir Ahmad Doshab)

PROVENANCE

The globe was on loan to the Central Asian Museum of the University of Kashmir from 1980 to 2015 February, when it was photographed by Nazir Ahmad Doshab.

BIBLIOGRAPHY

Sarma 2015b, no. [15].

G014 CELESTIAL GLOBE ATTRIBUTABLE TO LĀLAH BULHOMAL LĀHORĪ[1212]

Diameter 184 mm

PLU; ex-Rockford, Time Museum

ESS 90

The globe is cast as a single hollow sphere; there are 8 small plugs; a large circular plug at the north equatorial pole has come off and there remains just a hole. The original stand is lost.

CIRCLES

The equator and the ecliptic are represented by single lines divided in 1° and 6°; the intervals of 6° are marked by longer lines and numbered, on the equator continuously from 6 to 360 starting at the vernal equinox, and on the ecliptic from 6 to 30 separately in each zodiac sign. The names of the signs are written along the ecliptic. Ecliptic latitude circles and meridian circles are drawn; the latter are shifted 6° westwards. Tropics are drawn parallel to the equator on either side and also parallel circles at intervals of 12° and 20° on both sides.

CONSTELLATION FIGURES AND STARS

There are no constellation figures. The positions of 32 stars are marked with inlaid silver points, labelled and numbered with common Arabic/Persian numerals. Small silver points are inlaid also at the equinoxes and ecliptic poles and points of intersections of the meridians with the equator.

PROVENANCE

The globe was formerly with the Time Museum, Rockford, Ill. After the dissolution of the museum, the holdings were disposed off and it is not known who acquired the present globe.

[1212] Entry based on Savage-Smith 1985, No. 90, pp. 262-263, Fig. 26, p. 55.

BIBLIOGRAPHY

Savage-Smith 1985, no. 90, pp. 262-263, Fig. 26, p. 55.

Sarma 2015a, no. [12], p. 273.

G015 CELESTIAL GLOBE ATTRIBUTABLE TO LĀLAH BULHOMAL LĀHORĪ[1213]

Not dated, mid-19th Century

Diameter 495.3 mm

PLU

ESS 53; Répertoire 6



Figure G015.1 – Globe with stand (courtesy Museum of the History of Science, Oxford)

This globe is listed in the *Répertoire* as the sixth instrument to be produced by Bulhomal. In the archives of the Museum of the History of Science, Oxford, there is a photo with the remark: 'Indo-Persian Globe (?). Overall height 2′ 3″ [= 685.8 mm]

[1213] Entry based on Savage-Smith 1985, no. 53, p. 244 and a photo in the archives of the Museum of the History of Science, Oxford.

Globe diameter 19″ [= 495.3 mm]. Submitted by Sotheby 1976 for examination. Said to be in a palace of a Maharaja. Neg. 76-27.35.s.' Then this must be the largest extant celestial globe cast by the lost wax process. The photo of the north-south astrolabe mounted on a stand, which has been described above (B025), carries also a similar remark. It suggests that this huge globe as well as the very large astrolabe mentioned above must have come to Sotheby in 1976 for sale and they must have been acquired by Hew Kennedy of Shropshire. Its present location is not known.

Emilie Savage-Smith, who had access to more detailed photographs in the files of F. R. Maddison and Brieux, remarks: 'Although the star positions and general design correspond roughly to the globe made by Lālah Balhūmal Lāhūrī (No. 33 [G008 in this catalogue]), the iconography of constellations and the engraving and possibly metallurgical techniques differ substantially from those Balhūmal: furthermore the globe does not display the precision and accuracy of the Lālah Balhūmal globe.' I cannot comment on the iconography of the constellation figures because I have not seen any of the photos showing the constellation figures. But the preceding globes do not always display a uniform iconography; substantial differences can be seen in globes like G012. Moreover, the lack of precision could be due to the enormously huge size of the globe. Since the globe originated from the collection of the Maharaja of Kapurthala, it must be by Bulhomal or one of his assistants or pupils.

CIRCLES

The equator is graduated in 1° and 6°. Each single degree is marked with three dots arranged in a triangle. Intervals of 6° are numbered serially from 1 to 60, starting at the vernal equinox. The ecliptic is divided in ½° and 5°. The intervals of 5° are numbered from 5 to 30 separately in each zodiac sign. The numbers on both circles are in *Abjad* notation as well as in common Arabic/Persian numerals. Parallel to the equator are drawn the tropics, polar circles and two lesser circles at 12° and 20° on either side. There are six ecliptic latitude circles at right angles to the ecliptic and six great circles at right angles to the equator, the latter commencing at 6° west of the vernal equinox. The names of the zodiac signs are incised deeply along the ecliptic and filled with a black substance.

Constellation Figures and Stars

The figures of all the 48 classical constellations are engraved along with the labels and serial numbers. The positions of about 1022 stars are marked with inlaid silver points. Silver points are also inlaid at the ecliptic poles and equinoxes. The stars in each constellation figure are numbered serially in common Arabic/Persian numerals.

Stand

The stand consists of a horizon ring, a meridian ring, a zenith ring in two parts and three curved legs resting on circular bases. The divisions on the horizon ring are not discernible from the photos; its outer edge and upper surface are decorated with some engravings. The meridian ring is graduated in 1° and 6° and numbered in *Abjad* and common Arabic/Persian numerals from 6 to 90, separately in each quadrant. The upper half of the zenith ring is decorated on both sides with florals motifs; the outer edge with floral motifs and with a European-looking soldier carrying a bayonet. Another human figure in Indian dress is engraved on the triangular projection at the apex of the zenith ring. The slender legs are attached to the horizon ring by means of winged bolts. The axis is missing; the globe is loosely placed between the rings.

Provenance

Formerly in the private collection of the Maharaja of Kapurthala; Sotheby's 1976; Hew Kennedy, Shropshire, UK.

Bibliography

Savage-Smith 1985, no. 53, p. 244.
Sarma 2015b, no. [16]

G016⊙ CELESTIAL GLOBE ATTRIBUTABLE TO LĀLAH BULHOMAL LĀHORĪ

Not dated, 19th Century

Diameter 103 mm

Oxford, Museum of the History of Science (# 36638)

ESS 86



Figure G016.1 – Globe with stand (photo by S. R. Sarma)

Savage-Smith states that '[t]he star positions relative to the ecliptic generally conform with those of the seventeenth-century Lahore workshop'.1214 But the S-shaped legs in the stand and more particularly the graduated arc of 90° attached to the meridian ring establish without any doubt the close affinity between this globe and G011 which is attributable to Lālah Bulhomal Lāhorī. Therefore this globe also can be attributed to the same versatile instrument maker of the mid-nineteenth-century Lahore.

The globe is cast as a single hollow sphere by the lost wax method; two plugs are visible. The engravings are filled with a white substance.

Circles

The equator and the ecliptic are divided in 2° and 6°; the equator is numbered from 6 to 360 continuously from the vernal equinox, while the ecliptic is numbered from 6 to 30, separately in each zodiac sign. The names of the zodiac signs are engraved along the ecliptic. There are also ecliptic latitude circles, equatorial tropics and polar circles.

Stars

The positions of 57 stars are marked by asterisks or x-s and their names are engraved next to these symbols.

Stand

The stand consists of a massive horizon ring supported by four legs which are decorated by a leaf pattern and which rest on cone-like feet, as in the globe made by Bulhomal in 1842 (see Figure G008.1). The horizon ring is divided in 2° and 6° and numbered from 6 to 90, starting from the east and west points and converging at the north and south points, where there are notches cut for the meridian ring. A semi-circular arc attached to the underside of the horizon ring at its east and west points supports the meridian ring. The meridian ring is also graduated in the same manner as the horizon ring in 2° and 6° and numbered from 6 to 90 separately in each quadrant. In one half of the meridian ring, from zero point to zero point, the thickness is normal and is flush with the surface of the globe; in the other half the thickness is reduced so that there is a recess between the ring and globe. At the midpoint of this thinner half

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1214 Savage-Smith 1985, p. 260.

which is marked by 90° an arc of 90° is attached by a pin with a heavy conical head. The arc is graduated in single degrees; it can be rotated and is useful for measuring the altitude.[1215] At the zero points on either side of the meridian ring, there are protruding bits which rest on the horizon ring and keep the meridian ring firmly in position. Holes are bored in the meridian ring and labelled for northern latitudes of 21°, 24°, 32°, 48°, 66;30° and for southern latitudes of 21°, 24°, 29° and 72°. The meridian ring is set up in such a manner that the thicker half stays at the bottom and the pin holding the graduated arc at the zenith. A long rod with a circular tip at one end serves as the axis. The globe can be adjusted to different terrestrial latitudes by inserting the axis into the appropriate pair of holes in the meridian ring.

PROVENANCE

The globe was bought from Sayyid Bahadur Shah in Lahore by the well-known orientalist Henry Beveridge ((9 February 1837 – 8 November 1929) of the Indian Civil Service who translated Abā al-Faḍl's Akbarnāma into English. Beveridge sold it to Lewis Evans who presented it to the museum in 1924.

The globe was displayed at the exhibition on Science in India held at the Science Museum, London, in March-August 1982 in connection with the Festival of India.[1216]

BIBLIOGRAPHY

Anderson 1982, no. 125, p. 34.
Savage-Smith 1985, no. 86, pp. 260-261

[1215] This feature is introduced by Ḍiyā al-Dīn Muḥammad in his globe of 1055 /1645 (F008) and is emulated in G010 and G011 both attributable to Bulhomal Lāhorī.

[1216] Cf. Anderson 1982, no. 125, p. 34.

G017 CELESTIAL GLOBE, NOT SIGNED, NOT DATED[1217]

19th century

Diameter 140 mm

London, Science Museum (# 1914-597)

ESS 89

The globe is not signed, but the meridian ring is made in the same manner with varied thickness as in G010, G011 and G016, in order to receive a graduated arc of 90° for measuring the altitude. Therefore, like the above-mentioned globes, this globe too can be attributed to Lālah Bulhomal Lāhūrī.

The globe is cast as a single hollow sphere; several plugs are visible.

CIRCLES

The equator and ecliptic are divided in 1° and 6°; the equator is numbered from 6 to 360 continuously from the vernal equinox and the ecliptic from 6 to 30, separately in each zodiac sign.. Ecliptic latitude circles are represented by thick lines, but the tropics, equinoctial colure, equatorial and ecliptic polar circles by dotted lines. The names of the zodiac signs are engraved along the ecliptic; the names of the poles, colures and equinoxes are also engraved.

STARS

The positions of about 150 stars are indicated by inlaid silver points, each enclosed in an engraved circle. The star names are engraved next to the positions.

STAND

At present, the globe is mounted on a non-contemporary wooden quadruped stand. Of the original stand, only the meridian ring is extant. It is divided in 1° and 6° and numbered from 6 to 90 separately in each quadrant. Half of the ring, from one zero point to the other, is flush with the surface of the globe, while the other half is recessed to allow a rotating arc of 90° with which the altitude can be measured, but the arc is now

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[1217] Entry based on Savage-Smith 1985, no. 89, p. 262.

missing, although the pin to hold the arc is intact. The point where the pin is inserted is labelled as *niṣf al-nahār* (midday). Holes are bored in the meridian ring for the northern latitudes of 24°, 27°, 32°, 51° and 66;30°and for southern latitudes of 18°, 29°, 35° and 72°. When the meridian ring is properly set up in the stand, the lower half of the ring will be below the horizon ring. The latitude numbers next to the holes in both semicircles are engraved in such a manner that they can be read easily.

PROVENANCE

Lent by the Royal Astronomical Society to the Science Museum

BIBLIOGRAPHY

Savage-Smith 1985, no. 89, p. 262.

G018 CELESTIAL GLOBE, NOT SIGNED, 1255 AH (AD 1839-40)[1218]

Diameter 165 mm, height with stand 233 mm

PLU



Figure G018.1 – Globe with stand (courtesy Museum of the History of Science, Oxford)

[1218] Entry based on a photo and several photocopies of photos in the archives of the Museum of the History of Science, Oxford.

This globe is not signed, but is dated in 1255/1839-40, which is the same year when Bulhomal Lāhorī produced his celestial globe in Sanskrit (REF _Ref479938347 \r \h H002). However, the stand shows has no resemblance to the stands made by Bulhomal; on the other hand, it bears greater similarity to the stands made by Ḍiyā' al-Dīn.[1219] The constellation figures do not show any similarity with either those on the globes by Bulhomal or on the globes by Ḍiyā' al-Dīn. Therefore, it is difficult to situate the globe in a spatial context, except to say that it was made somewhere in India in the nineteenth century.

Circles

The equator and ecliptic are divided in 1° and 5°; on the equator, groups of 5° are numbered from 5 to 360 continuously from the vernal equinox onwards; on the ecliptic these are numbered from 5 to 30 separately in each zodiac sign. There are also drawn equatorial tropics, equatorial polar circles and ecliptic latitude circles. The names of the zodiac signs are not written along the ecliptic. The north celestial pole is labelled *quṭb shamālī,* but there is no label for the south celestial pole.

Constellation Figures and Stars

All the 48 constellation figures are drawn and the positions of about 1020 stars are marked with inlaid silver points. The names of the constellation figures are engraved together with the prefix *ṣurat* and sometimes also with their serial numbers. The names of several prominent stars are also engraved. The available photos and photocopies do not show all the constellations very clearly; the few that can be seen well, like Leo and Argo Navis, exhibit very unusual iconography; the human figures are also depicted in a manner which does not occur in any Indo-Persian globe. Andromeda, Virgo and strangely Bootes have very delicately drawn feminine faces.

[1219] Globe nos. F008, F013, F019 and F021 by Ḍiyā' al-Dīn Muḥammad are mounted on similar stands; in particular, there is a close similarity between the stand of the present globe and that of F013.

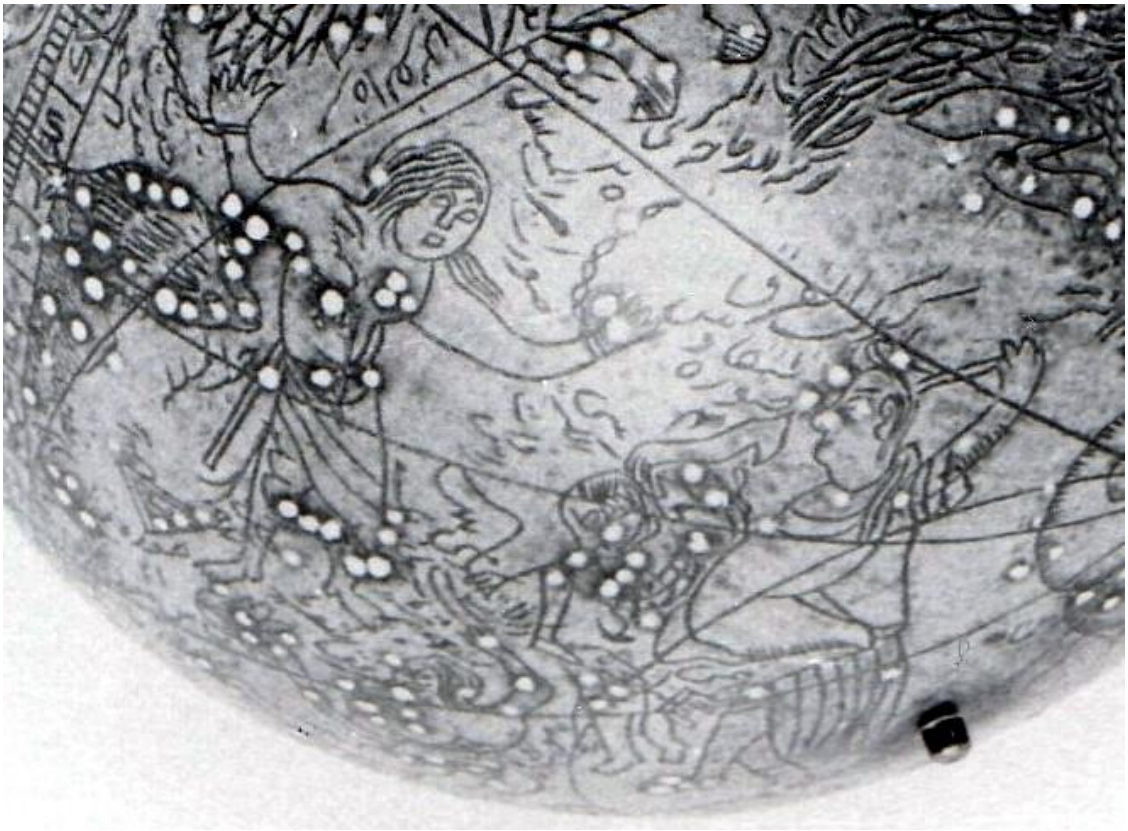


Figure G018.2 – Andromeda and Cepheus (detail of Figure G018.1)

Andromeda is depicted as a slender young women with heavy bosom; her upper torso is bare; the lower half appears to be covered by a piece of cloth wrapped around rather than by a dress. Her arms are stretched out into two directions; to the wrists are attached broken chains (as if she has freed herself from her captivity). The face in three quarters profile and her flowing hair are well done; the facial expression is very appropriate for a woman in distress. The title of the figure together with the serial number is engraved as *ṣūrat al-Mar'ah al-Musalsal[ah] 20,* 'figure of the chained woman'. The star at her waist is named *Janb al-Musalsalah,* 'side of the chained [woman]' (β Andromedae). The star on her forehead is given just one name which pertains to Pegasus, viz. *surrat al-Faras,* 'navel of the horse' (δ Pegasi).

The figure and the posture of **Cepheus** are most unusual; he is shown as a large man with a bald head and a huge belly. His left arm is raised high and there is a stick in his hand. With the right hand he seems to be touching Cassiopeia's head, or pulling her hair. No clothing is clearly discernable. The title reads *ṣūrat Qīqā'ūs 4,* 'figure of Cepheus 4'. Above his head is engraved the name *Kawkab[ā] al-Firq,* 'two stars of the

flock' (αβ Cephei); this name is derived from an older indigenous Arabic tradition which sees in this region a shepherd, his dog and his flock.[1220]

The figure of **Cassiopeia** is hardly discernable; there are faint traces of a head and two legs, but none of the chair. Next to the head is the star name *Rās Dhāt al-Kursī,* 'head of the one with the chair' (ζ Cassiopeiae).



Figure G018.3 – Bootes (detail of the photo in Sotheby's catalogue of 1989)

Most unusually **Bootes** is depicted as a female with a delicate face, long hair, a scarf floating in air westwards. The title reads *ṣūrat ʿAwwā',* 'the howler', followed by the serial number 3; but actually it should be 5.

[1220] Cf. Savage-Smith 1985, p. 138.



Figure G018.4 – Leo, Hydra and Argo Navis (from Anon 1989, p. 11)

On the right-hand side of Figure G018.4 can be seen, from the top to the bottom, the figures of Ursa Major, Leo, Hydra and Argo Navis. Here **Leo** is depicted as a tiger with many meticulously drawn stripes; its tail is coiled into a perfect circle. The only other globe where Leo is depicted as a tiger is the one made by Ḥāmid of the Lahore family in 1683 (see Figure F034.5).

At the bottom of the right-hand side is the figure of **Argo Navis** which is also depicted in a most unusual manner. There seems to be one mast; its upper portion is covered by the massive body of Hydra. From there are suspended eight large ropes to which are tied four wheel-like discs of unknown function. Also suspended is a rolled-up sail. Other details are not clearly discernable.



Figure G018.5 – Autumnal equinox
(photocopy courtesy Museum of the History of Science, Oxford)

In the lower half of Figure G018.5 can be seen the tail end of the massive body of the serpent **Hydra;** the tip of the tail is coiled in this rendering, which is also unusual. In the upper half is the figure of **Virgo,** with a delicately drawn face.



Figure G018.6 – Vernal equinox with Andromeda and Cetus
(photocopy courtesy Museum of the History of Science, Oxford)

In the upper half of Figure G018.6 is the figure of Andromeda which has already been described above. In the lower half the figure of **Cetus** is depicted, like the figure of Hydra, with a massive body terminating in a coil. This is the only rendering on the Indo-Persian globes which comes close to the European renderings of Cetus as a whale. The only available image does not clearly show how the head is depicted which lies between the graduated scales of the equator and ecliptic. The title *ṣūrat al-Qayṭus,* 'figure of Cetus', is engraved on the body. There are four named stars: *Fam Qayṭus,* 'mouth of Cetus' (γ Ceti); *Ṣadr al-Qayṭus,* 'breast of Cetus' (π Ceti); *Dhanab al-Qayṭus Shamālī,* 'northern tail of Cetus' (ι Ceti) and *Dhanab al-Qayṭus Janūbī,* 'southern tail of Cetus' (β Ceti).

STAND

The stand consists of horizon ring supported by three legs which are slightly curved like the inverted Roman letter *S* which rest on hexagonal bases. The horizon ring is divided in 1° and 5° and numbered in 5s from 5 to 90, starting at north and south points and ending at the east and west points. The cardinal points are labelled as *nuqṭah janūb,* 'south point'; *nuqṭah sharq,* 'east point'; the other two points are not visible in the available photos. At the north and south points, there are slots cut into the inner edge of the horizon ring for the meridian ring to pass through, but the meridian ring is missing. At the east and west points on the underside of the horizon ring is attached a semi-circular arc to support the meridian ring.

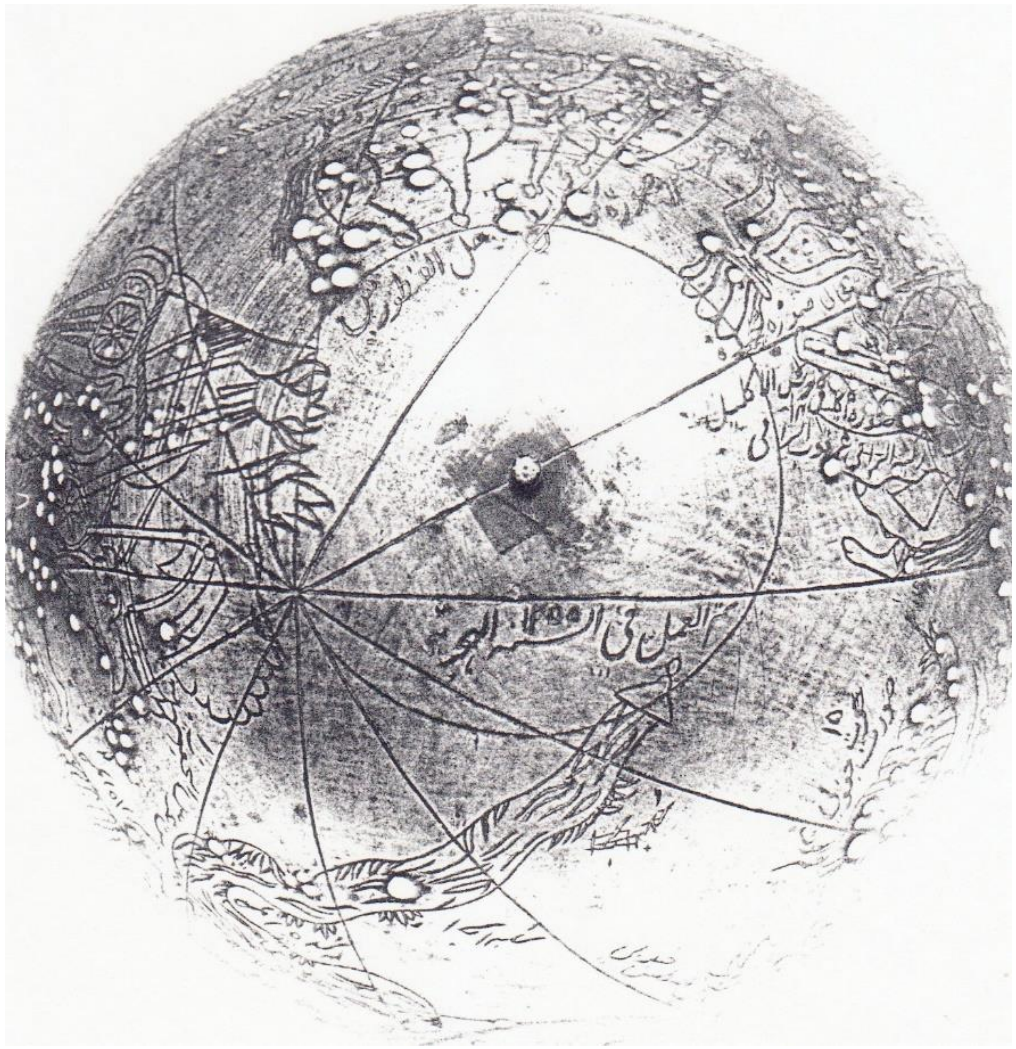


Figure G018.7 – Inscription
(photocopy courtesy Museum of the History of Science, Oxford)

INSCRIPTION

The six ecliptic latitude circles converge at the southern ecliptic pole. One of these circles is the solstitial colure which passes through the southern celestial pole. Unlike

the northern celestial pole, this one is not named. Along another ecliptic latitude circle is the inscription which reads:

> *khatam al-ʿamal fī sanah 1255 al-hijrī*
> 'completion of the work in the year 1255 Hijrī' [AD 1839-40].

PROVENANCE

In the archives of the Museum of the History of Science, Oxford, there is a photo and several photocopies of photos of this globe with the following remark by Francis Maddison:

> 'INDIAN GLOBE | Not signed | Inscribed near the south pole | 'Finished the work in the year | 1236 [sic!] of the Hijra' | Brass. Overall height 233 mm| Diameter of the globe 165 mm| Brought to the museum for | examination on 19 February 1986 | Stuart Talbot | 63 Portobello Road | London W 11 | Neg. 86-18 abc.35.S.'

There is also a typed letter from Stuart Talbot, of 11 February 1986, asking for an appointment.

On 12 April 1989, this globe came up for auction at Sotheby's, London. In July 1989, the High Commission for the Development of Arriyadh, Saudi Arabia, held an exhibition on *Islamic Science and Learning* at Washington, D.C., with manuscripts and artefacts collected from different museums. The present globe was also displayed in this exhibition. Obviously it must have been acquired by some museum at the Sotheby's auction of 12 April 1989. The exhibition catalogue reproduces a photo of this globe (Figure G018.7), but does not mention the source of the globe.

BIBLIOGRAPHY

Anon 1989, p. 11.

Sotheby's, London, auction catalogue of 12 April 1989, *Islamic Works of Art, Carpets and Textiles,* of this date, lot. 158.

G019⊙ CELESTIAL GLOBE BY MĪR BAHĀDUR MAHDĪ ḤUSSAYN KHĀN, 1279 AH (AD 1862-63)

Diameter 161 mm

Lucknow, Darul Uloom Nadwatul Ulama



Figure G019.1 – Globe with stand (photo by S. R. Sarma)

Mīr Bahādur Mahdī Ḥussayn Khān produced two globes in the year 1279 AH (AD 1862-63). Both are made of copper, but by different processes. The present one is made of two hemispheres first and then joined along the celestial equator. The second globe (G020) is very heavy and appears to have been cast as a solid sphere. Both these processes are unusual in the production of celestial globes in India. At present both the globes are mounted on stands of two different styles and of two different metals. The copper stand of globe G020 is very unusual in Indian context as will be explained in the

next entry. The brass stand of the present globe is of the traditional style, but it does not actually belong to the globe, for it is too small for this globe. This means that the original copper stand of the present globe is missing just as the original brass globe belonging to the present brass stand.



Figure G019.2 – Winter solstice (photo by S. R. Sarma)

CIRCLES

The ecliptic and the equator are represented by double bands, one band divided in 1° and the other band in 5°. Very unusually both the scales are numbered from 5 to 360 continuously from the vernal equinox. Equatorial tropics, equatorial polar circles and the ecliptic latitude circles are represented by single lines. Again, very unusually, the

equatorial polar circles are not continuous; at the equator they are shifted slightly (see Figure F019.2).

Several circles like equator, ecliptic, equatorial tropics, equatorial polar circles are named and also the points like the equatorial and ecliptic poles, as well as the equinoctial and solstitial points.



Figure G019.3 – North pole and meridian ring (photo by S. R. Sarma)

STAND

The stand consists of a horizon ring which is divided unevenly in 1°; groups of 6° are numbered from 6 to 90, separately in each quadrant, starting from the east and west points and reaching up to the north and south points. The horizon ring is supported by four balustrade-like legs which rest on an eight-lobed ring. To the underside of the horizon ring, at its east and west points, is attached a semi-circular arc which supports

the meridian ring. The meridian ring is divided unevenly in 1°; groups of 5° are numbered from 5 to 90, separately in each quadrant in such a way that the numbering ends at the two poles.

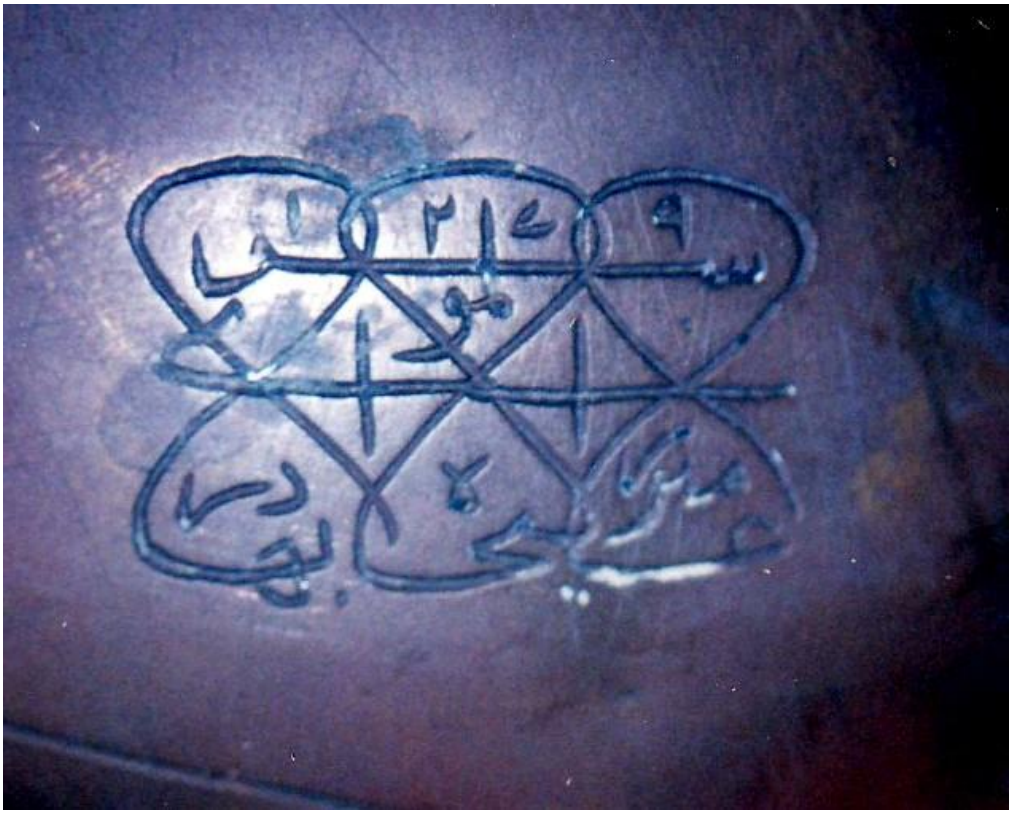


Figure G019.4 – Signature of the globe maker (photo by S. R. Sarma)

INSCRIPTION

The signature of the globe maker is engraved in the House of Virgo, in the form of a monogram created by an artistic arrangement of letters; the signature contains just the name of the maker and the year of production:

Mīr Bahādur Mahdī Ḥussayn Khān 1279.

The Hijrī year 1279 corresponds to AD 1862-63.

G020⊙ CELESTIAL GLOBE BY MĪR BAHĀDUR MAHDĪ ḤUSSAYN KHĀN, 1279 AH (AD 1862-63)

Diameter 104 mm

New Delhi, National Museum (# 56.98/b)



Figure G020.1 – Globe with stand (photo by S. R. Sarma)

The globe is cast as a solid sphere and is quite heavy; holes are bored at the equatorial poles.

CIRCLES

The equator and the ecliptic are drawn as single lines; divisions of single degrees are marked by short perpendicular lines and those of 5° by slightly longer perpendicular strokes. The names of the zodiac signs are engraved along the ecliptic. The equinoctial and solstitial colures are also drawn as single lines; the former is emphasized by dots placed along its length. Besides these, there are ecliptic latitude circles, equatorial tropics and equatorial polar circles.

Some of these circles are named. Tropic of Capricorn carries the name *madār rās al-jadī* and Tropic of Cancer *madār rās al-saraṭān*. Solstitial colure is designated as *dā'irah marrah bi-l-aqṭāb al-arbaᶜah.* On the solstitial colure, the segments between the ecliptic and equator are designated as *mayl kullī,* 'complete declination', i.e., the maximum declination of the ecliptic from the equator.

Moreover, some of the points on the globe are named. Thus the vernal equinox is named *iᶜtidāl rabīᶜī* and the autumnal equinox *iᶜtidāl kharīfī.* The north and south equatorial poles are labelled respectively as *quṭb fakak shamālī muᶜaddil* and *quṭb fakak janūbī muᶜaddil.* Both the poles of the ecliptic are named *quṭb falak al-burūj* without specifying the direction.

STAND

The stand looks exactly like the one illustrated in Ghulām Ḥussayn Jawnpūrī's *JāmiᶜBahādurkhānī* (see Figure G006.7). At the east and west points of the underside of the horizon ring is attached a semi-circular arc which passes through a cylindrical unit. The meridian ring also passes through a groove at the top of this cylindrical unit; it can be adjusted according to the terrestrial latitude. To the lower part of the cylindrical unit are attached three legs which are elegantly curved like the Roman letter *S.*

The outer diameter of the horizon ring measures 137 mm and the inner diameter 115 mm. The upper surface of the horizon ring is divided into three concentric bands. The innermost band is divided in single degrees marked by dots. In the middle band, groups of 5° are numbered in common Arabic/Persian numerals from 5 to 90, separately in each quadrant; in the outer band groups of 10° are numbered in *Abjad* notation from 10 to 90, separately in each quadrant. The counting in these two bands commences at the east and west points and ends at the north and south points.

The outer diameter of the meridian ring is 120 mm and the inner diameter 115 mm. The sides of the meridian ring are divided in 1° and 10° and numbered in Abjad from 10 to 90, separately in each quadrant.



Figure G020.2 – Horizon ring (photo by S. R. Sarma)

INSCRIPTION

The name of the globe maker is engraved as a monogram exactly as in the previous globe (Figure G019.4):

Mīr Bahādur Mahdī Ḥussayn Khān, 1279.

The Hijrī year 1279 corresponds to AD 1862-63.

G021 CELESTIAL GLOBE, NOT SIGNED, NOT DATED[1221]

19th century

Diameter 200 mm

Switzerland, Bern, Bernisches Historisches Museum (# Inv. 1914.610.0174)



Figure G021.1 – Andromeda, Perseus, Cassiopeia, Cepheus and others
© Bernisches Historisches Museum, Bern

The globe appears to have been cast as a single hollow sphere by the *cire perdue* method, but no plugs are visible. Holes are bored at the equatorial poles for inserting the axis. The stand is not extant. Some of the human figures display European influence.

[1221] Entry based on four images kindly sent by Flora Torelli, Bernisches Historisches Museum, Bern.

Circles

The equator and the ecliptic are divided in 1° and 5°; the former is numbered from 5 to 360 continuously from the vernal equinox onwards and the ecliptic from 5 to 30, separately in each zodiac sign. The names of the zodiac signs are engraved along the ecliptic. Ecliptic latitude circles are drawn at intervals of 30°. The north and south celestial poles are named respectively as *quṭb shamālī muᶜaddil* and *quṭb janūbī muᶜaddil.* The ecliptic pole in the north and in the south are designated as *quṭb shamālī falak al-burūz* and *quṭb janūbī falak al-burūz* respectively.

Constellation Figures and Stars

The full set of 48 classical constellation figures are neatly engraved; the positions of some 1020 stars are marked with inlaid silver nails and the names of some prominent stars are also written. Interestingly, Andromeda, Cassiopeia, Cepheus and Virgo are clothed in dresses of European style, borrowed obviously from some paintings or other images from Europe; likewise, the headgear of Cassiopeia and Cepheus are also more European than Islamic. Perseus, Hercules, Ophiuchus, Sagittarius and Aquarius wear Rajasthan-style turbans. Andromeda and Centaurus have their tied up in a double bun on their heads, a style I have not seen anywhere else. The eyes of the human figures, and of the animals, and birds have oval shape, but without any pupils.

The names of the constellation figures are often preceded by the prefix *ṣūrat* (spelt sometimes صورة and some other times صورت), but not in all cases. The names of the zodiac signs are written along the ecliptic, but the names of the figures representing these zodiac signs are not written; in the available photos show the pictorial representations of Leo, Virgo, Libra, Sagittarius, Capricorn, Aquarius and Pisces, but these are all without their titles, as the other constellation figures are.

Figure G021.1 shows Andromeda, Perseus, Cassiopeia and Cepheus, besides some zoomorphic figures. On the left is the tall figure of **Andromeda**. She wears a knee-length coat which opens in the front. Below the girdle, the two sides of the coat are turned back to show the lace-edged petticoat worn underneath. This dress is clearly borrowed from some European images. Cepheus wears a short jacket, which also opens in the front as in European jackets. The crown on the head of Cassiopeia and the hat worn by Cepheus display clear European influence.

The title of the figure of Andromeda is engraved above her right arm as *ṣūrat al-Mar'ah al-Musalsalah,* 'figure of the chained woman'. The name of the star on her head is engraved above her left arm as *Rās al-Mar'ah al-Musalsalah,* 'head of the chained woman' (α Andromedae); the second name of the star which pertains to Pegasus is written to the left of her head as *Surrat al-Faras,* 'naval of the horse' (δ Pegasi). Likewise the two names of the star on the right of her waist are written as *Janb al-Musalsalah,* 'side of the chained [woman] and *Baṭn,* 'belly [of the fish]' (β Andromedae). The star on her right foot carries the name *Rijl al-Musalsalah,* 'foot of the chained [woman]' (γ Andromedae).

To the lower left of Andromeda is the figure of **Cassiopeia** seated on a chair. She wears a long coat which reaches up to her ankles and opens in the front. Her head is adorned with a crown. The throne on which she is seated consists of four very thin legs, with heavy feet and with finials at the top that resemble spear-heads. The title of the figure is engraved along the height of the throne: *Dhāt al-Kursī,* 'the one with the chair'. The star on her right hand is named *Kaff al-Khaḍīb,* 'dyed hand' (β Cassiopeiae).

The figure of **Cepheus**, her husband, is drawn behind her chair in a kneeling posture, with his arms outstretched in both directions. The figure is entitled *Qīqā'ūs.* The star on his left knee is named *al-Rā'ī,* 'the shepherd' (γ Cephei); the double stars on his left arm carry the name *al-Firq,* 'the herd', (αβ Cephei).

The figure of **Perseus** is dressed in a short jacket, loose trousers which are quite unusual on Indo-Persian globes and a turban. It carries the title *Barsā'ūs Ḥāmil Rās al-Ghūl,* 'Perseus, the bearer of the Ogre's head'; the star on the Orge's head carries the name *Rās al-Ghūl,* 'head of the Ogre' (β Persei).

All the four figures wear a girdle or belt and not a Mughal sash and hanging ends.

The north ecliptic pole where the six ecliptic latitude circles converge is named *quṭb shamālī falak al-burūz* and the northern equatorial pole where a hole is bored carries the name *quṭb shamālī muᶜaddil.* The figure of **Draco**, which is coiled around the ecliptic pole, is entitled *ṣūrah al-Tinnīn,* 'figure of the dragon'.

The figure of Ursa Minor, drawn between the two northern poles, is entitled *Dubb Aṣghar,* 'small bear'. There are two named stars: *Anwar al-Farqdayn,* 'brighter of the two calves' (β Ursea Minoris) and *Jadī,* 'goat' (α Ursae Minoris, Polaris).



Figure G021.2 – Aquila, Cygnus, Pegasus and others
© Bernisches Historisches Museum, Bern

Figure G021.2 shows the graduated scales of the equator and the ecliptic intersecting at the vernal equinox on the far right. On the left of the image are the two figures of Hercules and Ophiuchus placed in opposed directions. Both wear elaborate turbans. Hercules wears a knee-length tunic and above it a shorter jacket, which opens in the front. The two sides below the girdle are turned back as in the coat worn by Andromeda. The figure is entitled *ṣūrat Jāthī,* 'figure of the kneeling [man]' and the star on his forehead *Rās al-Jāthī,* 'head of the kneeling [man]' (α Herculi). His companion Ophiuchus wears a short tunic with short sleeves and wavy hemline.

In the upper register are the figures of Lyra, Cygnus and Pegasus. The figure of **Lyra** is depicted as a vase with an arch-like cover; it is entitled *ṣūrat Shulyāq,* 'figure of

tortoise' and the star in it *Nasr Wāqi*^{c}*,* 'falling eagle' (α Lyrae, Vega). The Figure of **Cygnus** is drawn with both wings outstretched and the legs folded forward. The title of the figure reads *ṣūrat Dajājah,* 'figure of the fowl'. There are three named stars: *Dhanab al-Dajājah,* 'tail of the fowl' (α Cygni); *Minqār al-Dajājah,* 'beak of the fowl' (β Cygni) and *Rukbat al-Dajājah,* 'knee of the fowl' (ω^{1,2} Cygni).

In the figure of **Pegasus,** the wing is very elaborately decorated. The title reads *Faras A*^{c}*ẓam,* 'the larger horse'. The named stars are: *Matn al-Faras,* 'side of the horse' (α Pegasi); *Mankib al-Faras,* 'shoulder of the horse' (β Pegasi); *Janāḥ al-Faras,* 'wing of the horse' (γ Pegasi); *Surrat al-Faras,* 'navel of the horse' (δ Pegasi); *Fam al-Faras,* 'mouth of the horse' (ε Pegasi).

Just above the equator scale are the figures of Aquila, Sagitta, Delphinus, and Equuleus, which are drawn in a conventional manner. **Aquila** is entitled *ṣūrat* ^{c}*Uqāb,* **'**figure of the eagle'**;** there are two named stars: *Nasr Ṭā'ir,* 'flying eagle' (α Aquilae) and *Dhanab al-*^{c}*Uqāb,* 'tail of the eagle' (ζ Aquilae). **Sagitta** is entitled *ṣūrat Sahm,* 'figure of arrow'. **Delphinus** carries the title *ṣūrat al-Dālfīn,* 'figure of dolphin'. The star on its tail is named *Dhanab al-Dālfīn,* 'tail of the dolphin' (ε Delphini). **Equuleus** has the title: *al-Qiṭ*^{c}*at al-Faras,* 'the part of a horse'.

Along the ecliptic are the figures of the four zodiac signs Sagittarius, Capricornus, Aquarius and Pisces. **Sagittarius** is represented as half man and half-horse. The most notable feature is the elaborate turban, two loose ends of which float eastwards to include the stars located there. The title of the figure is not given. There are three named stars: *Rukbat al-Rāmī,* 'archer's knee' (α Sagittarii); *Urqūb al-Rāmī,* 'archer's tendon'(β^{1,2} Sagittarii); and ^{c}*Ayn al-Rāmī,* 'eye of the archer' (ν^{1,2} Sagittarii).

Capricorn is also a hybrid figure; in the front half is the head and forelegs of a goat and the hind part is with a fish tail. The goat's head with large horns and a beard under the chin is depicted well; so also the fish tail which makes a loop and stretches upwards. There is no title of this figure either. The double star on its ear is named *sa*^{c}*d dhābiḥ,* which roughly means 'omen of sacrifice' (α^{1,2}β Capricorni)

The figure of **Aquarius** wears a turban and a short tunic, the wavy hemline of which stops above the knees. His face is in complete profile. With his left hand, he is pouring water out of a vessel; the undulating stream of water flows up to the mouth of **Piscis Austrinus**, which is drawn as a fish with an almost human face, with eye-brows,

eyes, nose and a wide mouth. There is no title of the figure of Aquarius, but there are three star names. The star on the palm of his outstretched right hand is named *sa^{c}d bula^{c},* which refers to two or three stars which constitute the twenty-third lunar mansion of the same name. On the left side of tunic is engraved the name *sa^{c}d'l-malik*, 'the royal omen'; it refers to two stars on the left shoulder (αο Aquarii). On the right side of his tunic is the name *sa^{c}d al-su^{c}ūd,* 'omen of good fortune'; it is the name of twenty-fourth lunar mansion and refers to two stars on the right shoulder of Aquarius (βξ Aquarii) and one on the tail of Capricorn (c^{1} Capricorni).[1222]

Finally, on the ecliptic just west of the vernal equinox is the figure of the western fish of the constellation **Pisces;** it is a conventional drawing of the fish without the title and without any star name.

[1222] On these *sa^{c}d* stars, see Savage-Smith 1985, pp. 130-131, 181-185.



Figure G021.3 – Virgo, Hydra, Corvus, Centaurus and others
© Bernisches Historisches Museum, Bern

Figure G021.3 shows the pictorial representations of Leo and Virgo in the upper register, drawn on the ecliptic. Leo is drawn rather indifferently with a head that hardly looks lion-like. There is no title. The named stars are *Qalb al-Asad,* 'heart of the lion' (α Leonis); *al-Ṣarfa,* 'change of the weather' (β Leonis); *Ẓahr al-Asad,* 'back of the lion' (δ Leonis) and *Rās al-Asad [Shamālī],* '[northern] head of the lion' (μ Leonis).

The figure of **Virgo** is also done rather indifferently. Her head is completely in profile, facing south and her two feet are also turned southwards. This is contrary to the usual practice of representing Virgo as facing north and walking towards north. The head is drawn carelessly with hardly any features are discernable. Her clothing, however, shows clear European influence. She wears a long ankle-length gown with long sleeves and with a wavy hemline. Above it, she wears another jacket which is much

shorter, but also with wavy hemline. On the top of these, a sash is tied around the waist, one end of which hangs down as in Islamic clothing. Her right arm is straight with the palm resting on the equator. The left arm is stretched backwards with an ear of wheat in the hand. No title is visible. The star on her right palm is named *Simāk Aʿzal,* 'unarmed *Simāk'* (α Virginis); on the hemline is written *Ghafr,* it is the name of the fifteenth lunar mansion and represents the three stars ικλ Virginis.

In the lower register are the figures of Hydra, Crater and Corvus. The long figure of **Hydra** traverses though the four zodiac houses of Leo, Virgo, Libra and Scorpio. The roundness of its body is indicated by short oblique strokes on the outline. Its title is not visible. The star near its head is named *Mankhar al-Shujāʿ,* 'nose of the serpent' (σ Hydrae); the star on its body below the equator is named *Fard al-Shujāʿ,* 'isolated one of the serpent' (α Hydrae); there is also another name *ʿUnuq al-Shujāʿ,* 'neck of the serpent'. Al-Ṣūfī states that these two are the names of the same star.[1223] These two names occur also of on the globe made by Ḍiyā' al-Dīn in 1660 which is now in Berlin (F018).[1224]

Crater is located on the body of Hydra about the middle of its length. It has the shape of an open-mouthed vessel with a narrow bottom and a base; it is beautifully decorated with a pattern of tulips. Its title reads *ṣūrat Bāṭan,* which must be an error for *Bāṭiyah,* 'figure of the bowl'.

Next to it is the figure of **Corvus,** shown pecking at Hydra with its beak. It is entitled

ṣūrat Ghurāb, 'figure of the raven'; there are two stars: *Minqār al-Ghurāb,* 'beak of the raven' (α Corvi) and *Janāḥ al-Ghurāb,* 'wing of the raven' (γ Corvi).

Below the tail of Hydra is the figure of **Centaurus,** half human and half equine. The human half is clothed in a tunic, with a collar, long sleeves and wavy hemline at the waist. His face is shown in profile. As in the case of Andromeda, his hair is also tied up as a double bun on the top of his head. The vine twig in his right hand is drawn as a palm frond. The title reads *ṣūrat Qanṭūrus,* 'figure of Centaurus'; the star on the hoof of

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1223 Ṣūfī 1874, p. 233; see also Savage-Smith 1985, p. 203.

1224 Klüber 1935, p. 20; Klüber identifies *Fard al-Shujāʿ* as α Hydrae, but does not give any identification to *ʿUnuq al-Shujāʿ*.

the horse is named *Rijl al-Qanṭūrus,* ‘foot of Centaurus’ (α Centauri). With his left hand, he holds the hind legs of the wild beast which is entitled *ṣūrat al-Sabᶜ,* ‘ figure of the wild beast’.



Figure G021.4 – Argo Navis, © Bernisches Historisches Museum, Bern

The figure of the ship in the constellation **Argo Navis** is perhaps the most realistic representation of a ship on Indo-Persian globes, with tall masts, to which sails are attached, and without the oversized leonine figurehead. Title: *ṣūrat Safīnah,* ‘figure of the ship’. Instead of two oars, there is a single anchor with a star named *Suhayl,* Canopus, (α Carinae).

The southern ecliptic pole is named *quṭb janūbī falak al-burūj* and the southern equatorial pole *quṭb janūbī muᶜaddil.*

G022 CELESTIAL GLOBE, NOT SIGNED, NOT DATED[1225]

Probably 17th Century

Diameter 166 mm

Chicago, Adler Planetarium (# A-140)

ESS 41



Figure G022.1 – Globe with stand (accession no. A-140)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

[1225] Entry based on Savage-Smith 1985, no. 41, pp. 239-240, and photos kindly provided by the Adler Planetarium.

In her description of this globe, Emilie Savage-Smith writes: ‘star positions relative to the equinoxes conform to those of the seventeenth-century Lahore workshop. … Probably Indo-Persian product of the seventeenth-century Lahore’[1226] But the constellation figures, as far as one can see, are too crudely done to be a product of the Lahore workshop.

The globe is cast as a single hollow sphere; five plugs are visible and there is a large hole where the plug is missing (see Figure G022.2).

Circles

The equator and the ecliptic are graduated in 1° and 5°. The equator is numbered continuously from 5 to 360 from the vernal equinox onwards; the ecliptic is numbered from 5 to 30, separately in each zodiac sign. The names of the zodiac signs are engraved along the ecliptic. There are ecliptic latitude circles.

Constellation Figures and Stars

All the 48 constellation figures are drawn and the positions of about 1020 stars are marked by inlaid silver points. The names of the constellations and those of some prominent stars are engraved. The surface of the globe is very badly damaged. Therefore it is difficult to compare the constellation figures with those on the celestial globe made by the members of the Lahore family. The few figures that are distinctly visible, like those of Cepheus or Cygnus in Figure G022.2, are rather crudely drawn.

[1226] Savage-Smith 1985, p. 240.



Figure G022.2 – Another view the globe (accession no. A-140)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

STAND

The stand consists of a horizon ring which is supported by four straight legs resting on an eight-lobed ring with cross-bars. The horizon ring appears to be contemporary, but is too small for this globe. The entire stand must have been made for another globe.

The horizon ring is graduated in 1° and 5° and numbered from 5 to 90, separately in each quadrant, starting at the east and west points and reaching up to the north and south points. The names of the four cardinal points are engraved near the edge. A zenith ring, gradated in 1° and 5°, is made in two parts, which are hinged to the top of the horizon ring; at the zenith point there is a mechanism to lock these parts together. However, one of the parts is lost and there remains just one single arc of 90°. The

meridian ring is not graduated and appears to be a recent addition. No semicircular arc is attached to the underside of the horizontal ring to support the globe.

PROVENANCE

Acquired by the Adler Planetarium in 1941 from a private collector.

BIBLIOGRAPHY

Savage-Smith 1985, no. 41, pp. 239-240.

Emilie Savage-Smith in Pingree 2009, pp. 230-231.

G023 CELESTIAL GLOBE, NOT SIGNED, NOT DATED[1227]

19th Century

Diameter 127 mm

London, National Maritime Museum, Greenwich (# GLB0004)

ESS 48

The globe is cast as a single hollow sphere; there is a hole with a diameter of 26 mm where a plug was once. The reference circles are drawn very faintly, but the constellation figures are engraved with bolder lines.

CIRCLES

The equator is represented by a single ungraduated line drawn very faintly and the equator by an ungraduated dotted line. The ecliptic latitude circles are also drawn very faintly; the solstitial colure is dotted. The names of the zodiac signs, with the prefix *burj,* are engraved along the ecliptic

CONSTELLATION FIGURES AND STARS

All the 48 constellation figures are drawn and some 1020 positions of stars are marked by inlaid silver points, whose sizes vary roughly according to the star's magnitude. The names of constellation figures are engraved with the prefix *kawākib* and also the names of 83 stars.[1228] The constellation figures are often simple outlines without much detail.

STAND

Ungraduated horizon ring is supported by four legs resting on a circular base. The legs are decorated with cubic knobs in the middle. An inverted semi-circular arc is affixed to the circular base to support the meridian ring. The meridian ring is not graduated, lacks holes for mounting the axis of the globe and does not properly fit in the notches made in the horizon ring. Thus the stand is not quite functional.

[1227] Entry based on Savage-Smith 1985, no. 48, p. 243 and Ackermann 1999, pp. 182-184.

[1228] These are listed in Ackermann 1999, pp. 183-184.

PROVENANCE

Presented by Sir James Caird in February 1936.

BIBLIOGRAPHY

Savage-Smith 1985, no. 48, p. 243

Ackermann 1999, pp. 182-184, with three figures.

G024 CELESTIAL GLOBE, NOT SIGNED, NOT DATED [1229]

19th century

Diameter 170 mm, height of the globe with stand 295 mm

Jaipur, City Palace, Maharaja Sawai Man Singh II Museum



Figure G024.1 – Globe with stand (photo by Dr Giles H. R. Tillotson)

[1229] Entry based on the photos kindly provided by Dr Giles H. R. Tillotson, Director of Research, Maharaja Sawai Man Singh II Museum, City Palace, Jaipur.

Star positions are punch-marked on this globe. There are also some peculiarities in the rendition of the constellation figures. The figure of Auriga is not drawn, although its title is engraved, and Cepheus, the king of Ethiopia, is depicted as a servant with a fly-whisk in his hand.

The globe is cast as a single hollow sphere. Several plugs are visible: a large rectangular one is near the constellation Argo Navis and a smaller one in the constellation Canis Minor; there are also a few small circular plugs in the vicinity of Argo Navis.

Circles

The equator and the ecliptic are represented with double bands. The narrower band is divided in 1°; the wider band is divided in 6° and numbered in *Abjad* notation. There are double lines on either side of the wider band. The scale of the equator is numbered from 6 to 360 continuously from the vernal equinox onwards, while the ecliptic is numbered from 6 to 30, separately in each zodiac sign. The names of the twelve zodiac signs are engraved along the ecliptic in long flowing letters to cover the full extent of the zodiac sign concerned. Ecliptic latitude circles are drawn at right angles to the ecliptic at 30° intervals. There are also equatorial tropics and the equinoctial colure. Ecliptic polar circle is drawn in the south with the label *dā'irah quṭb minṭaqat al-burūj janūbī* ; presumably there is also a similar circle in the north with appropriate label.

Constellation Figures and Stars

From the available photos, it appears that almost all the 48 constellation figures are engraved on this globe, save that of Auriga. The positions of about 1020 stars are marked by dots enclosed by small circles. These are so uniform that they must have been punched rather than engraved individually. The stars in each constellation are numbered serially in common Arabic/Persian numerals. Because of the preponderance of these star pointers and the serial numbers, the surface of the globe has become very cluttered. Often it is difficult to see the outlines of the constellation figures or to identify the names of constellations or of the stars.

Among the human figures, the faces of Andromeda, Cassiopeia, Orion and Bootes are much too large in proportion to their bodies; great attention is paid in tracing moustaches, even on Andromeda's face. Orion and Bootes are shown with double chins.

Hands are drawn carelessly without delineating the fingers properly. Clothing is drawn perfunctorily: all the human figures wear short tunics, whose flared lower half is indicated by triangular projections on either side of the body.



Figure G024.2 – Missing figure of Auriga
Photo by Professor G L' E. Turner,[1230] from the archives
of the Museum of the History of Science, Oxford

In Figure G024.2, the lower part of the body of Perseus can be seen in the upper left. The figure of **Auriga** ought to have been drawn near the left foot of Perseus, in the right angle formed by the ecliptic and the ecliptic latitude circle. Marks are punched to indicate the positions of the stars that constitute the constellation of Auriga and these stars are numbered serially. The names of three prominent stars are also engraved. [1] *ᶜAyyūq* (α Aurigae); this would be on Auriga's right shoulder; [2] *Mankib Dhī al-ᶜInān,*

[1230] During his visit to India in February-March 1985, the late Professor G L' E. Turner took some photos of this globe which are with the Museum of the History of Science at Oxford.

'shoulder [of the man] having the reins' (β Aurigae); this star would be on his left shoulder; and [3] *Kiᶜāb Dhī al-ᶜInān,* 'heel [of the man] having the reins (γ Aurigae); this star would be on the left foot. Furthermore, the title of the figure is written above the area where the figure should have been: *ṣūrat Mumsik al-Aᶜinnah* [4]*,* 'figure of the one who holds the reins'.

Another peculiarity is the rendition of Cepheus as can be seen in Figure G021.3. Here are to be seen, from left to right, Andromeda, Perseus, Cassiopeia and Cepheus. Like many Indo-Persian globe makers, the maker of the present globe is not familiar with the mythological background of these persons. But he also takes liberty with the prevalent iconographical models on the Indo-Persian globes: he adds thick moustaches to Andromeda's face; more amusing is the rendition of Cepheus. Having seen the representation of Cepheus as kneeling behind the chair of Cassiopeia on other globes, our globe-maker must have concluded that Cepheus must be a servant of the exalted person on the chair, and so made him stand behind Cassiopeia and wave a fly-whisk over her head, which task, in his view, is the proper function of a servant.

Andromeda is drawn in the usual posture of standing with both arms stretched out in both directions. But her right arm is covered by the fish which should have been drawn a bit lower. The fingers of the left hand are shown clearly, but it looks as if Andromeda, instead of wailing for the release from the chains, has freed herself from the chains on her own and is proudly showing off the broken handcuff, which looks very modern. Her face is quite plump with a thick moustache. She is dressed in a tunic which is wide at the bottom. A belt is drawn at the waist, with three cells, each filled with a punched mark of a star. The title of the figure is written to the left of her head as *ṣūrat al-Musalsalah,* 'figure of the chained [woman]'. The star on her head is named *Rās al-Marāt* (sic! it should read *al-Mar'ah*) *al-Musalsalah,* 'head of the chained woman' (α Andromedae); the star on her waist is given the name *Janb al-Musalsalah,* 'side of the chained [woman]' (β Andromedae); the second name of this star is also written: *Baṭn al-Ḥūt,* 'belly of the fish'. The star on her foot is called *Rijl al-Musalsalah,* 'foot of the chained [woman]' (γ Andromedae).



Figure G024.3 – Andromeda, Perseus, Cassiopeia and Cepheus
(photo by Dr Giles H. R. Tillotson)

Cassiopeia is seated on a chair with a high back rest. Her face is also plump; she wears on her head a cap with a plume in front. Details of her clothing are not discernable. Both her hands are raised; with her left hand she holds the back post of chair. The four carved legs of the chair are drawn in a row without observing any perspective. The title is engraved on her leg: *ṣūrat Dhāt al-Kursī,* 'figure of the one with the chair'. This is repeated once again near her head as *Dhāt al-Kursī,* 'the one with the chair'. The star on her left hand is named *Kaff al-Khaḍīb,* ' dyed hand' (β Cassiopeia).

Cepheus is shown standing with his face in profile and with a tall conical hat on his head. He wears a short tunic; its flared lower half is indicated by triangular extensions; there is even a chain around his neck. The fly-whisk in his hand is drawn

meticulously. The title of the figure is not visible. On his right ankle is a star named *al-Rāᶜī,* ‘the shepherd’ (γ Cephei).

The most successful rendition is the figure of **Perseus**. His face is in profile; long hair combed to the back, broad forehead, long nose, eyebrow and eye, moustache, mouth and the pointed beard are all well drawn. The posture, with the face in profile as if looking at the head of the Ghoul in his right hand, his legs bent leftwards and the left hand raised high with the sword — all this suggests motion, as if he is rushing to rescue Andromeda. The title of the figure of Perseus is engraved next to his face: *ṣūrat Parshā’ūs,* ‘figure of Perseus’. A star on his left side carries the name *Janb Parshā’ūs,* ‘side of Perseus’ (α Persei) and the star on his right knee is called *Mankib al-Thurayyā,* ‘shoulder of *al-Thurayyā*’ (ξ Persei).

The head of the Ghoul is also well drawn, but for the two straight parallel lines to represent the nose. Quite unusually it is entitled *ṣūrat Rās al-Ghūl,* ‘figure of the Ghoul’s head’, thus treating it as an independence constellation.



Figure G024.4 – Orion (photo by Dr Giles H. R. Tillotson)

The figure of **Orion** is drawn with a very large head in proportion to the rest of the body. The arms and two legs cover the area where the upper torso should have been. He wears a cap with a pattern of triangles. The title is engraved to the left of the face: *ṣūrat Jabbā[r],* 'figure of giant'. Several stars are named. The star on the right foot is named *Rijl al-Jawzā' al-Yusrā,* 'the left foot of *al-Jawzā*'' (β Orionis); that on the left foot: *Rijl al-Jawzā' al-Yumnā,* 'the right foot of *al-Jawzā*'' (κ Orionis); that on the left shoulder: *Mankib al-Jawzā',* 'shoulder of *al-Jawzā*'' (α Orionis); that on the right shoulder: *yad al Jawzā' al-Yusrā,* 'left hand of *al-Jawzā*'' (γ Orionis). It may be noted that the confusion between 'right' and 'left' is due to the fact that the names refer to figures as seen from below the sky while the figures on Indo-Persian globes are drawn as seen from above the globe.



Figure G024.5 – Hercules and Ophiuchus (photo by Dr Giles H. R. Tillotson)

Figure G024.5 above shows the companion pair of Ophiuchus and Hercules, the former straight, the latter upside down. Usually their heads are drawn alike, but here

they are different. The head of **Ophiuchus** is shown in profile, the broad forehead, the long nose, eye brow, eye, mouth, moustache and chin are drawn quite elegantly. There is Mughal style turban on his head. He is clothed in a short tunic which is very wide below the waist; long sleeves and a collar are marked. There is a think necklace around the neck. A sash is tied around the waist, two loose ends hang down. Ophiuchus looks like Mughal nobleman. However, his left shoulder is not anatomically quite correct; his legs are far too short for the body and the serpent in his hand looks very stiff and wooden. The title is not visible. The star on his cheek is named *Rās al-Ḥawwā,* 'head of the serpent charmer' (α Ophiuchi).

The figure of **Hercules** is drawn upside-down, his head placed next to that of Ophiuchus. He his bare-headed. His face is also in profile, but not so well drawn as that of Ophiuchus. Both wear moustaches, but no beards. Hercules wears a short tunic, the flared lower half is indicated by triangular projections on either side of the body; a girdle or sash is around the waist. The weapon in his left hand is depicted as a simple bar, bent at right angles. The title reads: *ṣūrat al-Jāthī,* 'figure of the kneeling [man]'. The star on his forehead is named *Rās al-Jāthī,* 'head of the kneeling [man]' (α Herculis).



Figure G024.6 – Ursa Major and Bootes (photo by Dr Giles H. R. Tillotson)

Figure G024.6, **Bootes** is shown on the right. Here also the head is much too large in proportion to the body. His face is in three-quarters profile with a double chin. He wears a turban and a short tunic with a wide skirt. There is a necklace around the neck and a belt around the waist. His right arm is raised high almost in a vertical manner. His left arm, the whip in the left hand, the constellation figure of Corona Borealis and the head of the serpent held by Ophiuchus are all drawn too close together without marking the necessary distances between them.

The title of the figure, *ṣūrat al-Awwā,* 'figure of the howler' is inscribed along the right arm. The star below the hemline of his tunic is named *Simāk Rāmiḥ,* 'the armed Simāk' (α Bootis); the star on the right leg has the name *Mufrid al-Rāmiḥ,* 'solitary [star] of the lancer' (η Bootis).

Immediately next to his left arm is the figure of Corona Borealis, entitled *ṣūrat Iklīl,* 'figure of crown'. This is short for *Iklīl Shamālī,* 'northern crown'; the more

common designation is *al-Fakkah.* The star in this constellation is named *Nayyir al-Fakkah,* 'the luminous one of *al-Fakkah*' (α Coronae Borealis).

Below this can be seen the head of the serpent held by Ophiuchus; its title reads *ṣūrat al-Ḥayyah,* 'figure of the serpent'.

The figure of the bear in the constellation Ursa Major is on the right hand side of Figure G024.6. It has hardly any resemblance to a bear. Pairs of parallel vertical strokes are drawn along the entire outline, probably to indicate the hairy nature of the body, but these do not produce the desired effect. The title *ṣūrat Dubb Akbar,* 'figure of great bear', is engraved below the head. The star on the back is named *Ẓahr Dubb al-Akbar,* 'back of the great bear' (α Ursae Majoris). The stars on the tail are named respectively as *Jawn,* 'black horse' (ε Ursae Majoris); *ʿAnāq,* 'goat' (ζ Ursae Majoris); and *Qā'id,* 'leader' (η Ursae Majoris). The star on the knee of the hindmost leg is given the name *Fakḥdah Dubb al-Akbar,* 'thigh of the great bear' (γ Ursae Majoris).The pair of stars on the paw of the same leg are called *al-Qafzah al-Ūlā,* 'the first leap' (νξ Ursae Majoris). The pair on the other hind paw are not named at all. The pair of stars on the foremost paw are named *al-Qafzah al-Thālith,* 'the third leap' (ικ Ursae Majoris).



Figure G024.7 – The southern poles (photo by Dr Giles H. R. Tillotson)

The figure above shows the two southern poles and the meridian ring attached to the globe at the equatorial pole. The southern pole of the ecliptic is where the six ecliptic latitude circles converge. With the ecliptic pole as the centre, a circle is drawn with a

radius equal to the obliquity of the ecliptic so that it passes through the equatorial pole. This circle is named *dā'irah quṭb minṭaqat al-burūj janūbī.* The line that passes through both the poles is the solstitial colure and the line that intersects it at right angles at the equatorial pole is the equinoctial colure.

STAND

The globe is mounted on a 170 mm high stand. The stand consists of a wide horizon ring with an outer diameter of 217 mm. The overall height of the globe with the stand is 295 mm. The horizon ring is supported by four plain legs which rest on a plain circular ring.

The horizon ring is to small for the globe; it does not sit properly inside the ring up to the half. Moreover, the horizon ring, the legs and the ring at the base do not display the same workmanship as the rest of the stand; these are obviously replacements.

The meridian ring passes through two slots cut in the horizon ring at the north and south points. To the underside of the horizon ring is attached, at the east and west points, a semicircular arc which has an ornate tip at its middle. This supports the meridian ring. The meridian ring and the arc are apparently original.

The meridian ring is graduated on two sides in 2° and the intervals of 6° are numbered in *Abjad* notation from 6 to 90, separately in each quadrant. A series of holes are bored in thickness of the ring so that the axis can be shifted in these holes in accordance with the terrestrial latitude of the place where the globe is used. As can be seen in Figure G024.1 and Figure G024.7, the thickness of the meridian ring is not uniform throughout. At some places, the thickness is reduced almost up to a half. Probably a sleeve with a graduated arc was inserted here as was done in globe G011 (see Figure G011.1), but the arc is now missing.

G025⊙ CELESTIAL GLOBE, NOT SIGNED, NOT DATED[1231]

Probably 18th century

Diameter 197 mm; height of the stand 265 mm

Mumbai, K. R. Cama Oriental Institute

ESS 37



Figure G025.1 – Globe with stand (photo by S. R. Sarma)

[1231] During a brief visit to the Cama Institute in April 1998, I took a few photos of this globe, which turned out poorly because I had to use the flash. It has not been possible to obtain better photos since then.

An inscription near the south pole mentions the name of the patron who commissioned this celestial globe, but not the name of its maker. Nothing is known about this patron. The globe is cast as single hollow sphere; there is a large plug below the figure of Centaurus.

Circles

The equator and the ecliptic are graduated in 1° and 5°. The former is numbered from 5 to 360 continuously from the vernal equinox onwards; the latter is numbered from 5 to 30, separately in each zodiac sign. The names of the zodiac signs are engraved along the ecliptic. Ecliptic latitude circles and equatorial polar circles are drawn.

Constellation Figures and Stars

All the 48 constellation figures are drawn and the position of about 1020 stars are marked with inlaid silver points. The names of the constellations, of the equatorial poles and of some major stars are engraved.

Among the constellation figures, the snakes and fishes are drawn with minutely engraved scales. The human figures are drawn reasonably well, with clear facial features. Their clothing is not completely shown; while the lower part of the dresses are distinctly drawn, the upper torsos remain uncovered.



Figure G025.2 – Vernal equinox (photo by S. R. Sarma)

Figure G025.2 has vernal equinox at its centre, with diverse figures arrayed around. The graduated scales of equator and ecliptic which intersect at the vernal equinox are not perfectly straight. In the upper register on the left is the winged horse **Pegasus,** with its head touching the scale of the equator; the mane of the horse and the wing are drawn well. On the right is the figure of **Andromeda,** clothed in a very short skirt and a sash with many loops. A bead necklace adorns her neck. The strands of her long hair fall on either side of the face.

In the lower register are the figures of Capricorn and Aquarius drawn on the ecliptic. The rear part of **Capricorn** which should have a fish tail is not clearly delineated. **Aquarius** stands with his right arm stretched above Capricorn; his upper torso is bare; the lower part is covered by a long skirt that reaches up to the ankles. His face is in full profile, with the hair combed back. With his left hand, he pours out water from a vessel; the stream of water flows up to the mouth of the rather fat **Piscis**

Austrinus. To the right is the figure of Cetus, with the body of a bird, tail of a fish and head of dog. Its neck is adorned with a gem-studded collar.



Figure G025.3 – Virgo (photo by S. R. Sarma)

Virgo is dressed in a long ankle-length gown with a wavy hemline. Her face is in three-quarters profile; hair parted in the middle, and combed to both sides. Parallel lines on her left wrist indicate either a bracelet or the end of the sleeve; her left wing is meticulously drawn, as also the wings of Corvus to the left. The star on Virgo's right palm is named *Simāk al-Aʿzal,* 'unarmed *Simāk*' (α Virginis, Spica). Above her head can be seen the hind part of Leo. The end of its tail, which carries the star β Leonis, is shaped like a pretty flower.

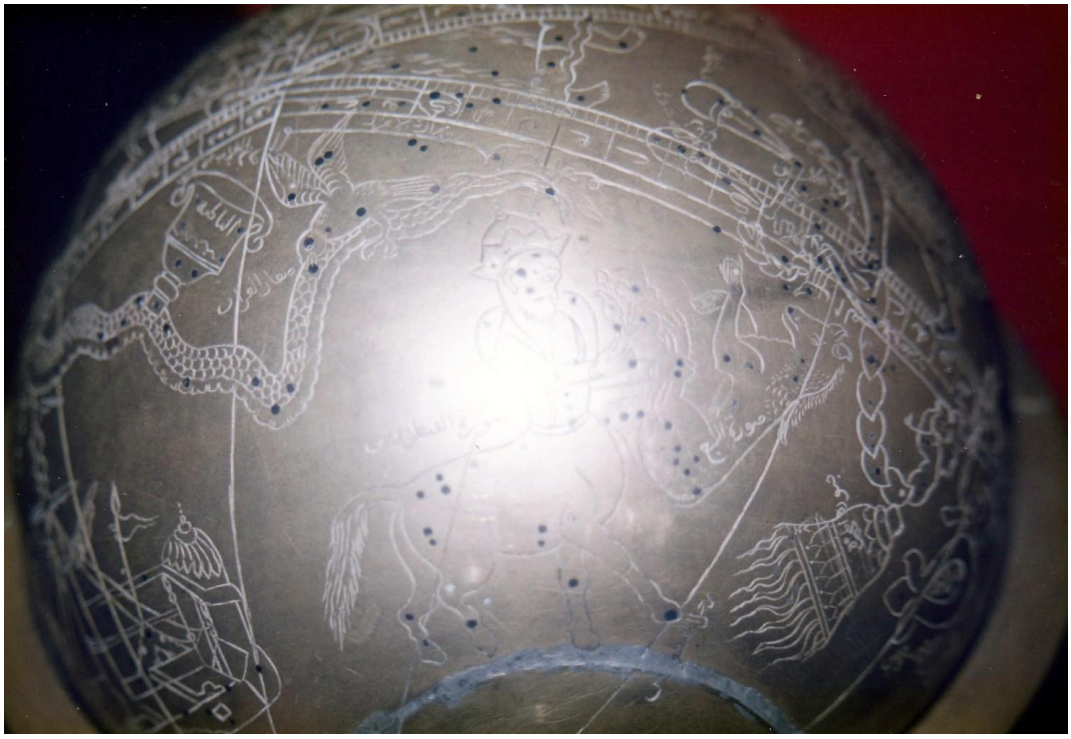


Figure G025.4 – Centaurus (photo by S. R. Sarma)

The most impressive figure on this globe is that of **Centaurus;** both the human and the equine halves well-proportioned. He sports a round cap with an ornate rim, as is found on many Lahore celestial globes. Above him on the left is the figure of **Hydra**; the bare underside of its body and the scaly upper side are well drawn. Above him is the figure of **Crater**, which resembles a trophy. Next to it is Corvus, alighting on the body of Hydra and pecking it with its beak; the star located here is appropriately named *Minqār al-Ghurāb,* 'beak of the raven' (α Corvi).

In the left hand corner can be seen the domed pavilion on the rear of the ship in constellation **Argo Navis.** In the opposite corner is the figure of **Ara**, the incense burner; the fumes of the incense are issuing out like the tongues of flame.

STAND

The globe is mounted on a stand which consists of an ungraduated horizon ring which is supported by four plain legs that rest on a ring with eight lobes and cross-bars. On the underside of the horizon ring is another wide ring at right angles to it; to this are attached two semi-circular arcs, one perpendicular to the other. The wide ring and the two arcs form a frame which supports the globe from below. From the four points where the cross-bars join the eight-lobed base ring, there arise four arcs which converge at the nadir of the globe and support the frame that holds the globe. There is no meridian ring

and no provision appears to have been made for it in this stand; therefore the stand is non-functional. Closer examination is necessary to determine whether the stand was made along with the globe or whether it is a later addition.

INSCRIPTION

Near the southern poles is an inscription in six lines which translates as follows:

> 'The one [who is] in need of God, Abū al-Qāsim, son of our master and teacher, the paragon of his age and unique of his time, ᶜAbd al-Raḥmān ibn Ḥasan, requested it to be made and figured for him. May God bestow much mercy on them both.'[1232]

BIBLIOGRAPHY

Rehatsek 1875, pp. 329-330.
Savage-Smith 1985, no. 37, pp. 237-238.

[1232] Translation from Savage-Smith 1985, p. 330.

G026⦿ CELESTIAL GLOBE, NOT SIGNED, NOT DATED

Probably 18th Century

Diameter 152 mm

New Delhi, Red Fort, Mumtaj Mahal Museum (# 40.413)

ESS 55



Figure G026.1 – Globe with stand (photo by S. R. Sarma)

This well-crafted celestial globe appears to be unfinished; it is engraved with all the 48 constellation figures, but their titles are not engraved and no stars are marked.

Circles

The equator and ecliptic are represented by double bands which are neatly drawn and accurately divided in 1° and 5°. The equator is numbered in *Abjad* notation from 5 to 360 continuously from the vernal equinox onwards, whereas the ecliptic is numbered from 5 to 30, separately in each zodiac sign. The names of the zodiac signs are written along the ecliptic. Ecliptic latitude circles are drawn at right angles to the ecliptic with intervals of 30°.



Figure G026.2 – Bootes and Virgo (detail of Figure G026.1)

Constellation Figures and Stars

All the 48 constellation figures are drawn, but their titles are not added, nor are any stars marked on the globe. Figure G026.2 shows Bootes and Virgo on the left and Hercules, Ophiuchus and Libra on the right. Bootes in clothed in a short tunic which closes on his right side. Virgo wears an ankle-length gown with a wavy hemline. One

loose end of the sash, with geometrical pattern, hangs down vertically. No other details are marked on the gown. Her left wing is depicted neatly, but with minimum detail.

At the top on the right-hand side is the upside-down figure of Hercules which is depicted as a female with large breasts and a very short pleated skirt (as in Figure F019.6; Figure F020.4 and Figure F027.16).

STAND

The stand (height 120 mm) consists of a horizon ring supported by four tapering legs resting on an eight-lobed ring with cross-bars. The horizon ring is divided in 2° and 6° and numbered in common Arabic/Persian numerals from 6 to 90, separately in each quadrant, starting from the east and west points and reaching up to the north and south points. The meridian ring is similarly divided; in contains a series of holes into which the axis can inserted in order adjust the globe for different terrestrial latitudes. A semi-circular arc is attached to the underside of the horizon ring at its east and west points; it supports the meridian ring from below.

BIBLIOGRAPHY

Savage-Smith 1985, no. 55, pp. 245-246.

G027 INDIAN COPY, UNSIGNED, UNDATED, OF A CELESTIAL GLOBE BY MUḤAMMAD IBN MAḤMŪD IBN ᶜALĪ AL-ṬABARĪ AL-ASṬURLĀBĪ, 684 AH (AD 1285-86)[1233]

19th century

Diameter 130 mm

Paris, Musée du Louvre, Islamic Arts section (# 6013)



Figure G027.1 – Globe with stand (photo by S. R. Sarma)

[1233] Entry based on Savage-Smith 1985, no. 6, pp. 220-221, Fig. 8; Maddison & Savage-Smith 1997, I, pp. 212-213.

The Nasser D. Khalili Collection of Islamic Art, London, owns a celestial globe made by Muḥammad ibn Maḥmūd ibn ᶜAlī al-Ṭabarī al-Asṭurlābī in 684 AH (AD 1285-86), which is engraved in Kufic script.[1234] It is the sixth oldest Islamic celestial globe that is extant. It is made of two hemispheres joined together along an ecliptic latitude circle passing between the houses of Taurus and Gemini and between the houses of Scorpio and Sagittarius. It has a diameter of 134 mm. Only the globe is extant; the stand and rings are lost.

On the globe are engraved the equator, ecliptic and the ecliptic latitude circles. The positions of about 1020 stars are marked with inlaid silver nails and the 48 constellation figures are drawn. Savage-Smith writes: 'The north celestial pole, the 12 zodiacal houses, 55 stars, 28 lunar mansions, and 32 of the constellations are labelled. … The artistic conventions of dress and hair styles of the constellation figures on the globe have been made to correspond to those of late 13th-century Iranian art under the Ikhanids.'[1235]

Sometime in the 19th century, a copy was made of this globe in India, employing *cire perdue* technique of casting. It is a near identical copy, but the Kufic engravings are poorly done with many spelling errors, the circles and graduations on the scales are not accurate and the star positions are very erratic. It is not known where exactly this inaccurate copy was made and for what purpose.

Circles

Equator and ecliptic are divided in 1° and 6°. The equator is numbered from the vernal equinox, but not continuously; it is numbered in three segments up to 100 and then up to 360. The ecliptic is numbered from 6 to 30, separately in each zodiac sign. The names of the zodiac signs are engraved along the ecliptic. Six ecliptic latitude circles are drawn at 30° intervals.

1234 Maddison & Savage-Smith 1997, I, pp. 212-213. See also Savage-Smith 1990, p. 26; Savage-Smith 1992a, pp. 55-57, Fig. 2.37.

1235 Maddison & Savage-Smith 1997, I, p. 212.

Constellation Figures and Stars

As in the original, here also about the positions of 1020 are marked with inlaid silver points and the full set of 48 constellation figures engraved. While the graduations on the circles and the positions of the stars are not accurate, the constellation figures are said to be ‘quite nicely engraved’.

Stand

The stand consists of a horizon ring which is supported by four legs resting on an eight-lobed base with central cross-bars. [1236] From the four points where the cross-bars join the eight-lobed base, there arise four arcs of 90°, converging at the top and forming the support for the meridian ring and for the semicircular arc attached to the underside of the horizon ring.

The horizon ring is divided in 2° and every tenth is labelled up to 90, four times, proceeding always clockwise. The meridian ring is graduated on one side in 2° and numbered up to 90, beginning at the points opposite the celestial equator and ending at the poles. To of the arcs attached to the base are graduated in 5° and numbered in Kufic *Abjad* letters from the top to the base. Two gnomons are attached to the semi-circular arc, but these are not aligned to the graduated arcs as they should be, obviously because the maker did not understand their function.

Provenance

The globe was acquired in 1892 by the French Archaeological Mission at Cairo and was deposited at the Louvre.

Bibliography

Savage-Smith 1985, no. 6, pp. 220-221, Fig. 8 on p. 28.
Savage-Smith 1990, p. 26.
Savage-Smith 1992a, pp. 55-57, Fig. 2.37.
Maddison & Savage-Smith 1997, I, pp. 212-213.

[1236] This stand is similar to that in the globe made by Qayṣar ibn Abī al-Qāsim ibn Musāfir al-Ashrafī al-Hanafī in 1225-26; cf. Savage-Smith 1985, no. 3, pp. 218-219.

G028 COPY NO. 1 BY NAʿĪM AL-DĪN MURĀDĀBĀDĪ, 1357 AH (AD 1938-39) OF A CELESTIAL GLOBE MADE ORIGINALLY BY AKBAR SHĀH MUHANDIS JAHĀNĀBĀDĪ, 1260 AH (AD 1844-45) [1237]

Diameter 133.6 mm

London, Nasser D. Khalili Collection of Islamic Art (# SC 14)



Figure G028.1 – Globe with the meridian ring
The Nasser D. Khalili Collection of Islamic Art, Accession No. SC 14
Photo courtesy of the Khalili Family Trust © Nour Foundation

[1237] Entry based on Maddison & Savage-Smith 1997, I, no. 138, pp. 172, 239-240, and the detailed photos generously provided by Nahla Nassar, the Registrar of the Nasser D. Khalili Collection of Islamic Art, London.

Akbar Shāh Muhandis Jahānābādī is said to have made a celestial globe for the Nawāb of Awadh Muḥammad Amjad ᶜAlī Shāh in 1260/1844-45. Nothing is known about this globe maker, nor is the globe extant, save for the two numbered copies fabricated by a certain Muḥammad Naᶜīm al-Dīn Murādābādī as late as 1357/1938-39. Nothing is known about this Naᶜīm al-Dīn either, nor do we know why or for whom he made the copies in the first half the twentieth century. We also do not know whether he made just two copies which came to light so far, or whether he made more. In a long inscription, Naᶜīm al-Dīn claims that in his copies he made improvements on the original. Since the original has not survived, it is not possible to see what improvements he made.

This is the first copy; the second copy will be described under G029. Both are almost identical except for some minor differences. These two entries should be read together.

Unusually, both these copies are made first as two separate hemispheres and then joined along the equator.[1238] These are the only specimens of globes which are produced in this fashion in India. All other extant specimens made in India were cast as single hollow spheres by the *cire perdue* process. Naᶜīm al-Dīn's *nisbah* indicates that he was from Moradabad (28;29,48° N, 78;46,48° E) in the state of Uttar Pradesh in India. This place has a long tradition of brass making, going back to the Mughal times as it is claimed. In the second half of the twentieth century, the town became a major exporter of brass handicrafts. Now it is also a major centre of fake astrolabes and celestial globes, a few specimens of which will be discussed in section Z. The fake celestial globes produced here are all cast as single hollow spheres by the lost wax process. This technique of casting should therefore have been available when Naᶜīm al-Dīn made the two copies. The reason why he did not produce his copies as single hollow spheres, but as two hemispheres joined at the equator, must be because the second process is much easier.

[1238] About the present globe, Savage-Smith writes: 'The sphere is constructed of two hemispheres joined along the equator by an internally soldered strip'; cf. Maddison & Savage-Smith 1997, I, p. 240. In the Lahore globe also a deeper groove is discernable along the equator.

Circles

The equator and ecliptic are represented by two bands each; a very narrow band divided in 1° and a wider band divided in 6° and numbered in *Abjad* notation; the equator is numbered from 6° to 360° continuously from the vernal equinox onwards and the ecliptic from 6 to 30, separately in each zodiac sign. Both these graduated scales are drawn very meticulously. There are also drawn ecliptic latitude circles at intervals of 30°, equatorial tropics, equatorial polar circles and smaller circles around the equatorial poles with a radius of about 12°.

A noteworthy feature of this globe is that the tropics, polar circles, equinoctial and solstitial points on the ecliptic, as well as the ecliptic poles are labelled. The equatorial tropics are named *madār Rās al-Jadī,* 'Tropic of Capricorn' and *madār Rās al-Saraṭān,* 'Tropic of Cancer'; the equatorial polar circles *madār quṭb minṭaqah*; the equinoctial points *nuqṭat iʿtidāl rabīʿī,* 'point of vernal equinox' and *nuqṭat iʿtidāl kharīfī,* 'point of autumnal equinox'; solstitial points *nuqṭat al-inqilāb al-sayfī,* 'point of summer solstice' and *nuqṭat al-inqilāb al-shatawī,* 'point of winter solstice'; ecliptic poles *minṭaqah quṭb shamālī* (in the north) and *quṭb minṭaqah janūbī* (in the south); solstitial colure *dā'irah marrah bi-l-aqṭāb al-arbaʿah.* The names of the zodiac houses are written along the ecliptic, in larger letters, but not extending to the entire length of the zodiac house. All these names are filled with a red pigment in order to distinguish them from the names of the constellations and those of individual stars which are filled with a black substance. The celestial poles are not named.

Constellation Figures and Stars

The full set of 48 constellation figures are drawn and the positions of about 1020 stars are marked by inlaid silver nails. The stars in each constellation are numbered serially in common Arabic/Persian numerals. The names of the constellation figures are engraved with the prefix *ṣūrat* (spelt صورة); engraved are also the names of some prominent stars.

The figures are drawn generally with thicker outlines. The most striking feature of the human figures are that their faces are left completely blank; the outlines of the faces are drawn, but these are not filled with eyes, noses and mouths. On the other hand, the clothes worn by these figures receive greater attention: the hemlines and the collars are emphasized with closely made oblique strokes. While Andromeda, Cassiopeia,

Perseus and Cepheus are clothed in full length tunics, Bootes and Hercules wear very short and flared skirts like those worn by female dancers in a ballet.

Figure G028.1 shows the area around the north poles, with Draco coiled around the north ecliptic pole and several figures arranged all around. The north ecliptic pole is named *minṭaqah quṭb shamālī* and the engraving is filled with a red pigment. The six ecliptic latitude circles converge at the pole. The celestial north pole is attached to the graduated meridian ring. A small circle with a radius of about 12° is described around this pole; the equatorial polar circle is described around this pole in such a manner that it passes through the ecliptic pole; this circle is named *madār quṭb minṭaqah.* The ecliptic latitude circle that passes through both the poles is the solstitial colure; it is named *al-dā'irah al-marrah bi-l-aqṭāb al-arbaᶜah*. These two names are also in red.

The figure of **Ursa Minor** is drawn in a conventional manner inside the coil of the dragon and is entitled *ṣūrat al-Dubb al-Aṣghar,* 'figure of the small bear'. The star at the tip of its tail is named *al-Jadī,* 'the goat' (α Ursae Minoris, Polaris) and the two on its body *Anwar al-Farqadayn,* 'brighter of the two calves' (β Ursae Minoris) and *Akhfa al-Farqadayn,* 'more obscure of the two calves' (γ Ursae Minoris).

Ursa Major is at the bottom of the figure with its title *ṣūrat al-Dubb al-Akbar,* 'figure of the great bear', written across the body. The four stars that form a rectangle are collectively named as *al-Naᶜsh,* 'the bier' (αβγδ Ursae Majoris) and their individual names are also engraved respectively as *Ẓahr al-Dubb al-Akbar,* 'back of the great bear' (α Ursae Majoris); *Mirāq al-Dubb al-Akbar,* 'loin of the great bear' (β Ursae Majoris); *Fakhdh al-Dubb al-Akbar,* 'thigh of the great bear' (γ Ursae Majoris) and *Maghriz al-Dubb al-Akbar,* 'base of the great bear' (δ Ursae Majoris). Likewise the three stars on the tail are named collectively as *al-Banāt,* 'the daughters' (εζη Ursae Majoris) and individually as *al-Jawn,* 'the black horse' (ε Ursae Majoris); *al-ᶜAnāq,* 'the goat' (ζ Ursae Majoris) and *al-Qā'id,* 'the leader' (η Ursae Majoris).

The pairs of stars on its paws are named respectively as *al-Qafzah al-Ulā,* 'the first leap' (νξ Ursae Majoris); *al-Qafzah al-Thānī,* 'the second leap' (λμ Ursae Majoris) and *al-Qafzah al-Thālithah,* 'the third leap' (ικ Ursae Majoris); but in all the three cases the diacritical points are placed wrongly so that the first word reads *al-faqzah.*

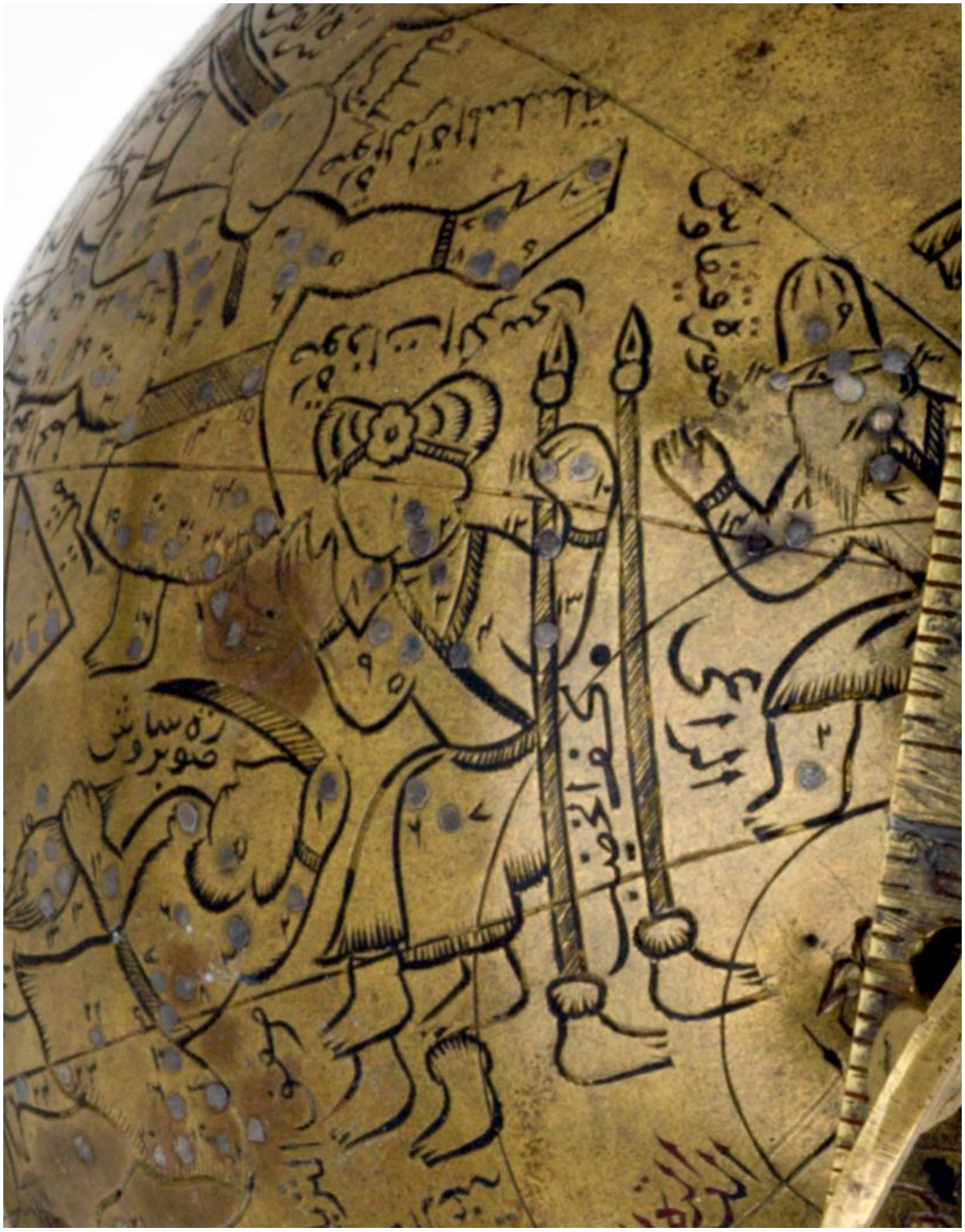


Figure G028.2 – Cassiopeia and others (detail of Figure G028.1)
The Nasser D. Khalili Collection of Islamic Art, Accession No. SC 14
Photo courtesy of the Khalili Family Trust © Nour Foundation

Cassiopeia wears a long gown; the thick short strokes along the hemline, waist, collar and wrists produce a three-dimensional effect; it looks as if she is wearing a heavy woollen coat. On the head is what looks like a fur cap with a with a huge flower in the middle. The chair on which she is seated consists of two long back posts, unconnected

with each other, with tops resembling spear-heads and feet shaped exactly like the feet of Cassiopeia. Of the front legs, just the feet are drawn, below Cassiopeia's feet, exactly like her feet. Similar bizarre chairs with human feet were drawn by Ḍiyā' al-Dīn in two of his globes F007 and F027). The title of the figure is engraved above her head: *ṣūrat Dhāt al-Kursī,* 'figure of the one with the chair'; the star on left elbow is named *Kaff al-Khaḍīb,* 'dyed hand' (β Cassiopeiae).

Cepheus is also depicted wearing a similar coat, but a simple cap. The constellation is named *ṣūrat Qīqā'ūs,* 'figure of Cepheus' and the star on his forward foot *al-Rāᶜī,* 'the shephard' (γ Cephei).

Andromeda is also dressed in a long gown with long sleeves. But here oblique strokes are made sparingly. The sash around her waist is not straight, but slanted; this is done in order to include three stars in it. The sash is filled with lightly drawn oblique lines. The figure is entitled *ṣūrat al-Mar'ah al-Musalsalah,* 'figure of the chained woman'. The star on her forehead is shared by the constellation Pegasus as well and is therefore given two names *Rās al-Musalsalah,* 'head of the chained [woman]' (α Andromedae) and *surrat al-Faras,* 'navel of the horse' (δ Pegasi). But the star at her waist is not named, and the figure of the fish close to her midriff is not properly shown.

In the figure of **Perseus**, oblique strokes are added to the outlines of the tunic, beard and sword. The outline of his face shown in profile. Above the face is the title of the figure *ṣūrat barsā'ūsh.* The star on his side is given the name *Mirfaq al-Thurayyā,* 'elbow of *al-Thurayyā*' (α Persei) and star on the Ghoul's head *Rās al-Ghūl,* 'head of the Ghoul' (β Persei).



Figure G028.3 – Leo, Virgo, Argo Navis and others
The Nasser D. Khalili Collection of Islamic Art, Accession No. SC 14
Photo courtesy of the Khalili Family Trust © Nour Foundation

Figure G028.3 shows the graduated scale of the ecliptic above and the graduated scale of the equator below, the two intersecting at the autumnal equinox on the right. The point of intersection is named, in red, *nuqṭat iʿtidal kharīfī.* The Tropic of Cancer is labelled in red, next to the figure of Leo, as *madār Rās al-Saraṭān.* The Tropic of Capricorn is named, also in red, above the figure of Centaurus as *madār Rās al-Jadī.* The names of the zodiac houses are written along the ecliptic in large letters and filled with a red substance. From left to right, they read as *al-Saraṭān, al-Asad, al-Sunbulah*

and *al-Mīzān.* Below the scale of the ecliptic, in the space between the figures of Cancer and Leo, is written in red *minṭaqat al-burūz,* 'the zodiac'.

In the upper half are the figures of the zodiac signs of Gemini, Cancer, Leo and Virgo drawn upon the scale of the ecliptic, with their usual titles and star names. The tail of the lion is very short; the outline of Virgo's face hardly discernible, but her hands and wings are drawn in bold lines.

Between the scales of the ecliptic and equator is the figure of **Canis Minor**, represented by a small dog with a long tongue. Usually the dog is depicted with its face in the west; here it is in the east, face-to-face with the serpent Hydra, whose figure has a very long stretch, reaching up to the region above the head of Centaurus. On its body are the figures of **Crater** and **Corvus**.

To the south of Hydra are the figures of Canis Major, Argo Navis and Centaurus. Of these, the ship of Argo Navis is depicted in a highly artistic manner; it is reminiscent of some of the ornate ships drawn by Ḍiyā' al-Dīn Muḥammad like the one on the globe at the Hermitage (Figure F009.14). While Ḍiyā' al-Dīn's ship has a figurehead shaped like the head of a parrot with its curved beak, the ship here has two figureheads: the parrot's head in the west and a huge dragon's head projecting into the east. The ship also has a large pavilion with an ornate dome and arched windows, three masts and pennants. The sail tied to the main mast looks like an ornate hand fan.



Figure G028.4 – Bootes, Hercules, Centaurus and others
The Nasser D. Khalili Collection of Islamic Art, Accession No. SC 14
Photo courtesy of the Khalili Family Trust © Nour Foundation

In Figure G028.4, the scale of equator is above and that of the ecliptic is below. Parallel to the equator are the two tropics. The Tropic of Cancer is above; it is labelled in red as *madār Rās al-Saraṭān* on the left-hand side. The Tropic of Capricorn is below; it is labelled in red as *madār Rās al-Jadī* also on the left-hand side just above the head of Centaurus. Below the ecliptic are engraved the names of the zodiac house in large letters filled with red; these are *al-Mīzān, al-Aqrab, al-Qaws and al-Jadī.* More important, the point between the houses of Sagittarius and Capricorn is named, also in red, as *nuqṭat al-inqilāb al-shatawī,* 'the point of winter solstice'.

The figures of Bootes, Arora Borealis and Hercules are in the upper register; Ophiuchus with his serpent straddles the equator; the zodiac signs of Virgo. Libra,

Scorpio and Sagittarius are on the ecliptic; Hydra, Centaurus with Lupus, Ara and Corona Australis are in the lower register. The figures are endowed with the usual titles and usual named stars. What is remarkable here is the rendition of certain figures. **Bootes** is dressed in a short tunic. In the upper half, the top has short sleeves and the collar is shaped like Y. The lower half consists of a very short skirt, like those worn by ballerinas. Thick lines on the ankles indicate the ends of the tight trousers. The head is covered by a turban. **Hercules**, depicted upside-down, is also clothed a like manner, in a very short skirt. The top has long sleeves and the collar is formed like V. No trousers or turban are indicated. Of the zodiac figures on the ecliptic, **Scorpio** has a very unusual shape, resembling a bull's head with curved horns and ears. The lower part of the figure is occupied by **Centaurus**, wearing a round cap, and holding the wild animal with his left hand and with the right hand a vine twig, which is given a very unusual shape.

STAND

The stand is lost, but the meridian ring survives. It is 10 mm wide and is divided in 1° and 6° and numbered in *Abjad,* from 6 to 90, separately in each quadrant; the counting commences at the poles. It is attached to the globe with a plain screw in the south and with a large winged screw in the north.

INSCRIPTION

Figure G028.5 shows the region around the southern poles, with the figure of Centaurus at the top, the meridian ring in the middle, and the inscription in the lower half. There is a dent at the ecliptic pole; it is labelled as *quṭb minṭaqah janūbī.* The equatorial polar circle, drawn around the celestial pole, is named *madār quṭb* … The six ecliptic latitude circles converge at the ecliptic pole.



Figure G028.5 – Inscription
The Nasser D. Khalili Collection of Islamic Art, Accession No. SC 14
Photo courtesy of the Khalili Family Trust © Nour Foundation

In the space of two segments created by these circles, the inscription is engraved in six lines. Above this inscription is written globe no. 1, indicating that this is the first copy. This can be seen above the meridian ring. In the third line of this inscription, the second digit of the year was not clearly visible as the polar circle passed through it. Emilie Savage-Smith read it as 2 and the year as 1257 AD (AD 1841-42), and had some difficulty in understanding the mutual relations between the three person named there, viz. Akbar Shāh Jahānābādī, Naᶜīm al Dīn Murādābādī and the ruler of Awadh Amjad ᶜAlī Shāh. But the year can be read clearly as 1357 AH (AD 1938-39) on the Lahore globe (Figure G029.6). The nearly identical inscription on both the globes has to be interpreted accordingly. In the two globes, there is a slight difference in the arrangement of the

lines; the attribute *thurayyā jāh* occurs here before the name of Muḥammad Amjad ᶜAlī Shāh; in the Lahore globe after this name.[1239]

(1) īn kurah manqūl ast az kurah-i akbar shāh muhandis jahānābādī keh dar

(2) sanah 1260 hijrī ba ḥuḍūr khāqān zamān abū al-ẓafar muṣliḥ al-dīn thurayyā jāh

(3) muḥammad amjad ᶜalī shāh bādshāh nazr guzārnīdah būd

(4) faqīr ḥaqīr muḥammad naᶜīm al-dīn murādābādī ghafar lahu dar sanah 1357 h[ijrī]

(5) īn naql rā mukammal kardad bafaḍl ilahī bihtar wa kāmil tar az [a]ṣl

(6) sākhtah shud. lahu al-hamd wa lahu al-minnah.

'This globe (*kurah*) is a copy (*manqūl*) of the globe of (i.e. made by) Akbar Shāh Muhandis Jahānābādi, which had been presented in the year 1260 Hijrī [AD 1844-45] to the emperor of the time (*ḥuḍūr khāqān zamān*), Abū al-Ẓafar Muṣliḥ al-Dīn Muḥammad Amjad ᶜAlī Shāh, the emperor who is exalted like the Pleiades (*Thurayyā*).

'The poor and base Muḥammad Naᶜīm al-Dīn Murādābādi, may God forgive him, completed this copy (*naql*) in the year 1357 Hijrī [AD 1938-39], by the grace of God, [in such a manner that it is] better and more perfect (*bihtar wa kāmil*) than the original (*aṣl*).

'For Him is the praise; from Him is the benevolence.'

1239 I am grateful to Mubashir Ul-Haq Abbasi for this transliteration and translation.

G029 COPY NO. 2 BY NAʿĪM AL-DĪN MURĀDĀBĀDĪ, 1357 AH (AD 1938-39) OF A CELESTIAL GLOBE MADE ORIGINALLY BY AKBAR SHĀH MUHANDIS JAHĀNĀBĀDĪ, 1260 AH (AD 1844-45) [1240]

Diameter 160 mm

Lahore, Lahore Museum (# A 8/1)



Figure G029.1 – Globe, showing the area around the northern poles
(photo by Mubashir Ul-Haq Abbasi)

[1240] Entry based on the detailed information and photos kindly provided by Mubashir Ul-Haq Abbasi.

This is the second copy made by Naᶜīm al-Dīn Murādābādī; it is slightly larger than the first one.

Circles

The equator and ecliptic are represented by two bands each; a very narrow band divided in 1° and wider band divided in 6° and numbered in *Abjad* notation; the equator is numbered from 6° to 360° continuously from the vernal equinox onwards and the ecliptic from 6 to 30, separately in each zodiac sign. Both these graduated scales are drawn very meticulously. There are also drawn ecliptic latitude circles at intervals of 30°, equatorial tropics, equatorial polar circles and smaller circles around the equatorial poles with a radius of about 12°.

A noteworthy feature of this globe is that the tropics, polar circles, equinoctial and solstitial points on the ecliptic, as well as the ecliptic poles are labelled. The equatorial tropics are named *madār Rās al-Jadī,* 'Tropic of Capricorn' and *madār Rās al-Saraṭān,* 'Tropic of Cancer'; the equatorial polar circles *madār quṭb minṭaqah*; the equinoctial points *nuqṭat iᶜtidal rabīᶜī,* 'point of vernal equinox' and *nuqṭat iᶜtidāl kharīfī,* 'point of autumnal equinox'; solstitial points *nuqṭat al-inqilāb al-sayfī,* 'point of summer solstice' and *nuqṭat al-inqilāb al-shatawī,* 'point of winter solstice'; ecliptic poles *minṭaqah quṭb shamālī* (in the north) and *quṭb minṭaqah janūbī* (in the south); solstitial colure *dā'irah marrah bi-l-aqṭāb al-arbaᶜah.* The names of the zodiac houses are written along the ecliptic, in larger letters, but not extending to the entire length of the zodiac house. All these names are filled with a red pigment in order to distinguish them from the names of the constellations and those of individual stars which are filled with some black substance. The celestial poles are not named.

Constellation Figures and Stars

The full set of 48 constellation figures are drawn and the positions of about 1020 stars are marked by inlaid silver nails. The stars in each constellation are numbered serially in common Arabic/Persian numerals. The names of the constellation figures are engraved with the prefix *ṣūrat* (spelt صورة); engraved are also the names of some prominent stars.

The figures are drawn generally with thicker outlines. The most striking feature of the human figures is that their faces are left completely blank; the outlines of the faces

are drawn, but these are not filled with eyes, noses and mouths. On the other hand, the clothes worn by these figures receive greater attention: the hemlines and the collars are emphasized with closely made oblique strokes. While Andromeda, Cassiopeia, Perseus and Cepheus are clothed in full length tunics, Bootes and Hercules wear very short and flared skirts like those worn by female dancers in a ballet. A few of these figures will be described in the following pages.



Figure G029.2 – Bootes and Hercules (photo by Mubashir Ul-Haq Abbasi)

In Figure G029.2, the graduated scale of the celestial equator can be seen at the bottom. The single line drawn above parallel to it is the Tropic of Cancer. Its name *madār Rās al-Saraṭān* is written on the left. **Bootes** is dressed in a short tunic. The upper half of the tunic has short sleeves and the collar is shaped like the Roman letter *Y*. The lower half consists of a very short skirt, like those worn by ballerinas. Thick lines on the ankles indicate the ends of the tight trousers. The head is covered by a turban. The figure is entitled *ṣūrat al-ʿAwwā,* 'figure of the howler'. The star below the hemline of

his tunic is named *Simāk al-Rāmiḥ.* 'the armed *Simāk*' (α Bootis); that on his right knee carries the name *Mufrid al-Rāmiḥ,* 'solitary [star] of the lancer'.[1241]

Hercules, depicted upside-down, is also clothed in a very short skirt. The top has long sleeves and a collar shaped like the Roman letter V. No trousers or turban are indicated.

Between these two is the figure of **Arora Borealis**, represented by two concentric circles with the title *Iklīl Shamālī,* 'northern crown' without the prefix *ṣūrat.* One of the stars in it is named *Nayyir Faqqah*, 'luminous one of *al-Fakkah*' (α Coronae Borealis). Below is the head of **Serpens,** the serpent of Ophiuchus. The figure is entitled *ṣūrat al-Ḥayyah,* 'figure of the serpent' and the star on its neck *ᶜUnuq al-Ḥayyah,* 'neck of the serpent' (α Serpentis).

Figure G029.3 shows the graduated scale of ecliptic above; below it the names the names of the signs *al-Qaws* and *al-Jadī* are engraved in large letters and filled with some red pigment. The figures of the zodiac signs Scorpio and Sagittarius are drawn upon the ecliptic. Below are the constellation figures of Lupus, Ara and Corona Australis. At the bottom can be seen two segments of circles; the upper one is the southern equatorial polar circle and the lower one is the smaller circle drawn with the southern celestial pole as the centre. The point where the ecliptic latitude circle intersects the ecliptic between the houses of Sagittarius and Capricorn, i.e., at the upper end of the bow held by Sagittarius, is named *nuqṭat al-inqilāb al-shatawī,* 'point of the winter equinox'

[1241] A comparison of this figure with the same on the previous globe (Figure F027.4) shows slight difference in the relative placement of Bootes and Virgo. On the previous globe, Virgo's southern arm is drawn parallel to the right leg of Bootes. But on the present globe, it looks as if Virgo is hitting at Bootes with her fist!



Figure G029.3 – Scorpio Sagittarius and others (photo by Mubashir Ul-Haq Abbasi)

The figure of **Scorpio** has peculiar iconography; the main body looks more like the head of a bull with curved horns; the tail is depicted in the same style as on the globes by Ḍiyā al-Dīn. The title reads *ṣūrat al-ᶜAqrab,* 'figure of the scorpion'.

In the figure of **Sagittarius,** the legs and body of the horse are competently drawn, but not the human half; the torso, shoulders, arms and head are not properly defined. The title of the figure is *ṣūrat al-Rāmī,* 'figure of the archer'. Two stars on the equine legs are named *Rukbat al-Rāmī,* 'archer's knee' (α Sagittarii) and *Urqūb al-Rāmī,* 'archer's tendon' ($\beta^{1,2}$ Sagittarii).

Lupus, the wild beast held by its hind legs by Centaurus, is entitled *ṣūrat Sabᶜ* 'figure of wild beast', but depicted as a lion cub.

Next to it is the figure of **Ara**, which is drawn very meticulously with an ornate pattern around the middle and fumes of incense arising like the tongues of flame; the title reads *ṣūrat Ajmarah,* 'figure of the incense burner'.

The figure of **Corona Australis** is also carefully drawn with the title *ṣūrat al-Iklīl al-Janūbī,* 'figure of the southern crown'.



Figure G029.4 – Centaurus (photo by Mubashir Ul-Haq Abbasi)

Figure G029.4 above shows the constellation figures of Centaurus and Lupus. On the upper right corner is the graduated scale of the ecliptic which is intersected by the single line representing the Tropic of Capricorn; its name is engraved above the figure of Centaurus as *madār Rās al-Jadī* and is filled with a red pigment.

In the figure of **Centaurus**, the equine half is somewhat smaller than the upper half, but is still passable. The face of the human figure is drawn in profile, with an elaborately patterned turban on the head. The clothing is suggested by thick lines around the neck and waist. The vine twig carried by Centaurus with his right hand has an interesting furry look. The figure is named *ṣūrat al-Qanṭūrus,* 'figure of Centaurus' and the star on the horse's hoof *Rijl al-Qanṭūrus,* 'foot of Centaurus' (α Centauri).

Lupus, as mentioned above, is entitled *ṣūrat Sabᶜ,* 'figure of wild beast' but depicted as a lion cub with traces of mane. The tail which encloses three stars is shown with three symmetrical parts, but the two hind legs by which Centaurus is holding the beast are not drawn at all.



Figure G029.5 – Horizon ring (photo by Mubashir Ul-Haq Abbasi)

STAND

The original stand is lost, but the horizon ring and the meridian ring survive. At present, the globe with the two rings is placed upon a modern stand. Both rings are graduated in 1° and 6° and numbered in *Abjad,* from 6 to 90, separately in each quadrant.



Figure G029.6 – Inscription (photo by Mubashir Ul-Haq Abbasi)

INSCRIPTION

The inscription is engraved in the space of two segments created by the ecliptic latitude circles. Above this inscription is written globe no. 2, indicating that this is the second copy. The inscription reads as follows: [1242]

(1) īn kurah manqūl ast az kurah-i akbar shāh muhandis jahānābādī

[1242] I am grateful to Mubashir Ul-Haq Abbasi for this transliteration and translation.

(2) keh dar sanah 1260 hijrī ba ḥuḍūr khāqān zamān abū al-ẓafar muṣliḥ al-dīn

(3) muḥammad amjad ᶜalī shāh thurayyā jāh bādshāh nazr guzārnīdah būd.

(4) faqīr ḥaqīr muḥammad naᶜīm al-dīn murādābādī ghafar lahu dar sanah 1357 h[ijrī]

(5) īn naql rā mukammal kardad bafaḍl ilahī bihtar wa kāmil tar az aṣl

(6) sākhtah shud. lahu al-hamd wa lahu al-minnah.

'This globe (*kurah*) is a copy (*manqūl*) of the globe of (i.e. made by) Akbar Shāh Muhandis Jahānābādi, which had been presented in the year 1260 Hijrī [AD 1844-45] to the emperor of the time (*ḥuḍūr khāqān zamān*), Abū al-Ẓafar Muṣliḥ al-Dīn Muḥammad Amjad ᶜAlī Shāh, the emperor who is exalted like the Pleiades (*Thurayyā*).

'The poor and base Muḥammad Naᶜīm al-Dīn Murādābādi, may God forgive him, completed this copy (*naql*) in the year 1357 Hijrī [AD 1938-39], by the grace of God, [in such a manner that it is] better and more perfect (*bihtar wa kāmil*) than the original (*aṣl*).

'For Him is the praise; from Him is the benevolence.'

G030 CELESTIAL GLOBE, NOT SIGNED, NOT DATED[1243]

17th Century

Diameter 80 mm

London, National Maritime Museum, Greenwich (# GLB0005)

ESS 85



Figure G030.1 – Globe with stand (photo by S. R. Sarma)

[1243] Entry based on Ackermann 1999, pp. 188-189, and Savage-Smith 1985, no. 85, p. 260.

The globe is cast as single hollow sphere; there are two circular plugs with a diameter of about 10 mm at opposite points on the equator.

CIRCLES

The equator and the ecliptic are both divided in 1° and 6°. The equator is numbered from 6 to 180, twice, starting from each equinox. The ecliptic is numbered from 6 to 30, separately in each zodiac signs. The names of the 12 zodiac signs and those of the 28 lunar mansions are engraved on either side along the ecliptic. The circles of ecliptic latitudes are drawn at intervals of 30°. There are also the equinoctial colure, the tropics, the equatorial polar circles and the ecliptic polar circles; the last pair drawn rather faintly. The two celestial poles are named *quṭb shamālī* and *quṭb janūbī* respectively.

STARS

The positions of 35 stars are marked by inlaid silver points of different sizes and their names are engraved next to them.[1244]

STAND

The globe is mounted on a stand which consists of a horizon ring supported by four legs which rest on a circular ring. The legs are decorated with cubic knobs in the middle and at the bottom. The globe is attached to a meridian ring by the polar axis. There is no support for the meridian ring in the stand. Both the horizon ring and the meridian ring are not graduated and are later additions.

PROVENANCE

Presented by Sir James Caird in February 1938.

BIBLIOGRAPHY

Savage-Smith 1985, no. 85, p. 260.
Ackermann 1999, pp. 188-189 with two figures.

[1244] These are listed in Ackermann 1999, p. 188.

G031 CELESTIAL GLOBE, NOT SIGNED, NOT DATED[1245]

17th Century

Diameter 60 mm

London, National Maritime Museum, Greenwich (# GLB0026)

ESS 84

The globe is cast as a single hollow sphere by the lost wax process; one plug is visible.

CIRCLES

The equator and the ecliptic are divided in 1° and 6°; the equator is numbered from 6 to 90, separately in each quadrant; the ecliptic is numbered from 6 to 30, separately in each zodiac sign. The names of the zodiac signs and those of the lunar mansion are engraved on either side of the ecliptic. There are also the ecliptic latitude circles at intervals of 30°, the tropics, equinoctial colure and equatorial polar circles.

STARS

The positions of 41 stars are marked by inlaid silver points of different sizes and the names of the stars are engraved next to them.[1246]

STAND

The stand consists of a horizon ring supported by four legs which rest on a circular ring. The legs are decorated by cubic knobs at the top, in the middle and at the bottom. The horizon ring is divided in 2° and 6° and numbered from 6 to 90, separately in each quadrant. To the underside of the horizon ring is attached a semi-circular arc to support the meridian ring. The meridian ring is not graduated, but has holes for adjusting the globe according to the terrestrial latitude.

[1245] Entry based on Ackermann 1999, pp. 186-187, and Savage-Smith 1985, no. 84, p. 259-260.

[1246] These are listed in Ackermann 1999, p. 186.

PROVENANCE

Formerly of the Landau collection; acquired by Sir James Caird in April 1936 and presented to the museum.

BIBLIOGRAPHY

Savage-Smith 1985, no. 84, pp. 259-260.
Ackermann 1999, pp. 186-187, with one figure.

G032 CELESTIAL GLOBE, NOT SIGNED, NOT DATED[1247]

17th century

Diameter 76 mm

Oxford, Museum of the History of Science (# 33466)

ESS 88



Figure G032.1 – Globe (© Museum of the History of Science, Oxford)

[1247] Entry based on Savage-Smith 1985, no. 88, pp. 261-262.

The globe is cast as a single hollow sphere. The stand is missing; there is a long axis passing through the equatorial poles, one end of which is bent to form a small hook.

Circles

The equator and the ecliptic are both graduated in 2° and 6° and numbered from 6 to 30 twelve times. There are ecliptic latitude circles, equatorial tropics, equatorial polar circles, and the equinoctial colure. The names of the zodiac signs are engraved along the ecliptic.

Stars

The positions of 22 stars are marked by inlaid silver points, with their names written next to them.

Provenance

Formerly of Chadenat Collection.

Bibliography

Maddison 1957, p. 41, no. 183, Pl. XXVIII, showing two views of the globe.
Savage-Smith 1985, no. 88, pp. 261-262.

G033 CELESTIAL GLOBE, NOT SIGNED, NOT DATED[1248]

19th Century

Diameter 75.2 mm, weight 610 grams

PLU; ex-Sotheby's, London

ESS 87



Figure G033.1 – Globe with stand (from Sotheby's catalogue of 1 April 2009)

[1248] Entry based on Sotheby's catalogue of 1 April 2009 and a set of photos in the archives of the Museum of the History of Science, Oxford.

The globe is cast as a single hollow sphere with two large circular plugs of diameters 27 mm and 28 mm, one below the houses of Aquarius and Pisces and the other below the Houses of Leo and Virgo. There are holes at the equatorial poles as well as at the ecliptic poles.

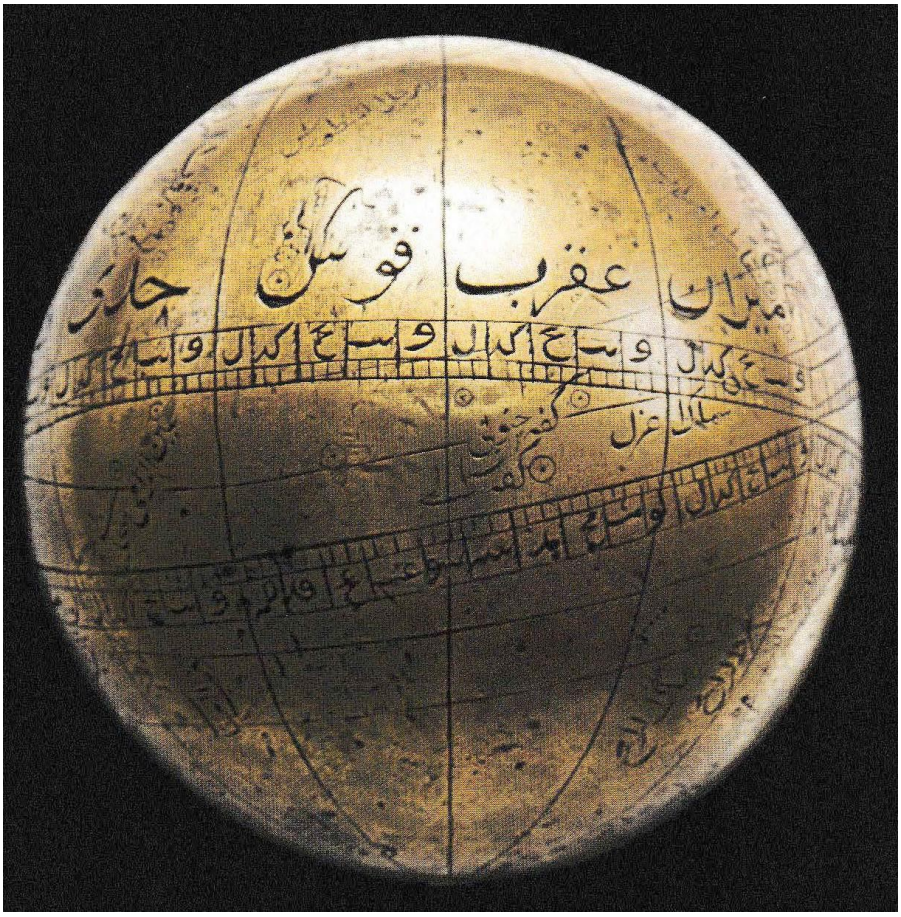


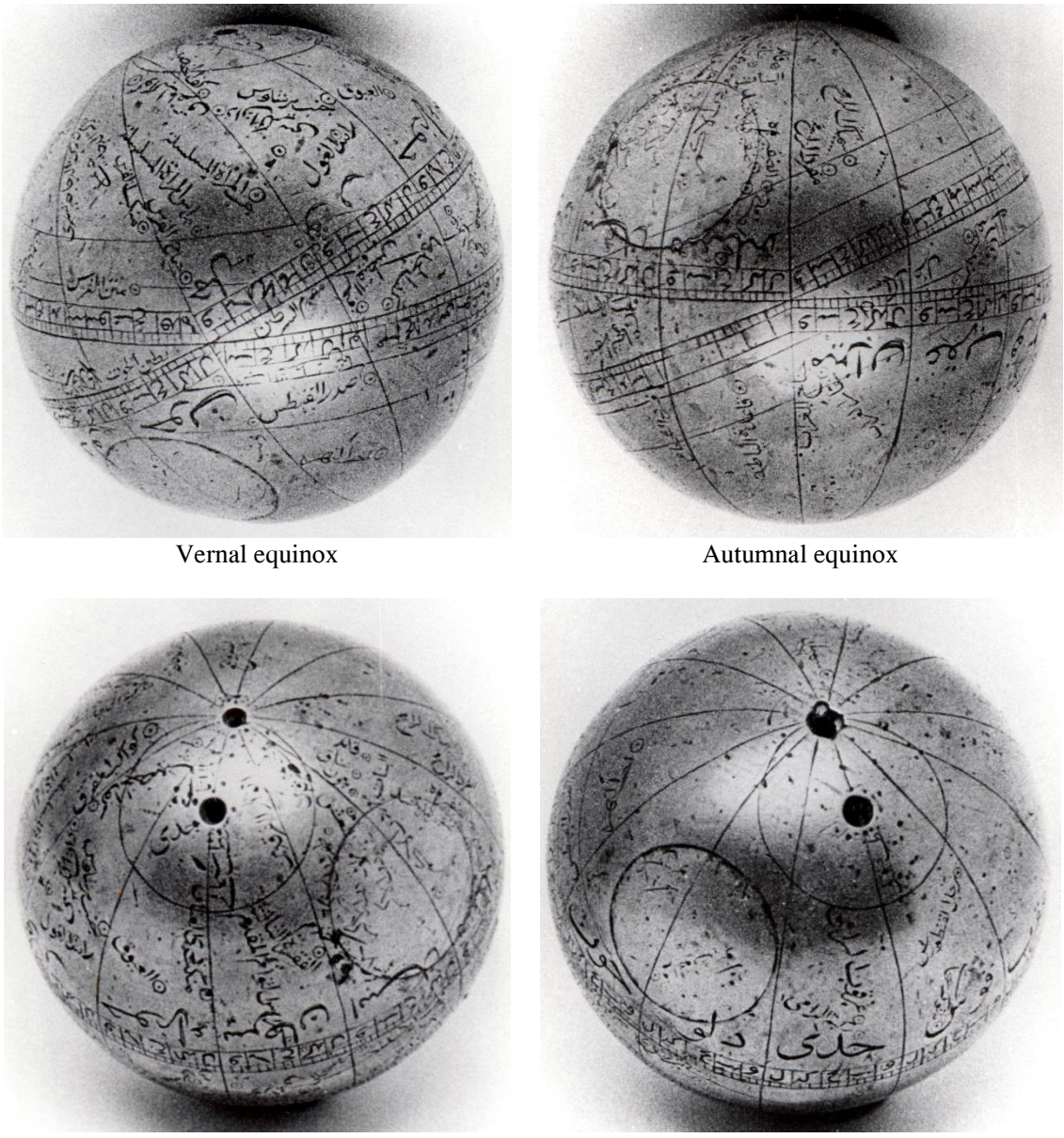
Figure G033.2 – Globe showing the equator and ecliptic intersecting at the autumnal equinox (from Sotheby's catalogue of 1 April 2009)

CIRCLES

The equator and the ecliptic are divided in 2° and 6°; the equator is numbered from 6 to 180 twice, each time from one equinox to the other. The ecliptic is numbered from 6° to 30° separately in each zodiac sign. The names of the zodiac signs are engraved along the ecliptic. The names of the celestial poles are engraved. Besides the ecliptic latitude circles, there are tropics, circles at 12° and polar circles on either side of the equator.

STARS

The positions of about 87 stars are marked by dots enclosed in small circles. The engraved star names are followed by serial numbers of the stars within each constellation.



Vernal equinox Autumnal equinox

Northern poles Southern poles

Figure G033.3 – Four views of the globe
(courtesy Museum of the History of Science, Oxford)

STAND

The stand does not appear to belong to the globe; the horizon ring is much larger than the globe. It is supported by four legs which rest on a ring base. These legs are decorated by two embossed rings each at the top and bottom and by three rings in the

middle. A semi-circular arc with a loop in the middle is attached to the underside of the horizon ring to support the meridian ring, which is missing.

PROVENANCE

Formerly in a private collection in France. In the archives of the Museum of the History of Science, Oxford, there are five photos with a note which reads thus: 'Brass. Diameter of the globe 75.2 mm. Weight 610 gm. Calculated thickness of the shell of the globe 4.9 mm assuming S. G. 8. Brought by Mr. Garnier of Christies to Mr. Maddison for examination in April 1982.' It was offered for sale at Christie's on 7 October 1982 and at Sotheby's on 1 April 2009. Its present location is not known.

BIBLIOGRAPHY

Christie's, London, auction catalogue of 7 October 1982, lot 17, p. 6.

Savage-Smith 1985, no. 87, p. 261.

Sotheby's, London, *Arts of the Islamic World,* auction catalogue of 1 April 2009, lot. 101.

G034⊙ CELESTIAL GLOBE, NOT SIGNED, NOT DATED

19th Century

Diameter 155 mm

Hyderabad, Salar Jung Museum (# 112/3/xxxv)



Figure G034.1 – Globe, showing the vernal equinox (photo by S. R. Sarma)

This large globe is cast as a single hollow sphere by the lost wax process. Moreover, it is weighted in such a manner that it always comes to rest on the south celestial pole. Large holes are bored at the poles of the equator as well as the poles of the ecliptic. The stand is missing.

CIRCLES

The equator and the ecliptic are represented by double bands; the narrower band is graduated in 1° and the broader band in 6°. Most unusually, both the circles are

numbered, from the vernal equinox onwards, from 6 to 30, which is repeated 12 times. Six meridian circles are drawn perpendicularly to the equator, which converge at the two equatorial poles. There are no ecliptic latitude circles. Equatorial tropics and circles at 12° and 20° on either side of the equator are drawn, so also the equatorial and the ecliptic polar circles. The names of the zodiac signs are engraved along the ecliptic.



Figure G034.2 – The northern poles (photo by S. R. Sarma)

More important, several circles and points are named as follows.

Celestial equator: *dā'irat muᶜaddil al-nahār*

Ecliptic: *dā'irat minṭaqat al-burūj*

Solstitial colure: *dā'irat marrah bi-l-aqṭāb al-arbaᶜah*

Equinoctial colure: *dā'irat mayl*

Tropic of Capricorn: *madār jadī*

Tropic of Cancer: *madār saraṭān*

Equatorial polar circle in the north: *dā'irat quṭb muᶜaddil al-nahār shamālī*

Equatorial polar circle in the south: *dā'irat quṭb muᶜaddil al-nahār janūbī*

Ecliptic polar circle in the north: *dā'irat quṭb minṭaqat al-burūj shamālī*

Ecliptic polar circle in the south: *dā'irat quṭb minṭaqat al-burūj janūbī*

Point of summer solstice: *nuqṭat al-inqilāb sayfī*

Point of winter solstice: *nuqṭat al-inqilāb shatwī*

Point of vernal equinox: *nuqṭat al-inqilāb rabīᶜī* (sic! *nuqṭat al-iᶜtidāl rabīᶜī*)

Point of autumnal equinox: *nuqṭat al-inqilāb kharīfī* (sic! *nuqṭat iᶜtidāl kharīfī*)

G035 CELESTIAL GLOBE, NOT SIGNED, NOT DATED[1249]

19th Century

Diameter 82 mm

Karachi, National Museum of Pakistan (# 1958-210)

ESS 130



Figure G035.1 – Globe showing autumnal equinox on the right
(photo by Mubashir Ul-Haq Abbasi)

On this well-crafted globe, all the circles are represented by thick embossed lines which are patterned like ropes. The equator and ecliptic are graduated in single degrees marked by dots. On the equator, intervals of 10° are numbered from 10 to 360 from the vernal equinox; on the ecliptic these are numbered as 10, 20 and 30, separately in each

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[1249] Entry based on photos and information kindly provided by Mubashir Ul-Haq Abbasi.

zodiac sign. The names of the zodiac signs are engraved along the ecliptic. There are also equatorial tropics, ecliptic tropics, ecliptic latitude circles and ecliptic polar circles.



Figure G035.2 – Globe showing winter solstice
(photo by Mubashir Ul-Haq Abbasi)

Figure G035.2 shows the winter solstice. Here the Tropic of Cancer is labelled as *madār rās al-saraṭān* and the segment of the solstitial colure intercepted between the ecliptic (above) and equator (below) is labelled as *mayl kullī,* 'maximum declination'.

The stand is missing; only the ungraduated meridian ring survives.

G036⦿ CELESTIAL GLOBE, NOT SIGNED, NOT DATED

19th Century

Diameter 115 mm; height of the stand 240 mm

Lucknow, Darul Uloom Nadwatul Ulama



Figure G036.1 – Globe with stand (photo by S. R. Sarma)

CIRCLES

The globe is made of some light wood and painted in maroon. The circles and the labels are in white. The equator and the ecliptic are represented by ungraduated simple lines; similar lines represent also the equatorial tropics, ecliptic latitude circles and ecliptic polar circles. Names of the zodiac signs are written along the ecliptic. The equinoctial points and the poles of the ecliptic are labelled.



Figure G036.2 – Autumnal equinox (photo by S. R. Sarma)

STAND

The tripod stand is made of iron; one of the legs is broken. The horizon ring is ungraduated. The meridian ring is divided in 5° and numbered from 5 to 90, separately in each quadrant.

G037⊙ CELESTIAL GLOBE, NOT SIGNED, NOT DATED[1250]

19th Century

Diameter 103 mm; height of the stand 107 mm

Oxford, Museum of the History of Science (# 37195)

ESS 115



Figure G037.1 – Globe with stand (photo by S. R. Sarma)

[1250] Entry based on Savage-Smith 1985, no. 115, pp. 272-273.

Circles

The globe is cast as a single hollow sphere; eight plugs are visible at different places. The equator and the ecliptic are drawn as single lines without any graduations. Ecliptic latitude circles, equatorial tropic and polar circles are drawn. The names of the zodiac signs are engraved along the ecliptic. The poles, tropics and polar circles are labelled. The segments of the solstitial colure intercepted between the equator and the ecliptic are labelled as *mayl kullī,* 'maximum declination'.

Stand

The stand resembles the same in G027; it consists of a horizon ring supported by four slender legs resting on an eight-lobed base with central cross-bars. From the four points where the cross-bars join the eight-lobed base, there arise four arcs of 90°, converging at the top and forming the support for the meridian ring and for the semi-circular arc attached to the underside of the horizon ring.

The horizon ring is divided in 2° and every sixth is indicated by a longer line. The meridian ring is graduated on one side in 2° and every sixth is marked by a longer line; on the other side every 30° is marked by a longer line. As in G027, two gnomons are attached to the semi-circular arc, but arcs of 90° are not graduated as in G027.

Bibliography

Savage-Smith 1985, no. 115, pp. 272-273.

G038⦿ CELESTIAL GLOBE, NOT SIGNED, NOT DATED

19th Century

Diameter 172 mm

Rampur, Rampur Raza Library (# 27/5070 D)



Figure G038.1 – Globe with stand (courtesy Rampur Raza Library)

The globe and the stand are made of some light metal and are of indifferent workmanship. The globe is cast as a single hollow sphere by the lost-wax method. There is one large plug which covers the entire equatorial polar circle in the north. This plug is now loose, but fits tightly like a lid upon the rest of the globe.



Figure G038.2 – Globe with the meridian ring (courtesy Rampur Raza Library)

Circles

The equator and the ecliptic are represented by single ungraduated lines. Similar lines represent also the ecliptic latitude circles, the equatorial tropics and the equatorial polar circles. The names of the zodiac signs are engraved along the ecliptic.

Stand

The stand is 158 mm high. It consists of a horizontal ring to which three S-shaped legs are attached. The legs terminate in lion's paws with four claws in each paw. There are two notches in the horizontal ring through which the meridian ring passes but there is nothing below to support the meridian ring. Consequently the globe and the meridian ring slip through the horizontal ring and fall to the ground. Thus the globe cannot be mounted on the stand. The horizontal ring is graduated in 1° and 10° and numbered

from 10 to 90, separately in each quadrant. The meridian ring is also graduated in the same manner.

BIBLIOGRAPHY

Sarma 2003, no. 7, pp. 73-75.

G039 CELESTIAL GLOBE, NOT SIGNED, NOT DATED[1251]

19th Century

Diameter 112 mm; height 190 mm

PLU; ex-Paris, Libraire Alain Brieux 1990.



Figure G039.1 – Globe with stand (from the catalogue of Alain Brieux)

[1251] Entry based on Libraire Alain Brieux, *Histoire des Sciences et de la Medicine,* September 1990, no. 16581, p. 91.

The globe appears to have been cast as single hollow sphere. The axis passes through the ecliptic poles.

Circles

The equator and the ecliptic are divided in 1° and 5°; the equator is numbered from 5 to 360 from the vernal equinox; the ecliptic is numbered from 5 to 30, separately in each zodiac sign. The names of the zodiac signs are engraved along the ecliptic. Equatorial tropics, ecliptic latitude circles and ecliptic polar circles are engraved. Like the equator and the ecliptic, the solstitial colure is represented with double bands divided in 1° and 5°, but not numbered.

Stand

The stand consists of a graduated horizon ring supported by four slender legs which rest on an eight-lobed ring with cross-bars. A semicircular arc is attached to the underside of the horizon ring to support the meridian ring which is graduated in 1° and 5° and numbered in 5s.

Bibliography

Libraire Alain Brieux, *Histoire des Sciences et de la Medicine,* September 1990, no. 16581.

Drouot, *Instruments Scientifiques anciens,* auction catalogue of 22 June 1979, no. 155.

G040 CELESTIAL GLOBE, NOT SIGNED, NOT DATED[1252]

19th Century

Diameter 111 mm

PLU



Figure G040.1 – Globe showing the vernal equinox
(courtesy Museum of the History of Science, Oxford)

This globe is almost identical with the previous globe G039, but without a stand. Maddison states that the mising stand is ‘replaced by a modern stand of perspex’.

[1252] Entry based on a set of 6 photos and a note by F. R. Maddison, dated 9.1.84, in the archives of Museum of the History of Science, Oxford.

Therefore, it appears that the maker made at least two identical globes of almost the same size. Of these only one specimen survived with the original stand, while the other did not. About the present globe, Maddison states that '[i]t is very heavy, seamless globe weighing approximately 1816 gms (4 lbs), which means that the casting must be about 6.6 mm thick'.



Figure G040.2 – Summer solstice
(courtesy Museum of the History of Science, Oxford)

CIRCLES

The equator and the ecliptic are divided in 1° and 5°; the equator is numbered from 5 to 360 from the vernal equinox; the ecliptic is numbered from 5 to 30, separately in each zodiac sign. The names of the zodiac signs are engraved along the ecliptic. Equatorial tropics, equatorial polar circles, ecliptic polar circles and ecliptic latitude circles are engraved. Like the equator and the ecliptic, the solstitial colure is also represented with double bands divided in 1° and 5°, but not numbered. The equatorial poles are labelled as *quṭb ʿālam shamālī* and *quṭb ʿālam janūbī.*

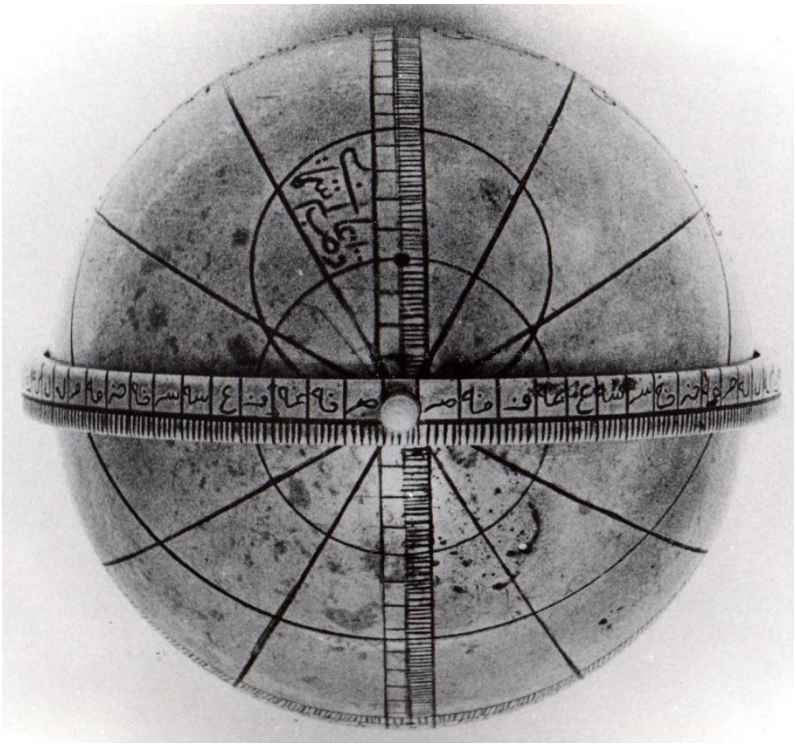


Figure G040.3 – Northern poles
(courtesy Museum of the History of Science, Oxford)

STAND

The original stand is missing, but the meridian ring is extant. It is divided in 1° and 5° and numbered from 5 to 90, four times, the numbering converging at the poles.

G041 CELESTIAL GLOBE, NOT SIGNED, NOT DATED[1253]

19th century

Diameter 70 mm

Chicago, Adler Planetarium (# A-38)

ESS 102



Figure G041.1 – Globe with stand (accession no. A-38)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

[1253] Entry based on Savage-Smith 1985, no. 102, pp. 267-268, and the photos generously provided by the Adler Planetarium, Chicago.

This and the following ten globes have nearly identical features and must emanate from the same globe maker or from the same workshop. The globes are engraved with the equator, ecliptic, ecliptic latitude circles at intervals of 30°. The most striking feature of the globes is that the names of the zodiac signs are engraved in large 'outlined' letters. Sometimes other circles are also labelled in such 'outlined' letters (see Figure G041.2 below).

The stand consists of a graduated horizon ring supported by four legs which rest on a circular ring. To the underside of the horizon ring is attached, at its east and west points, a semi-circular arc which supports the meridian ring. The most conspicuous features of the stand are that the legs are decorated at the top, bottom and in the middle by 'knops' which are decorative protuberances all around a cylindrical body. The patterns engraved on these 'knops' vary from globe to globe. Second, at the centre of the semi-circular arc is an ornate vertical bit with a hole in it. A wing screw is inserted in the hole to tighten the meridian ring so that it stays in the same position. A third feature is that in many cases, the *Abjad* numerals in the scales on the horizon ring and on the meridian ring are enclosed in arches (see Figure G041.2 below).

Some of the globes are said to be made of two hemispheres; in some cases no seam could be detected. It appears that these globes were produced in Persia in the nineteenth century. However, because some of the descriptions in published literature refers to these as Indo-Persian globes, these are included here at the very end of the series G.



Figure G041.2 – Detail showing the engravings on the globe,
on the horizon ring and the meridian ring (accession no. A-38)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

Circles

On the present globe, the equator and the ecliptic are graduated in 2° and 10°; the equator is numbered from 10 to 360 continuously from the vernal equinox; the ecliptic is numbered from 10 to 30, separately in each zodiac sign. There are also ecliptic latitude circles, equatorial tropic and polar circles; ecliptic tropic and polar circles and the equinoctial colure. The names of the zodiac signs are engraved along the ecliptic in large 'outlined' letters. The equatorial tropic and polar circles are also labelled in large 'outlined' letters. On the solstitial colure, the two segments showing the maximum obliquity are labelled *mayl kullī* in the same style.

Stand

The horizon ring is supported by four legs resting on a base ring. The legs are decorated at the top, in the middle and at the bottom by 'knops' bearing floral patterns. The semicircular arc attached to the underside of the horizon ring for supporting the meridian ring has at its centre a vertical bit with a large wing screw to keep the meridian ring in position. The horizon ring and the meridian ring are both divided in 2°; intervals of 6° are enclosed in arches and numbered from 6 to 90, separately in each quadrant. The numbering on the horizon ring commences at the north and south points where notches are made for the meridian ring. The numbering on the meridian ring commences at the poles where it is attached to the globe by pins.



Figure G041.3 – Detail showing the decorative ‘knops’ on the legs
and the vertical bit with a wing screw at the centre of the semicircular arc (accession no. A-38)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

PROVENANCE

Purchased from E. S. David in 1940.

BIBLIOGRAPHY

Savage-Smith 1985, no. 102, p. 267-268.

Emilie Savage-Smith in Pingree 2009, p. 238.

G042 CELESTIAL GLOBE, NOT SIGNED, NOT DATED[1254]

19th century

Diameter 69 mm

Chicago, Adler Planetarium (# A-39)

ESS 101



Figure G042.1 – Globe with stand (accession no. A-39)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

[1254] Entry based on Savage-Smith 1985, no. 101, p. 267, and the photos generously provided by the Adler Planetarium, Chicago.

Circles

The equator and the ecliptic are graduated in 2° and 10°; the equator is numbered from 10 to 360 continuously from the vernal equinox; the ecliptic is numbered from 10 to 30, separately in each zodiac sign. The names of the zodiac signs are engraved along the ecliptic in large 'outlined' letters. There are also ecliptic latitude circles, tropics and polar circles of the equator and of the ecliptic, and the equinoctial colure. The poles, the equatorial tropic and polar circles are labelled in large 'outline letters'. On the solstitial colure, the two segments showing the maximum obliquity are labelled *mayl kullī* in similar letters.

Stand

The horizon ring is supported by four legs resting on a base ring. The legs are decorated at the top, in the middle and at the bottom by 'knops' bearing diamond patterns. The semicircular arc attached to the underside of the horizon ring for supporting the meridian ring has a large wing screw to keep the meridian ring in position. The horizon ring and the meridian ring are both divided in 2°; intervals of 6° are numbered from 6 to 90, separately in each quadrant. The numbers are enclosed in arches on the horizon ring, but not on the meridian ring. The numbering on the horizon ring commences at the north and south points where notches are made for the meridian ring. The numbering on the meridian ring commences at the poles where it is attached to the globe by pins.

Provenance

Purchased from Ali Kuli Khan 1934.

Bibliography

Savage-Smith 1985, no. 101, p. 267.
Emilie Savage-Smith in Pingree 2009, p. 237.

G043 CELESTIAL GLOBE, NOT SIGNED, NOT DATED[1255]

19th Century

Diameter 88 mm

Oxford, Museum of the History of Science (# 46262)

ESS 103



Figure G043.1 – Globe with stand (© Museum of the History of Science, Oxford)

The globe is made first in two hemispheres and then joined together.

[1255] Entry based on Savage-Smith 1985, no. 103, p. 268.

CIRCLES

The equator and the ecliptic are divided in 2° and 10°; the equator is numbered from 10 to 360 continuously from the vernal equinox; the ecliptic from 10 to 30, separately in each zodiac sign. There are also ecliptic latitude circles and equatorial tropic and polar circles. The names of the zodiac signs are engraved along the ecliptic in large 'outlined' letters; also in similar letters *mayl kullī,* 'complete declination' engraved along the two segments of the solstitial colure intercepted between the equator and ecliptic.

STAND

Stand with four 'knopped' legs as in the previous specimens. The horizon ring is graduated in 2° and 6° and numbered from 6 to 90 in each quadrant, beginning at the notches made for the meridian ring at the north and south points. The meridian ring is also similarly divided and numbered, the numbering beginning at the points where it is attached to the celestial poles of the globe. The numbers on both the rings are not enclosed in arches.

PROVENANCE

Formerly in the Chadenat Collection, Paris.

BIBLIOGRAPHY

Maddison 1957, no. 186, p. 41, pl. XXVIII.
Savage-Smith 1985, no. 103, p. 268.

G044 CELESTIAL GLOBE, NOT SIGNED, NOT DATED[1256]

19th Century

Diameter 69 mm

Paris, PC

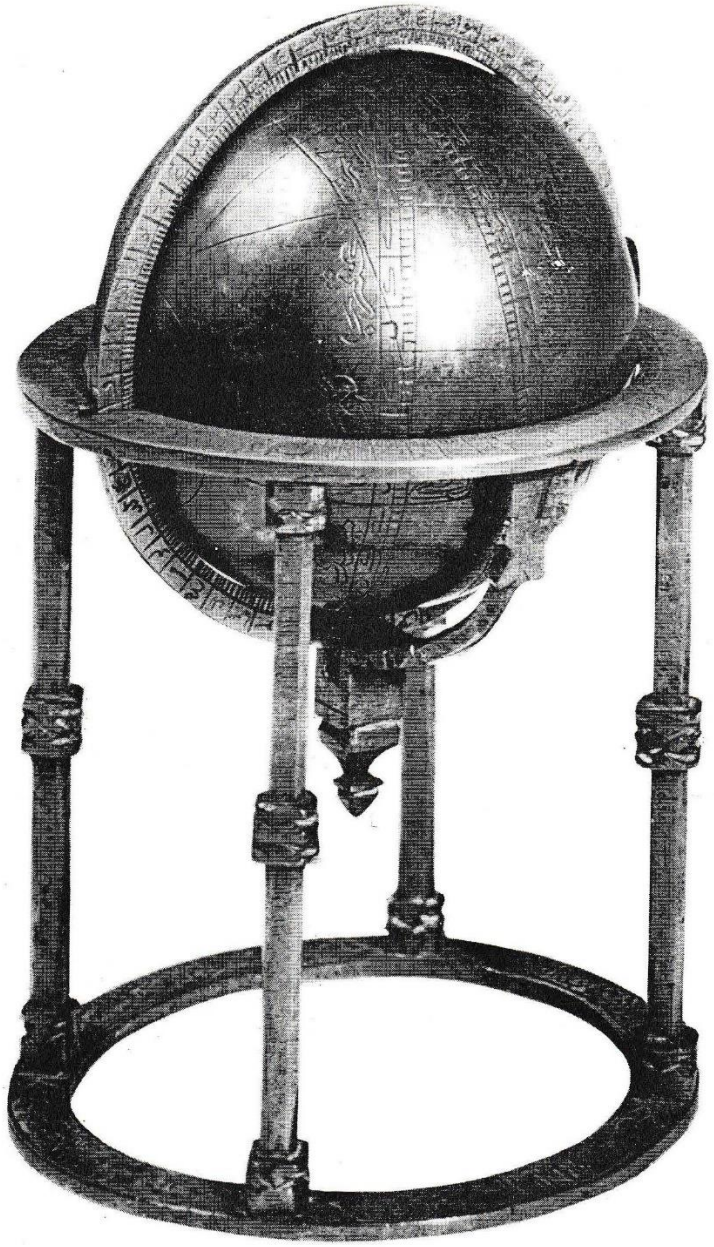


Figure G044.1 – Globe with stand (from Alain Brieux's catalogue)

[1256] Entry based on the catalogue of the Libraire Alain Brieux, Paris, of June 1976, no. 8551, p. 74.

Circles

The equator and the ecliptic are divided in 2° and 10°; the equator is numbered from 10 to 360 continuously from the vernal equinox; the ecliptic from 10 to 30, separately in each zodiac sign. The names of the zodiac signs are engraved along the ecliptic in large 'outlined' letters. There are ecliptic latitude circles, equatorial tropics and equatorial polar circles.

Stand

The graduated horizon ring is supported by four 'knopped' legs which rest on a circular ring. A semi-circular arc is attached to the underside of the horizon ring to support the meridian ring. There is an ornate vertical bit at the centre of the arc, but the screw is missing. The meridian ring is divided in 1° and 5°, but the intervals of 5° are numbered wrongly as 6°.

Inscription

On the ring at the base is engraved a long inscription in Persian, which Brieux rendered into French thus:

> 'Digne de l'assemblée de son Exllence l'Omniscient des âges, Mojtehed de l'époque et du temps, l'Imam des musulmans, celui qui est nanti des Conséquences et de l'Essentiel des choses de la loi Islamique, la somme des intelligences et de ce qui est rapporte par tradition, le chef des érudites, le fierté des Savants: Mirza Mohammad Taqi Xatarat (c'est-à-dire celui qui present le droit chemin religieux à suivre), que ses bénédictions se perpétuent éternellement.'

It is difficult to identify the dedicatee Mirzā Muḥammad Taqī Khatarat; possibly he is the Qajar prince Mirzā Muḥammad Taqī (1791-1853) who was the governor of Kermanshah.

Bibliography

Alain Brieux 1976, no. 8551, p. 74.

G045 CELESTIAL GLOBE, NOT SIGNED, NOT DATED[1257]

19th Century

Diameter 150 mm

PLU; ex-Paris, Drouot 1987

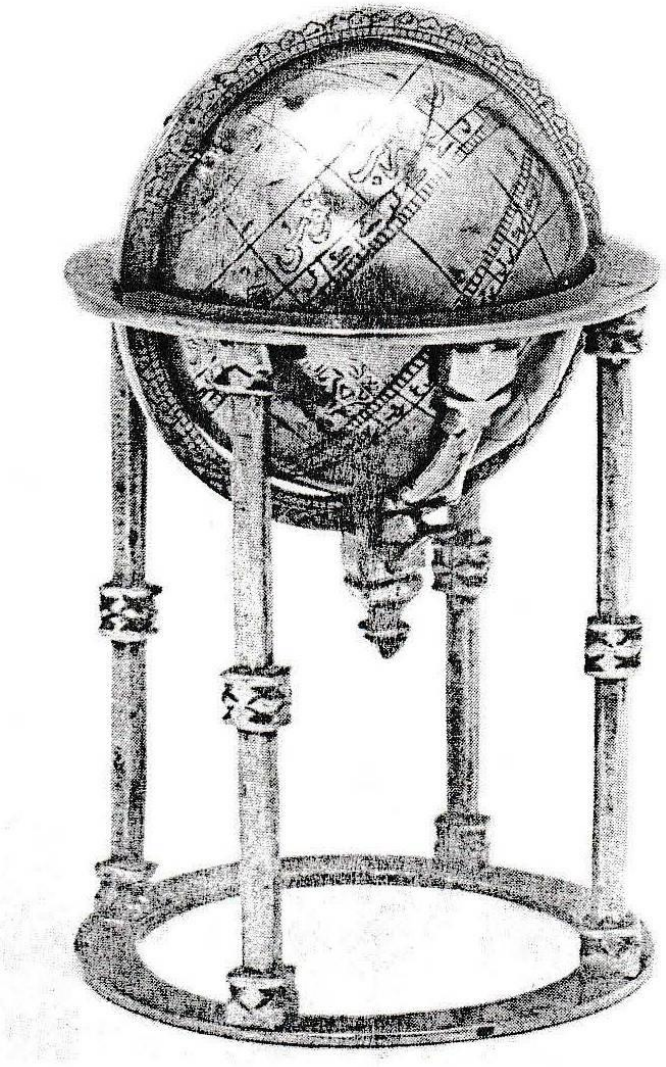


Figure G045.1 – Globe with stand (from the Drouot catalogue)

The globe is cast as a single hollow sphere by the lost wax process; one large plug and several small ones are visible; some of these plugs are now missing, leaving small holes.

[1257] Entry based on the catalogue of 4 June 1987 of Drouot, Paris, no. 58, p. 24; the description here does not match with the photo printed alongside. The description states wrongly: 'The globe is engraved with lines for the equator and the ecliptic without divisions, and with 12 meridian/hour circles. The constellations are figured and have their names marked in Naskhi.'

Circles

The equator and the ecliptic are divided in 2° and 10°; the equator is numbered from 10 to 360 continuously from the vernal equinox; the ecliptic from 10 to 30, separately in each zodiac sign. There are also ecliptic latitude circles, equatorial tropic and polar circles, ecliptic tropic and polar circles, and equinoctial colure. The names of the zodiac signs are engraved along the ecliptic in large 'outlined' letters; also in similar letters *mayl kullī,* 'complete declination' engraved along the two segments of the solstitial colure intercepted between the equator and ecliptic.

Stand

Stand with four 'knopped' legs as in the previous specimens. There is an ornate vertical bit at the centre of the semi-circular arc which supports the meridian ring. The numbers on the meridian ring are enclosed in arches.

Bibliography

Drouot, Paris, catalogue of 4 June 1987, no. 58, p. 24.

G046 CELESTIAL GLOBE, NOT SIGNED, NOT DATED[1258]

19th Century

Diameter 90 mm

PLU; ex-Sotheby's, London



Figure G046.1 – globe with stand (from Sotheby's catalogue of 2007)

[1258] Entry based on Sotheby's, London, *Arts of the Islamic World,* auction catalogue of 24 October 2007, lot. 197; and Sotheby's, London, *Arts of the Islamic World,* auction catalogue of 7 October 2015, lot. 325.

Circles

The equator and the ecliptic are divided in 2° and 10°; the equator is numbered from 10 to 360 continuously from the vernal equinox; the ecliptic from 10 to 30, separately in each zodiac sign. The ecliptic latitude circles, ecliptic polar circles, equatorial tropics and the equatorial polar circles are drawn. The names of the zodiac signs are engraved in large 'outlined' letters along the ecliptic. The Tropic of Capricorn and the Tropic of Cancer are named respectively as *madār al-jadī* and *madār al-saraṭān* and the ecliptic polar circles as *madār quṭb falak al-burūj* and the celestial poles as *quṭb muʿaddil shamālī* and *quṭb muʿaddil janūbī;* the maximum declination is labelled as *mayl kullī.*

Stand

The stand is similar to those in the previous specimens, except that here there is a circular sheet of metal below the circular ring on which the four 'knopped' legs rest. The knops on the legs are in the shape of rings, two each at the top and bottom and three in the middle. In between the knops, there are X-shaped engravings. The ring pattern is repeated on the vertical bit at the centre of the semicircular arc. The horizon ring and the vertical ring are divided in 2° and 6°, and numbered from 6 to 90, separately in each quadrant.

Bibliography

Sotheby's, London, *Arts of the Islamic World,* catalogue of 24 October 2007, lot. 197.
Sotheby's, London, *Arts of the Islamic World,* catalogue of 7 October 2015, lot. 325.

G047 CELESTIAL GLOBE, NOT SIGNED, NOT DATED[1259]

19th Century

Diameter 69 mm; overall height 169 mm

London, National Maritime Museum, Greenwich (# GLB0176)

ESS 104

No seam can be seen in this globe, nor any plugs.

CIRCLES

The equator and the ecliptic are divided in 2° and 10°; the equator is numbered from 10 to 360 continuously from the vernal equinox, while the ecliptic is numbered from 10 to 30, separately in each zodiac sign. There are also ecliptic latitude circles, equatorial tropic and polar circles, ecliptic tropic and polar circles and the equinoctial colure. The names of the zodiac signs are engraved along the equator in large 'outlined' letters. The equatorial tropics are named *madār rās al-jadī* and *madār rās al-saraṭān*; the equatorial polar circles are named *madār quṭb al-burūj*; the equinoctial colure *dā'irat al-mayl*; the north and south celestial poles *quṭb shamālī muᶜaddil* and *quṭb janūbī muᶜaddil*. On the solstitial colure, the two segments showing the maximum obliquity are named *mayl kullī*.

STAND

The horizon ring is supported by four legs resting on a base ring. The legs are decorated at the top, in the middle and at the bottom by 'knops' bearing diamond patterns. The semicircular arc attached to the underside of the horizon ring for supporting the meridian ring has a large vertical bit at its centre. The horizon ring and the meridian ring are both divided in 2°; intervals of 6° are numbered from 6 to 90, separately in each quadrant. The numbers are enclosed in arches on the horizon ring, but not on the meridian ring. The numbering on the horizon ring commences at the north

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[1259] Entry based on Ackermann 1999, pp. 191-192 (with two images) and Savage-Smith 1985, no. 104, p. 268.

and south points where notches are made for the meridian ring. The numbering on the meridian ring commences at the poles where it is attached to the globe by pins.

PROVENANCE

Presented by Sir James Caird in May 1936.

BIBLIOGRAPHY

Savage-Smith 1985, no. 104, p. 268.
Ackermann 1999, pp. 191-192 with two images.

G048 CELESTIAL GLOBE, NOT SIGNED, NOT DATED[1260]

19th Century

Diameter 86 mm

New York, Brooklyn Museum, Department of Asian Art (# X659.1)

The globe is made in two hemispheres and joined.

CIRCLES

The equator and the ecliptic are divided in 1° and 10°; the equator is numbered from 10 to 180 twice, each time from one equinox to the other, while the ecliptic is numbered from 10 to 30, separately in each zodiac sign. Besides these, ecliptic latitude circles, tropics and polar circles of the equator and of the ecliptic and the equinoctial colure are drawn.

The names of the zodiac signs along the ecliptic, of the two celestial poles, of the polar circles, of the equator and of the equinoctial colure are engraved in large 'outlined' letters.

STAND

The horizon ring is supported by four six-sided legs which rest on a circular ring. The legs are decorated by very elegant 'knops' at the top, middle and bottom. On the underside of the horizon ring, there are traces of soldering; probably the semicircular arc attached here came off and is lost. Consequently there is no support for the meridian ring at present. The horizon ring has an outer diameter of 114 mm and inner diameter 86 mm. Both the horizon ring and the meridian ring are divided in 1° and intervals of 6° are numbered. These numbers are enclosed in arches. The horizon ring is numbered from 6 to 90, separately in each quadrant, beginning at the notches made for the meridian ring. The meridian ring is also numbered from 6 to 90, separately in each quadrant, beginning at the points of attachment to the globe and converging at the points opposite the equator.

[1260] Entry based on an unpublished description and a photo kindly provided by Professor Emilie Savage-Smith.

G049 CELESTIAL GLOBE, NOT SIGNED, NOT DATED[1261]

19th Century

Diameter 91 mm; height of the stand 122 mm

Ann Arbor, University of Michigan, Hatcher Graduate Library, Department of Rare Books and Special Collections (# GL-1)

The globe is made in two hemispheres and joined.

CIRCLES

The equator and the ecliptic are divided in 1° and 10°; the equator is numbered from 10 to 360 continuously from the vernal equinox, while the ecliptic is numbered from 10 to 30, separately in each zodiac sign. Ecliptic latitude circles, equinoctial colure, tropics and polar circles of the equator and of the ecliptic are first engraved lightly and then retraced heavily. The names of the zodiac signs along the ecliptic are engraved in large 'outlined' letters; the two celestial poles, the equatorial tropics and the *mayl kullī* are also labelled in similar large 'outlined' letters.

STAND

The horizon ring is supported by four legs which rest on a circular ring. Only one leg appears to have been decorated with 'knops' at the top, middle and bottom; the other four legs must be replacements. No semicircular arc is attached to the underside of the horizon ring to support the meridian ring. The horizon ring has an outer diameter of 106 mm and inner diameter of 87 mm; it is divided in 1° and 6° and numbered from 6 to 90, separately in each quadrant, beginning at the north and south points where notches are made for the meridian ring. The meridian ring is 7 mm wide and 4 mm thick. It is also divided in 1° and 6° and numbered from 6 to 90, separately in each quadrant; the numbering begins at the points where it is attached to the globe by pins and ends at points opposite the equator. The numbers on both the rings are enclosed in arches.

[1261] Entry based on an unpublished description and four photos kindly provided by Professor Emilie Savage-Smith.

G050 CELESTIAL GLOBE, NOT SIGNED, NOT DATED[1262]

19th Century

Diameter 68 mm

Oxford, Museum of the History of Science (# 40716)

ESS 105



Figure G050.1 – Globe with stand (© Museum of the History of Science, Oxford)

The globe is made in two hemispheres.

[1262] Entry based on Savage-Smith 1985, no. 105, pp. 268-269.

CIRCLES

The equator and the ecliptic are represented by ungraduated single lines. There are also ecliptic latitude circles, equatorial tropic and polar circles, and equinoctial colure. The names of the zodiac signs are engraved along the ecliptic in normal letters.

STAND

Stand with four ‘knopped’ legs as in the previous specimens. At the centre of the semi-circular arc which supports the meridian ring from below, there is a highly ornate vertical bit with a hole for the screw to tighten the meridian ring, but the screw is missing. The horizon ring is graduated in 2° and 6° and numbered from 6 to 90 in each quadrant, beginning at the notches made for the meridian ring at the north and south points. The meridian ring is also similarly divided and numbered, the numbering beginning at the points where it is attached to the celestial poles of the globe. The numbers on both the rings are not enclosed in arches.

PROVENANCE

Formerly in the Chadenat Collection, Paris.

BIBLIOGRAPHY

Maddison 1957, no. 185, p. 41, pl. XXVIII.
Savage-Smith 1985, no. 105, pp. 268-269.

G051 CELESTIAL GLOBE, NOT SIGNED, NOT DATED[1263]

19th Century

Diameter 84 mm

PLU; ex-Sotheby's, London

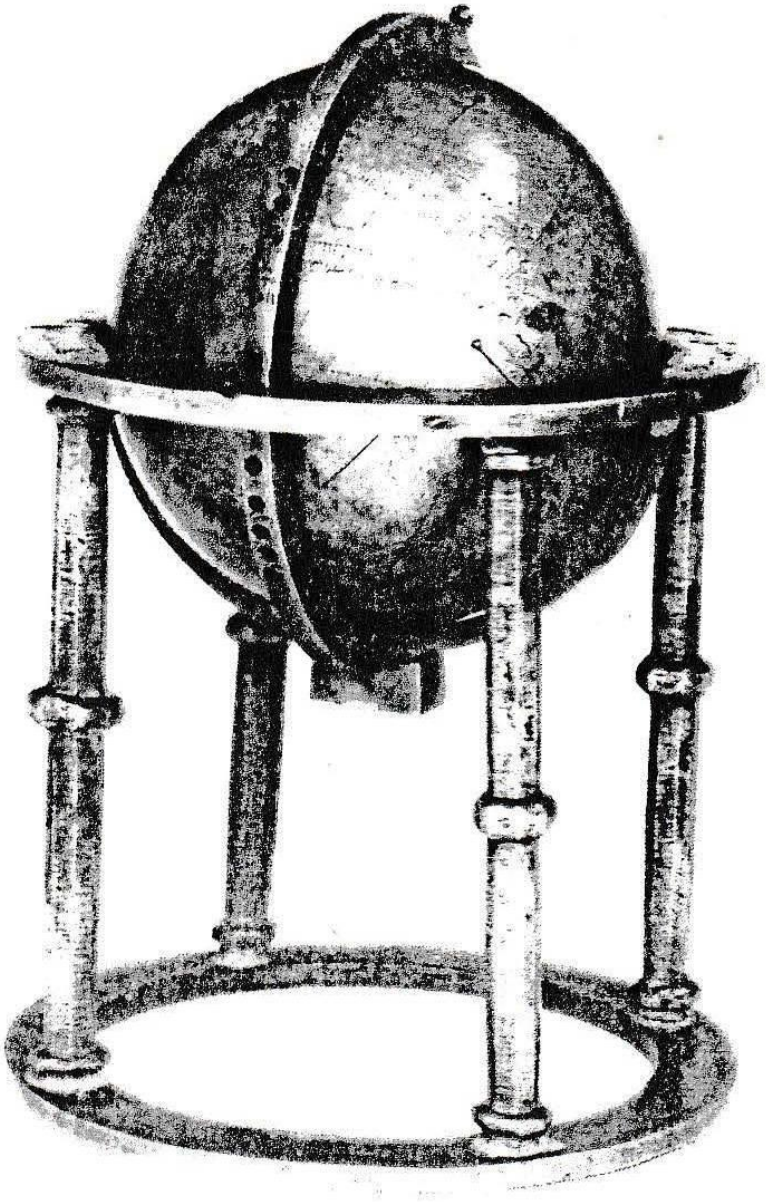


Figure G051.1 – Globe with stand (from Sotheby's catalogue of 1991)

[1263] Entry based on Sotheby's, London, auction catalogue of 10 December 1991, lot 22.

Circles

The ecliptic and equator are divided in 1°, but it is not known how they are numbered. Ecliptic latitude circles are represented by normal lines while dotted lines represent the equinoctial colure, the polar circles of the equator and of the ecliptic. The zodiac signs and several circles are named.

Stand

The four legs which support the graduated horizon are endowed with very simple ‘knops’ at the top, middle and bottom; the graduated meridian arc has several holes so that the globe can be adjusted for use at various terrestrial latitudes ranging from 18° to 72°.

Bibliography

Sotheby’s, London, auction catalogue of 10 December 1991, lot 22.

H. SANSKRIT CELESTIAL GLOBES

INTRODUCTION

It has been mentioned above that the Sanskrit name *Samudra-pakṣī* (sea-bird), given by Mahendra Sūri to the astrolabe star β Ceti - in his Sanskrit manual on the astrolabe which he composed in 1370 at the Delhi court of Firūz Shāh Tughluq - indicates his familiarity with the iconography of the constellation figure Cetus on Islamic celestial globes. Therefore the celestial globe must have reached India at least in the fourteenth century, if not earlier. But it is only in the seventeenth century that celestial globes began to be produced actively with Arabic/Persian inscriptions by Muslim instrument makers, notably by Ḍiyā' al-Dīn Muḥammad of Lahore.

But even before Diyā' al-Dīn's time, the celestial globe was mentioned in 1621 by Nṛsiṃha Daivajña in his commentary on Bhāskara's *Siddhāntaśiromaṇi*, where he describes it under the name *bhagola* and adds that Muslims call the sphere *kura* and the stand on which it is mounted *kursī*.[1264]

However, there exist very few Sanskrit celestial globes, the main reason being that a higher degree of technical expertise is needed in its production than in the production of astrolabes. As against 130 Sanskrit astrolabes, there exist today just six Sanskrit celestial globes, four of these with constellation figures and two with just the reference circles and a small number of stars. The earliest of these (H001) is preserved in Sawai Jai Singh's observatory at Jaipur and must have been commissioned by him in the 1720s. The next specimen (H002) is not actually a Sanskrit celestial globe as such; it is the Indo-Persian celestial globe made by Muḥammad Ṣāliḥ in 1074/1663-64 (G003) which was reworked with Sanskrit names and numbers about a hundred years later at the instance of Nadarāma who was a resident of Kāmyakavana on the banks of the river Yamunā, near Mathura. Nandarāma composed several works on astrology and astronomy. One of these is *Yantrasāra* on the construction and use of various instruments including the astrolabe and the celestial globe. The third (H003) and fourth (H004) Sanskrit celestial globes were made by the versatile Lālah Bulhomal of Lahore,

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[1264] Cf. Nṛsiṃha, p. 438.

who produced several kinds of instruments with inscriptions in Arabic/Persian or in Sanskrit. The last two (H005 and H006) carry just the basic circles and the positions and names of a small number of stars and no constellation figures. They are not signed or dated; they must have been produced in the nineteenth century somewhere in Rajasthan.

The iconography of the constellation figures of these Sanskrit celestial globes broadly follows the iconography on the globes by Ḍiyā' al-Dīn Muḥammad, but the Sanskrit names given to some of these figures requires an explanation. The original Greek names of the 48 constellations, as recorded in the *Almagest* by Ptolemy, are partly derived from Greek mythology; these names underwent several changes in their transmission to India through Arab-Islamic mediation. Besides these six extant celestial globes, there are two other sources where some of the Sanskrit names occur. At the court of Sawai Jai Singh, Jagannātha translated Ptolemy's *Almagest* into Sanskrit from the Arabic version of Naṣīr al-Dīn al-Ṭūsī in the 1730s under the title *Samrāṭ-siddhānta*.[1265] The star catalogue in book 7 of this work contains the names of the 48 constellations. These were rendered by Jagannātha sometimes into Sanskrit and sometimes into contemporary Rajasthani; for example, he renders Ursa Major as *Baḍā Bhālū* (big bear) while it ought to be *Bṛhad-bhallūka* in pure Sanskrit. One of the manuscript copies of Nandarāma's *Yantrasāra* contains a star catalogue, along with Sanskrit names of the constellations.[1266] These names agree, more or less, with the Sanskrit names engraved on Muḥammad Ṣāliḥ' globe. Since these Sanskrit names did not become standardized, they occasionally vary from one source to another.[1267]

The main problem in the Sanskrit names lay in rendering the names of the human figures, a problem which is carried over from the Islamic globes. We consider first the names of Andromeda, Cassiopeia, Cepheus and Perseus, who are all connected by a Greek myth. On Islamic globes, as we have seen, **Andromeda**'s name is rendered as *al-*

1265 Jagannātha, *Samrāṭ-siddhānta,* ed. Ram Swarup Sharma, New Delhi 1967, vol. 2, pp. 643-764.

1266 Manuscript No. 851 of 1884-87 of the Bhandarkar Oriental Research Institute, Pune, folios 19-36.

1267 Kaye 1918, pp. 95-115, reproduces an extract from what he calls 'Jai Singh's version of Ulugh Beg's catalogue'; all that Kaye informs about this source is that it is a manuscript in Devanagari characters copied in VS 1964 (AD 1907-08). Here the Sanskrit names of constellations and stars are mostly transliterations (cf. Kaye 1918, p. 97). These will not be considered in the present discussion.

Mar'ah al-Musalsalah (the chained woman); quite often also in a shorter form as *al-Musalsalah* (the chained one). This is translated correctly into Sanskrit as *Śṛṃkhalā-baddha* (more correctly *śṛṅkhalā-baddha*) (bound in chains), or *Śṛṃkhalā-dhara* (bearing chains); but the Sanskrit writers were not sure about the gender. Thus we have *Śṛṃkhalābaddha-strī-mūrtiḥ* (figure of a woman bound in chains) in H001; *Śṛṃkhalā-bandha-mū[rtiḥ], strī mū[rtiḥ]* (figure of imprisonment in chains, figure of a female) in H002; *Śṛṃkhalādhara* (bearing chains) in H003; but *Śṛṃkhalādhara-puruṣa-mūrtiḥ* (figure of a man bearing chains) in the *Yantrasāra* and in H004. On the other hand, the *Samrāṭ-siddhānta* calls the figure *āyasī* (made of iron or metal, in feminine) which is intriguing.

Similar is the case with Andromeda's mother **Cassiopeia,** who is referred to on the Islamic globes merely as *Dhāt al-Kursī* (one with a chair); accordingly, she is called in Sanskrit *Pīṭhāsana-stha* (situated or seated on the chair) on H003 and in the *Yantrasāra;* H004 calls her *Pīṭhāhā-manuṣya-mūrtiḥ* (sic! read *Pīṭhāsanastha-manuṣya-mūrtiḥ* (human being seated on the chair) without specifying the gender. But H001 and H002 see here a man *Pīṭhāsanastha-puruṣa-mūrtiḥ* (figure of a man seated on a chair) and *Pīṭhāsanastha-pu[ruṣa]* (a man seated on a chair) respectively. In Sanskrit, there is no exact equivalent for the Arabic *kursī,* and the term *pīṭhāsana* is a tautology, both *pīṭha* and *āsana* having the same connotation of a seat. Interestingly, the *Samrāt-siddhānta* uses another word in this context and calls the figure *mañci-lalanā* (sic! read *mañca-lalanā*), which means 'a woman on a raised seat or throne'.

The name of Andromeda's rescuer **Perseus** is often transliterated on the Islamic globes as *Barsā'ūs* (also *Parsā'ūs* or *Parshā'ūsh*). Following this, he is named *Varasyāuṣ* on H001. But in Arabic he is occasionally referred to also as *Ḥāmil Rās al-Ghūl* (the bearer of Ogre's head'); accordingly, in Sanskrit also he is called *Preta-śiro-grāhaka* (one who carries the head of a corpse) on H004 and in the *Yantrasāra* and *Pretaśirogrāhī* on H003. H002 has a variation: *Pretakayug-gaṇaḥ*; here *gaṇa* refers to a class of demi-gods who attend on Śiva or Rudra. Therefore *Pretakayug-gaṇaḥ* means 'an attendant of Śiva with [the head of] a corpse'. The *Samrāṭ-siddhānta* calls him not quite correctly a *Kāpālika* (an ascetic who carries a human skull and uses it as the receptacle for food).

The name of **Cepheus** is also merely transliterated in Arabic as *Qīqā'ūs;* likewise in Sanskrit as *Kīkāvus* on H001 or *Kaikāvusa-nṛpaḥ* in the *Samrāṭ-siddhānta.* But other sources have an entirely different name: *Jvālā-kṣepaka-naṭa-gaṇaḥ* (H002:), *Jvālā-kṣepaka-rudra-gaṇaḥ* (*Yantrasāra*), *Jvālā-kṣepa-rudra-gaṇa* (H003:) or *Jvālā-kṣepa-gaṇā-murtiḥ* (H004). The word *gaṇa,* as explained above, refers to an attendant of Śiva. Accordingly, the whole expression then means 'a demi-god attached to Śiva, who throws flames'. Apparently this notion is derived from the attribute *al-multahab* (inflamed, blazing, aflame etc.) applied to *Qīqā'ūs* in certain Arabic sources.[1268]

Hercules is referred to by Ptolemy as one who is resting on his knees; therefore in Arabic he is called *al-Jāthī.* All Sanskrit sources call him *Jānūpaviṣṭa.* However on H001, his figure is labelled *Nṛtya-kālī-mūrtiḥ* (figure of the dancing [goddess] *Kālī*). We have seen that the short skirt worn by Hercules according to the Greek fashion confused already Indo-Persian globe makers and that on three globes (F019, F020 and F027) the figure is depicted with large breasts. Assuming that a figures depicted on celestial globes must be a celestial or divine figure, some Sanskrit astronomers saw it as the dancing goddess Kālī.

Muslim astronomers did not quite understand the names and functions of the Bootes and Auriga. They called the former *al-ᶜAwwā' wa al-Baqqār,* 'the howler, that is, the ploughman'. Accordingly, he is named *Avvā-puruṣa* (the man called *Avvā*) in Sanskrit on H001. But others reasoned thus; *ᶜAwwā'* means 'howler', but a Muslim who howls regularly is the Muezzin who calls the people for the prayers. Accordingly they gave him the Sanskrit name *Dharmi-jana-āhvāyaka* (one who invites or calls the pious people [for prayer].) This expression, with slight variations occurs on H002, H003, H004 and in the *Yantrasāra.*

Auriga is called in Arabic *al-Mumsik al-Aᶜinnah* (he who holds the reins). H001 has just the transliteration *Muṃsekula ānaiṃ mūrtiḥ.* The labels on H003 (*Vallāhaka*) and H004 (*Bala-hasta-pra-ma-mūrtiḥ*) and in the *Yantrasāra* (*Valāha-hasta-puruṣaḥ grāhakah*) are highly corrupt and do not yield any coherent meaning. The *Samrāṭ-siddhānta* has *Yajña-paśu-grāhaka* (one who takes the animals to the sacrifice).

[1268] Cf. Ideler 1809, p. 45.

Orion, *al-Jabbār,* is rendered mostly as *Gadādhārī puruṣa* (a man holding a club) in the *Yantrasāra,* and on H002 and H004. The *Samrāṭ-siddhānta* merely calls him *Vīraḥ* (brave man, hero). H001 carries a different name: *Mithuna-saṃjña-mūrtiḥ* (figure of the one who carries the 'name' *Mithuna*) in order to clearly distinguish this figure from the actual *Mithuna*, which is the zodiac sign Gemini.

The name of **Centarus** is merely transliterated in Arabic as *Qanṭūrus*; so also in Sanskrit. On H001 it is engraved as *Kantūrasa-murtiḥ*; the *Samrāṭ-siddhānta* renders the name as *Ketūrasa*. The *Yantrasāra* offers *kinnara* as an equivalent; this Sanskrit term denotes semi-divine musicians with human bodies and the heads of horses (also equine bodies and human heads). In the *Yantrasāra,* both words *kantūrasa* and *kinnara* occur together. H002 and H004 have just *kinnara*.

Besides the names of the human figures, the pictorial representations of certain inanimate objects also created problems in translation. Corona Borealis (Arabic *al-Fakkah*) is generally represented with two concentric circles. Sanskrit sources see here *Mātṛ-maṇḍala* or *Mātṛ-cakra* (circle of the mothers), a mystic circle formed by mother goddesses, which is said to be situated at α Coronae Borealis. Accordingly this star is named *Viśākhā-mātṛ-maṇḍala;* here the first term *Viśākhā* is the name of the sixteenth lunar mansion.[1269] The *Samrāt-siddhānta,* however, sees a mere *Caṣaka* (cup or wine-glass) in the circular figure of Corona Borealis.

Lyra is rendered in Arabic as *Shulyāq* (tortoise) because the musical instrument lyre was made out of the upper shell of tortoises. The *Samrāṭ-siddhānta,* therefore, renders it with the Rajasthani word *kachuvā* (tortoise); a transliteration of *Shulyāq* is attempted on H001 as *Trilīyaka.* For others (H003, H004 and *Yantrasāra*), the pictorial representation suggested a *Pāna-pātra* (drinking vessel). Since gods in the celestial regions drink only the nectar of immortality (*sudhā*), H002 called it *Sudhā-pātram* (vessel for nectar).

Likewise the pictorial representation of **Crator**, Arabic *Bāṭiyaḥ,* suggests a vessel, and so it was called in the *Yantrasāra* and on H004 *sudhā-patra* (vessel for drinking

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[1269] The star α Coronae Borealis is often represented on the retes of Indo-Persian as well as Sanskrit astrolabes.

nectar). H001 and H002 call it *Bahuguṇa-patra* (vessel with many good qualities). The *Samrāṭ-siddhānta* has some word which is unintelligible.

Ara, Arabic *mijmarah,* is an incense-burner. In the pictorial depictions, the fumes of incense rising out of the vessel are drawn like the tongues of flame. Therefore it was thought that it was a brazier or a portable stove. The *Samrāṭ-siddhānta* and H002 call it *Hasantī* (portable stove) and in H001 and the *Yantrasāra* it is named *Agni-śakaṭī* (fire-cart).

H001⊙ SANSKRIT CELESTIAL GLOBE, NOT SIGNED, NOT DATED

Early 18th century

Diameter 293 mm

Jaipur, Jai Singh's Observatory



Figure H001.1 – Globe with stand (photo by S. R. Sarma)

This well-crafted globe must have been commissioned by Sawai Jai Singh in the first quarter of the eighteenth century and is thus the earliest extant Sanskrit celestial globe. Apparently the globe maker had in front of him a globe made by Ḍiyā' al-Dīn

Muḥammad as his model, but displays his own artistic talent by the fine rendition of the human faces. Here an attempt was made for the first time to render all the Arabic names of the 48 constellation figures and the names of several prominent stars into Sanskrit. In this process of translation, the same strategy appears to have been followed which was employed in translating Arabic and Persian scientific texts into Sanskrit at the court of Jai Singh, and earlier at the Mughal and Sultanate courts.[1270] In the present case, a Muslim scholar pointed to each constellation figure and explained the meaning of the Arabic name in the local Rajasthani which the Sanskrit astronomers rendered into Sanskrit. Some names could not be satisfactorily explained by the Muslim scholar or were not fully understood by the Sanskrit scholar; such names were merely transliterated into Devanagari.

A striking case of cultural and linguistic miscomprehension occurred in rendering the name of Hercules. The Muslim scholar explained that the Arabic name *al-Jathī* (pronounced more like *al-Jāsī* in Indo-Persian and Urdu) means 'one who is kneeling', but could not explain why the person is kneeling and why the person is wearing a very short skirt like a woman. Probably the Muslim scholar mentioned that, according to *al-Ṣūfī,* the figure is also called *al-Rāqiṣ,* 'the dancer',[1271] or probably the globe by Ḍiyā al-Dīn which was used as model carried a figure of Hercules with big breasts (as on F019 and F020). The outcome of this ineffective communication was that the Sanskrit scholar was convinced that the figure represents a dancing woman. Assuming that a figure placed on the celestial regions must be of divine nature, he concluded that the figure represents the dancing goddess Kālī and named it in Sanskrit *Nṛtya-Kālī-murtiḥ* (figure of the dancing [goddess] Kālī).[1272]

The artisan who engraved the figures on the present Sanskrit celestial globe, however, depicted Hercules as a man; he also depicted Andromeda in men's clothing, although the Sanskrit title reads *Śṛṃkhalā-ba[d]dha-strī-mūrti* (figure of a woman

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1270 Cf. Sarma 1998.

1271 Ṣūfī 1874, p. 70.

1272 See also the Sanskrit astrolabe D013 where the star α Herculi was named *Nṛtyakālīśira* (head of the dancing [goddess] Kālī).

bound in chains). Nevertheless, the labels he engraved in Devanagari display elegant calligraphy and fairly correct Sanskrit orthography.

The globe was cast as a single hollow sphere by the lost wax method; there are five almost rectangular plugs on the right wrist of Virgo, on the neck of Serpens, on the neck of Cetus, beneath Cetus, beneath Argo Navis and at the south pole.

Circles

The ecliptic and the equator are graduated in 1° and 6°. The equator is numbered from 6 to 360, starting from the vernal equinox. The ecliptic is numbered from 6 to 30, separately in each zodiac sign. The names of the zodiac signs are engraved along the ecliptic. There are ecliptic latitude circles, drawn at right angles to the ecliptic at intervals of 30° and polar circles of the equator, but no tropics. Holes are bored at the poles of the equator and of the ecliptic.

Constellation Figures and Stars

All the forty-eight constellation figures are elegantly drawn and the positions of many stars are marked by inlaid silver nails. The names of the constellation figures are engraved with the prefix *mūrtiḥ* (figure), a term which is analogous to *ṣūrat* on Indo-Persian globes. The names of several prominent stars and the names of the junction stars of the 28 lunar mansions are engraved. The figures generally follow the iconography of the figures on the Indo-Persian globes made by Ḍiyā' al-Muḥammad of Lahore, but the globe maker makes his personal style come through. Some of these figures will be described in the following pages, first the animal figures and then the human figures.



Figure H001.2 – Ursa Major (photo by Dr Jean-Michel Delire)

The figure of the second constellation Ursa Major is the best example to show the juxtaposition of the great bear of the Ptolemaic tradition and the seven sages (*saptarṣi*) of the Sanskrit tradition. The bear is realistically drawn, perhaps more realistically than on any Indo-Persian globe. The Sanskrit title *Bṛhad-bhallūka-mūrtiḥ* (figure of the Great Bear) is engraved in front of the face. Sanskrit names of four stars on the body and those of the three stars on the tail are engraved (these names and their modern identification will be listed in the table below). But they could not find the correct Sanskrit equivalents for the three pairs of stars on the paws. Therefore, the Arabic names are merely transliterated, that too not very accurately. Thus under the two front paws is written *phikaraisā lisai tri. dha.* (Arabic: *Qafzah al-Thālith*).



Figure H001.3 – Pegasus (photo by S. R. Sarma)

The figure of Pegasus is exactly as on the globes by Ḍiyā' al-Dīn. The Sanskrit title draws attention to the fact that only a truncated portion of the horse is depicted and not the full horse: *Mahā-aśva-khaṇḍa-grivā-mūrtiḥ* (figure of the segment of the great horse [including the] neck). Several stars are marked, of which four are named (see the Table H001-1 below).



Figure H001.4 – Hydra (photo courtesy Anthony J. Turner)

Hydra and the other two serpents Draco and Serpens are depicted in the same style as on Ḍiyā' al-Dīn's globes, with the bodies filled with innumerable tiny scales. Hydra is entitled *Dakṣiṇa-sarpa-mūrtiḥ* (figure of the southern snake). The star *Fard al-Shujā^{c}* is an astrolabe star and rendered as *Mahāpuruṣa* (great man), for inexplicable reasons.

Upon the Hydra are situated the constellations Crater and Corvus. The former is depicted as an ornate bowl with a base, covered by a hemispherical lid. The Arabic name *Bāṭiyah* (jar) is qualified in Sanskrit as *Bahu-guṇa-pātraṃ* (vessel with many [good] qualities). Corvus, the ubiquitous raven or crow, presents no problems in translation.

Now we shall look at the human figures. These, whether women or men, are generally clothed in tunics of varying lengths, some closed on the right and some on the left, but always with a sash, the loose ends are often tucked forming a loop, in the Mughal fashion.



Figure H001.5 – Andromeda (courtesy Anthony J. Turner)

Andromeda is depicted as a man wearing a martial helmet with a sharp peak on the head and a knee-length tunic with a sash around the waist; but there are no chains. The title, however, lays stress on her being a woman, *Śṛṃkhalā-ba[d]dha-strī-mūrtiḥ* (figure of a woman bound in chains). There are two named stars in this figure. These names are not actual translations of the Arabic names, but rather explanations in Rajasthani language. The star on the waist is named *Pāsalī me tārā* (star on the side) and that on her right foot *Pag mai tārā* (star on the foot).

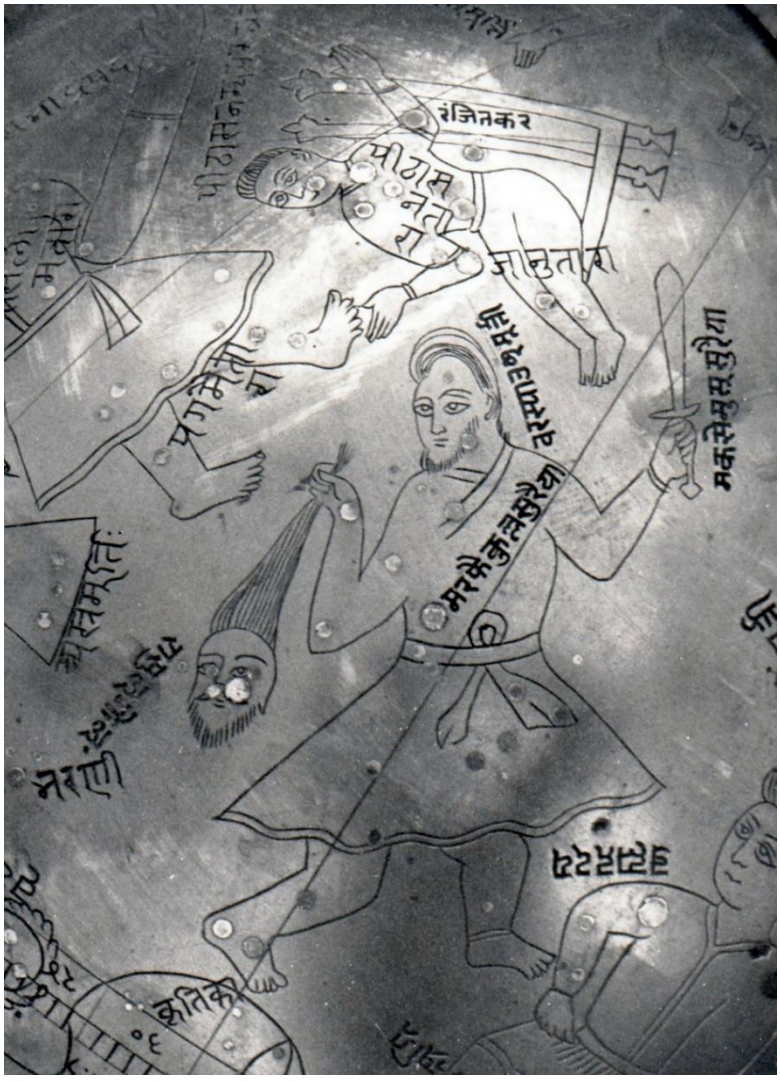


Figure H001.6 – Cassiopeia and Perseus (courtesy Anthony J. Turner)

Cassiopeia is depicted in a conventional manner seated on a chair in which the front legs are not drawn. Likewise, her dress is drawn perfunctorily without much detail. While the title of Andromeda mentions expressly that she is a woman (*strī*), the title of Cassiopeia states that it is a man (*puruṣa*): *pīṭhāsāna-stha-puruṣa-mūrtiḥ* (figure of the man seated on a chair). The star on Cassiopeia's hand, *Kaff al-Khaḍīb,* is an astrolabe star; on Sanskrit astrolabes, it is named *Rañjita-kara,* the same is done here. The star on her knee is named *Jānu-tārā* (knee star). On the upper part of the body is written *Pīṭhāsana-tārā* (chair star) which is obviously an error.

Perseus is clothed in a tunic which almost reaches up to the knees, with a sash the two loose ends of which are arranged symmetrically. Other details of clothing are not drawn completely; part of the collar is drawn. The end of the long sleeves is indicated by two lines only on the left wrist; the end of the trouser leg is indicated by two parallel

lines only on the right ankle. His head is covered by an unusual type of turban, not found anywhere else; his upper lip is clean shaven; the beard is shown only on the chin.

All the names on this figure are transliterations. The figure is entitled *Varasyā'uṣ-mūrtī* (sic! read *-mūrtiḥ*). The star on the body is named *Maraphaikulla Suraiyā* (*Mirfaq al-Thurayyā,* α Persei); the pair of stars on his wrist holding the sword are called *Makasemus Suraiyā* (*Miᶜṣam al-Thurayyā*; hχ Persei); and the star on the head of the Ghoul is named *Rāsul Gol* (*Rās al-Ghūl,* β Persei).



Figure H001.7 – Virgo (photo by S. R. Sarma)

Virgo is clothed in a long gown that reaches up to her ankles; there is no sash at the waist; the gown itself becomes narrow there. The long sleeves are indicated by parallel lines on the wrists; the collar is marked by two parallel lines around the neck. Hair on the head is shown by one single line; otherwise the face has a severe look. In contrast, the wings are drawn with all the details of the feathers.

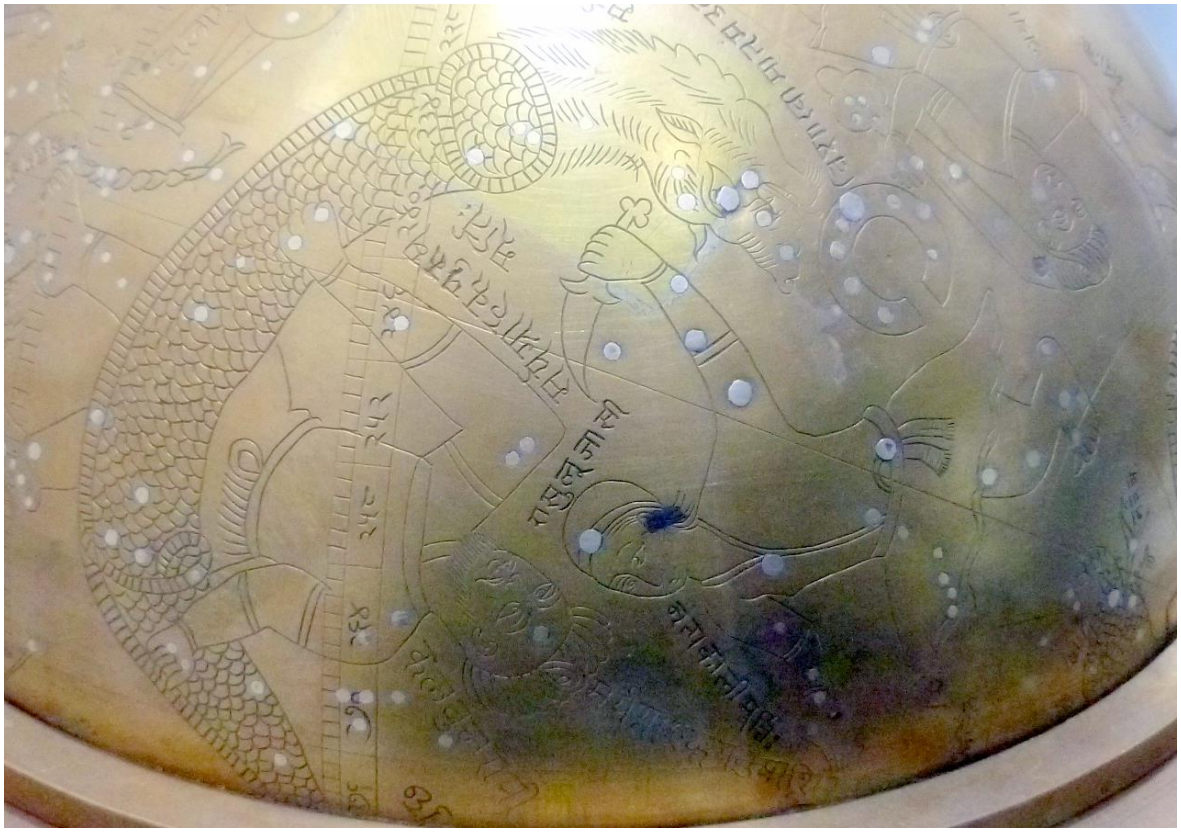


Figure H001.8 – Hercules and Ophiuchus (photo by Dr Jean-Michel Delire)

Hercules, as already mentioned, is depicted as a man, with a boyish face, clothed in a short tunic that stops above the knees. He wears a skull-cap on the head and wields a short dagger with an ornate hilt. The figure is entitled *Nṛtya-kālī-mūrtiḥ;* the star on his forehead is called *Rāsul Jāsī,* which is a transliteration. In contrast, Ophiuchus is a mature person with moustaches and beard, an elaborate turban on the head and a tunic covering his body. Both wear sashes, but the loose ends are tucked into the sashes in different styles. The serpent held by Ophiuchus is most imposing, with the multitudes of scales engraved meticulously on the body, and with its hairy neck and head. The title *Sarpa-grāhaka-puruṣa-mūrtiḥ* (figure of the man holding the serpent) is engraved in large letters next to his right arm and once again in smaller letters above his turban. The second label must be an error for *Sarpa-grāhaka-puruṣa-śiraḥ* (head of the man holding the serpent) which is the name of the star on his forehead, α Ophiuchi. *Kalb al-Rāᶜī,* 'the shepherd's dog' (β Ophiuchi), the name of the star on his shoulder, is transliterated as *Kalabularāyī.*



Figure H001.9 – Bootes (photo by S. R. Sarma)

Bootes is depicted with a turban, a short tunic, a sash with looped ends, holding a sword with a large handle. His Arabic name has been incorporated into the Sanskrit title which reads *Āvā-puruṣa-mūrtiḥ* (figure of the Āvā man). The star situated between his legs carries the name *Svāti* (α Bootis) which is the fifteenth lunar mansion. On the right is the figure of Corona Borealis entitled in Sanskrit *Viśākhā-mātṛ-maṇḍala.*



Figure H001.10 – Auriga and Orion (courtesy Anthony J. Turner)

In Figure H001.10, **Auriga** is in the upper register above the graduated scale of the ecliptic, dressed in a turban and a short tunic and holding a shepherd's crook in his left hand. His title is not translated into Sanskrit, it is merely transliterated in Devanagari as *Mumsekula Ānaiṃ Mūrttī* (sic! read *Mūrtiḥ*) from the Arabic *Mumsik al-Aᶜinnah.* The star on his right shoulder is named *Brahma-hṛdaya* (Arabic *ᶜAyyūq,* α Aurigae) and that on his left shoulder *Prajāpatiḥ* (*Mankib Dhī al-ᶜInān,* β Aurigae). The star on his left

foot (γ Aurigae) is common to one of the horns of Taurus (β Tauri). β Tauri is called *Agniḥ* in Sanskrit. But this is not correctly represented on this globe. Here the star on the left foot of Auriga is named in Rajasthani as *Yeḍī kā tārā* (star of the heel) (Arabic *Kiᶜāb Dhī al-ᶜInān,* 'ankle or heel having the reins', γ Aurigae) and the name *Agniḥ* is wrongly given to a star on the right ankle of Auriga.

Beneath the figure of Auriga is the figure of Orion straddling the celestial equator. He has a round cap on his head, thin moustaches on his youthful face; of his clothing can be seen only a small part of the skirt covering his right thigh. A dagger with a trifoliate handle is tied to his waist. His right arm is covered by a long sleeve; with the left hand he holds a weapon with a trifoliate end at the bottom. The Sanskrit astronomers had difficulty with his title. They see that Gemini is called *al-Jawzā'* in Arabic; on the other hand, they also see that the stars on Orion's hands and feet called in Arabic 'the right hand of *al-Jawzā''*, 'the left hand of *al-Jawzā''*, and so on. They were unaware of the Bedouin concept which sees in this region a huge female figure called *al-Jawzā'*. Therefore, they named the figure of Orion as *Mithuna-saṃjña-mūrtiḥ* (figure of one who carries the 'name' *Mithuna*, but who is different from *Mithuna*). The star names here are the same as those found on Sanskrit astrolabes.



Figure H001.11 – Aquarius (photo by S. R. Sarma)

The iconography of **Aquarius** is nearly the same as found on the globes by Ḍiyā' al-DĪn, including the tunic closed under the left arm, except that here he is depicted as a young person.



Figure H001.12 – Centaurus (photo by S. R. Sarma)

In the figure of **Centaurus**, the human and the equine halves are drawn well, but the engraver made a mistake by shifting Hydra's tail a little to the south, with the result that it overlaps with the face of Centaurus. The figure is entitled *Kantūrasa-mūrtiḥ* and the star on the foot of the horse is named *Kantūrasa-pāda.* The title of Lupus is not correctly engraved: *Lpālī-mūrtiḥ* does not make much sense.

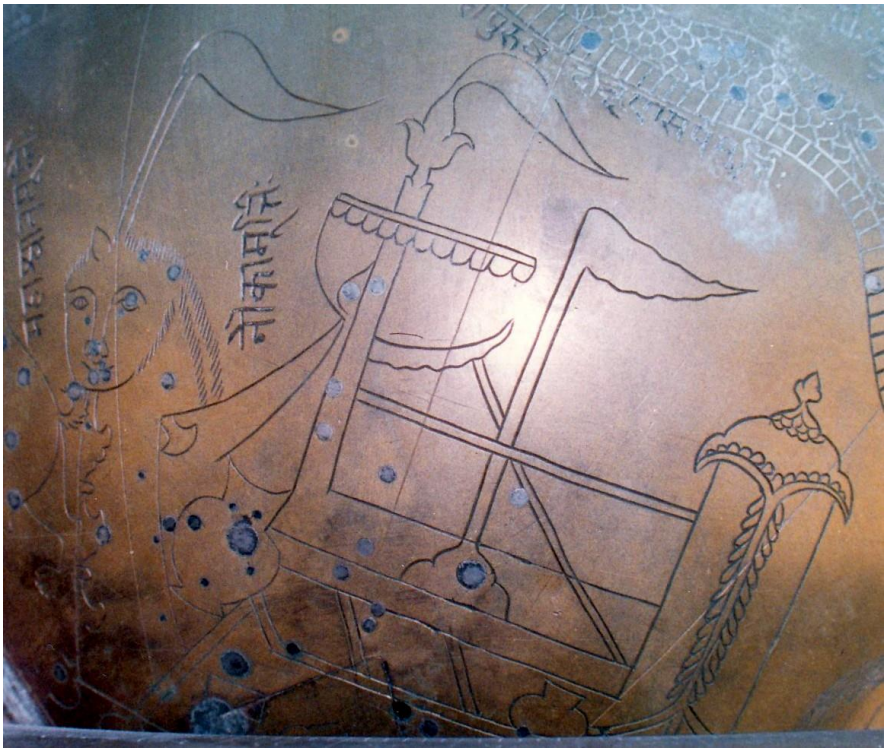


Figure H001.13 – Argo Navis (photo by S. R. Sarma)

Ḍiyā' al-Dīn's influence is unmistakable in the figure of **Argo Navis**,; the large figurehead in the front, the domed pavilion at the back, and the masts and pennants are exactly as on the globes by Ḍiyā' al-Dīn.



Figure H001.14 – Detail of the stand (photo by Dr Jean-Michel Delire)

STAND

The globe is mounted on a 277 mm high stand. It consists of horizon ring (outer diameter 358, inner diameter 30, thickness 9), supported by eight 'knopped' legs resting on a eight-lobed ring. Attached to the underside of the horizon ring are two semicircular arcs to support the meridian ring. At the intersection of the two arcs is a unit with a hole

in it and a bolt to hold the meridian ring firmly in position. The horizon ring and the meridian ring are both graduated for single degrees and groups of 6° are numbered from 6 to 90 separately in each quadrant. Several holes are bored in the meridian ring so that the globe can be adjusted according to the terrestrial latitude of the place where it is used. The globe is attached to the meridian ring by means of the axis, which is a tapering iron rod with a broad head. When the photo as seen in Figure H001.1 was taken, the meridian ring was not properly mounted on the stand; it was laid horizontally upon the horizon ring.

Sanskrit Names of Constellations and Stars

Sanskrit names engraved on the globe are listed in the table below. The constellations are arranged in the same order as in Ptolemy's *Almagest.* Under each constellation are listed the names of the stars situated in that constellation. In the fifth column are given the Sanskrit names of the constellations which occur in Jagannātha's *Samrāt-siddhānta.* In a few cases the meanings of the Sanskrit names are added in parentheses.

Table H001-1 Sanskrit names of Constellations and Stars

	Modern Name	Arabic name	Sanskrit name engraved on the globe	Sanskrit name in the *Samrāṭ-siddhānta*[1273]
1	Ursa Minor	*Dubb al-Aṣghar*	*Laghu-bhallūka-mūrtiḥ*	*Laghu-bhallūkaḥ*
	α UMi		*Prasiddha-dhruva* (well-known pole [star])	
	β UMi		*Dhruva-markaṭī*	
2	Ursa Major	*Dubb al-Akbar*	*Bṛhad-bhallūka-mūrtiḥ*	*Baḍā Bhālū*

[1273] I am grateful to Professor K. Ramasubramanian for providing these names from the *Samrāṭ-siddhānta.*

	Modern Name	Arabic name	Sanskrit name engraved on the globe	Sanskrit name in the *Samrāṭ-siddhānta*[1273]
	α UMa	*Ẓahr Dubb al-Akbar*	*Kratuḥ*	
	β UMa	*Mirāq Dubb al-Akbar*	*Pulahaḥ*	
	γ UMa	*Fakhd Dubb al-Akbar*	*Pulastiḥ*	
	δ UMa	*Maghriz Dubb al-Akbar*	*Atriḥ*	
	ε UMa	*Jawn*	*Aṅgirāḥ*	
	ζ UMa	*ᶜAnāq*	*Vasiṣṭhaḥ*	
	η UMa	*Qā'id*	*Marīciḥ*	
	νξ UMa	*Qafzah al-Ūlā*	*Phikarai ullā a.ca.*	
	λμ UMa	*Qafzah al-Thānī*	*Phikarausā niye chi.ca*	
	ικ UMa	*Qafzah al-Thālith*	*Phikaraisā lisai tri. dha.*	
3	Draco	*al-Tinnīn*	*Ajagara-mūrtiḥ*	*Ajagaraḥ*
	μ Draconis	*al-Rāfiḍ*	*Nartaka* (dancer)	
4	Cepheus	*al-Qīqā'ūs*	*Kaikāvus-mūrtiḥ*	*Kaikāusa Nṛpaḥ* (king)
	γ Cephei	*al-Rā'ī*	*Alarāī*	
			Alasākī ? on the left foot	
5	Bootes	*al-ᶜAwwā'*	*Āvā-puruṣa-mūrtiḥ*	
	α Bootis	*Simāk al-Rāmiḥ*	*Svāti*	

	Modern Name	Arabic name	Sanskrit name engraved on the globe	Sanskrit name in the *Samrāṭ-siddhānta*[1273]
6	Corona Borealis	*al-Fakkah*	*Viṣākhā-mātṛ-maṇḍala*	*Caṣakaḥ*
7	Hercules	*al-Jāthī*	*Nṛtya-kālī-mūrtiḥ*	*Jānūpaviṣṭaḥ*
	α Herculis	*Rās al-Jāthī*	*Rāsul Jāsī*	
8	Lyra	*al-Shulyāq*	*Trilīyak-mūrtiḥ*	*Kachuā* (Tortoise)
	α Lyrae	*Nasr Wāqi*^{c}	*Abhijit*	
9	Cygnus	*al-Dajājah*	*Uḍḍīyamāna-kukkuṭa-mūrtiḥ* (figure of the flying chicken)	*Pakṣī* (bird)
	α Cygni	*Dhanab al-Dajājah*	*Kukkuṭa-puccha*	
	ω^{1,2} Cygni	*Rukbat al-Dajājah*	*Kukkuṭa-jānuḥ*	
10	Cassiopeia	*Dhāt al-Kursī*	*Pīṭhāsāna-stha-puruṣa-mūrtiḥ*	*Mañci-lalanā*
	β Cas	*Kaff al-Khaḍīb*	*Raṃjita-kara*	
	δ Cas	*Rukbat Dhāt al-Kursī*	*Jānu-tārā*	
11	Perseus		*Varasyā'uṣ-mūrtī*	*Kāpālikaḥ*
	α Persei	*Mirfaq al-Thurayyā*	*Maraphaikulla Suraiyā*	
	β Persei	*Rās al-Ghūl*	*Rāsul Gol*	
	hχ Persei	*Mi*^{c}*ṣam al-Thurayyā*	*Makasemus Suraiyā*	
12	Auriga	*Mumsik al-A*^{c}*innah*	*Mumsekula Ānaiṃ Mūrttī*	*Vālīkaḥ*
	α Aurigae	^{c}*Ayyūq*	*Brahma-hṛdaya*	

	Modern Name	Arabic name	Sanskrit name engraved on the globe	Sanskrit name in the *Samrāṭ-siddhānta*[1273]
	β Aurigae	*Mankib Dhī al-ᶜInān*	*Prajāpatiḥ*	
	γ Aurigae	*Kiᶜāb Dhī al-ᶜInān*	*yeḍī kā tārā*	
13	Ophiuchus	*al-Ḥawwā*	*Sarpa-grāhaka-puruṣa-mūrtiḥ*	*Vyālakaraḥ* (one who has a snake in his hands)
	β Ophiuchi	*Kalb al-Rāᶜī*	*kalabularāyī*	
14	Serpens	*al-Ḥayyat al-Ḥawwā*	--- not engraved ---	*Vyālaḥ* (snake)
15	Sagitta	*al-Sahm*	*Bhāla-mūrtiḥ* (sic! read *Bāṇa-mūrtiḥ*)	*Bāṇaḥ*
16	Aquila	*al-ᶜUqāb*	*Kāka-pakṣī-mūrtih* (figure of the ‘crow bird’)	*Gṛdhraḥ* (vulture)
	ζ Aquilae	*Dhanab al-ᶜUqāb*	*Kāka-pakṣī-puccha*	
17	Delphinus	*al-Dulfīn*	*Machī-mūrtiḥ* (figure of the fish)	*Jalajīvaḥ* (aquatic animal)
	ε Delphini	*Dhanab al-dulfīn*	*Puccha-māchī*	
18	Equuleus	*Qiṭᶜat al-Faras*	*Aśvamu[kha]* (face of the horse)	*Aśvānanam* (face of the horse)
19	Pegasus	*Faras Aᶜẓam*	*Mahā-aśva-khaṇḍa-grivā-mūrtiḥ*	*Aśvaḥ*
	α Pegasi	*Matn al-Faras*	*Aśva-pṛṣṭa*	
	β Pegasi	*Mankib al-Faras*	*Pūrvā Bhādrapadā*	

	Modern Name	Arabic name	Sanskrit name engraved on the globe	Sanskrit name in the *Samrāṭ-siddhānta*[1273]
			(lunar mansion 26)	
	γ Pegasi	*Janāḥ al-Faras*	*Aśva-Pakṣa; Uttarā Bhādrapadā* (lunar mansion 27)	
	ε Pegasi	*Fam al-Faras*	*Aśva-mukha*	
20	Andromeda	*al-Mar'ah al-Musalsalah*	*Śṛṃkhalā-ba[d]dha-strī-mūrtiḥ*	*Āyasī*
	β And	*Janb Musalsalah*	*Pāsalī me tārā*	
	γ And	*Rijl Musalsalah*	*Pag mai tārā*	
21	Triangulum	*Al-Muthallath*	*Trysra-mūrtiḥ*	*Tryasram*
	α Trianguli	*Rās al-Muthallath*	*Trasra-śiraḥ*	
22	Aries	*al-Hamal*	*Meṣa-mūrtiḥ*	*Meṣaḥ*
	β Arietis		*Aśvinī* (lunar mansion 1)	
	41 Arietis		*Bharaṇī* (lunar mansion 2)	
23	Taurus	*al-Thawr*	*Vṛṣa-mūrtiḥ*	*Vṛṣaḥ*
	α Tauri	*ᶜAyn al-Thawr*	*Rohiṇī* (lunar mansion 4)	
	η Tauri		*Kṛttikā* (lunar mansion 3)	
24	Gemini	*al-Jawzā'*	*Mithuna-mūrtiḥ*	*Mithunam*
	α Gem	*Rās al-Taw'am al-Muqaddam*	*Prathama-punarvasu*	

	Modern Name	Arabic name	Sanskrit name engraved on the globe	Sanskrit name in the *Samrāṭ-siddhānta*[1273]
	β Gem	*Rās al-Taw'am al-Mu'akkhar*	*Punarvasu* (lunar mansion 7)	
25	Cancer	*al-Saraṭān*	*Karka-mūrtiḥ*	*Karkaḥ*
	δ Cancri		*Puṣya* (lunar mansion 8)	
	ζ Cancri		*Aśleṣā* (lunar mansion 9)	
26	Leo	*al-Asad*	*Siṃha-mūrtiḥ*	*Siṃhaḥ*
	α Leonis		*Maghā* (lunar mansion 10)	
	β Leonis		*Uttaraphālgunī* (lunar mansion 12)	
	δ Leonis		*Pūrvaphālgunī* (lunar mansion 11)	
27	Virgo	*al-Sunbulah*	*Kanyā-mūrtiḥ*	*Kanyā*
	α Virginis	*Simāk A^{c}zal*	*Citrā* (lunar mansion 14)	
	δ Virginis		*Āpaḥ*	
	θ Virginis		*Apāṃvatsaḥ*	
28	Libra	*al-Mīzān*	*Tulā-mūrtiḥ*	*Tulā*
	α Librae	*Kiffah Janūbī*	*Viśākhā* (lunar mansion 16)	
29	Scorpio	*al-^{c}Aqrab*	*Vṛścika-mūrtiḥ*	*Vṛścikaḥ*
	α Scorpii		*Jyeṣṭhā* (lunar mansion 18)	
	δ Scorpii		*Anūrādhā* (lunar mansion 17)	

	Modern Name	Arabic name	Sanskrit name engraved on the globe	Sanskrit name in the *Samrāṭ-siddhānta*[1273]
	λ Scorpii		*Mūla* (lunar mansion 19)	
30	Sagittarius	*al-Qaws*	*Dhanur-murtiḥ*	*Dhanuḥ*
	δ Sagittarii		*Pūrvāṣāḍhā* (lunar mansion 20)	
	σ Sagittarii		*Uttarāṣāḍhā* (lunar mansion 21)	
31	Capricorn	*al-Jadī*	*Makara-mūrtiḥ*	*Makaraḥ*
32	Aquarius	*al-Dalw*	*Kumbha-mūrtiḥ*	*Kumbhaḥ*
	λ Aquarii		*Śatabhiṣā* (lunar mansion 25)	
33	Pisces	*al-Ḥūt*	*Mīna-mūrtiḥ*	*Mīnaḥ*
	ζ Piscium		*Revatī* (lunar mansion 28)	
34	Cetus	*al-Qayṭus*	*Samudrapakṣī-mūrtiḥ*	*Sūrati Jinvakrī*?
	β Ceti	*Dhanab al-Qayṭus Janūbī*	*Puccha kā dakṣiṇa kā tārā*	
	ι Ceti	*Dhanab al-Qayṭus Shamālī*	*Puccha kā Uttara kā tārā*	
35	Orion	*al-Jabbār*	*Mithuna-saṃjña-mūrtiḥ*	*Vīraḥ*
	α Orionis	*Yad al-Jawzā' al-Yumnā*	*Ārdrā* (lunar mansion 6)	
	β Orionis	*Rijl al-Jawzā' al-Yusrā*	*Mithuna-vāma-pāda*	
	γ Orionis	*Yad al-Jawzā' al-Yusrā*	*Mithuna-vāma-hasta*	

	Modern Name	Arabic name	Sanskrit name engraved on the globe	Sanskrit name in the *Samrāṭ-siddhānta*[1273]
	κ Orionis	*Rijl al-Jawzā' al-Yumnā*	*Mithuna-dakṣiṇa-pāda*	
	λ Orionis		*Mṛgaśī[r]ṣa* (lunar mansion 5)	
36	Eridanus	*al-Nahr*	*Kulyā-mūrtiḥ* (figure of the canal)	*Jalāśayaḥ* (pond or lake)
	θ Eridani	*Ākhir al-Nahr*	*Nadyantaka*	
37	Lepus	*al-Arnab*	*Śaśa-mūrtiḥ*	*Śaśaḥ*
38	Canis Major	*Kalb al-Akbar*	*Mahā-śvāna-mūrtiḥ*	*Baḍā Kuttā*
	α CMa	*Shiʿrā Yamānī*	*Lubdhaka*	
39	Canis Minor	*Kalb al-Aṣghar*	*Laghu-śvāna-mūrtiḥ*	*Choṭā Kukkur*
	α CMi	*Shiʿrā Shāmī*	*Lubdhaka-bandhu*	
40	Argo Navis	*al-Safīnah*	*Naukā-mūrtiḥ*	*Nauḥ*
	α Carinae	*Suhayl*	*Agasti*	
41	Hydra	*al-Shujāʿ*	*Dakṣiṇa-sarpa-mūrtiḥ*	*Bhujagaḥ* (snake)
	α Hydrae	*Fard al-Shujāʿ*	*Mahāpuruṣa*	
42	Crater	*al-Bāṭiyah*	*Bahuguṇa-pātram*	*Maghnānghrī ?*
43	Corvus	*al-Ghurāb*	*Kāka-mūrtiḥ*	*Kākaḥ*
	α Corvi	*Minqār al-Ghurāb*	*Kāka-cañcuḥ*	
	γ Corvi	*Janāḥ al-Ghurāb*	*Kāka-pakṣaḥ*	

	Modern Name	Arabic name	Sanskrit name engraved on the globe	Sanskrit name in the *Samrāṭ-siddhānta*[1273]
44	Centaurus	*al-Qanṭūrus*	*Kantūrasa-mūrtiḥ*	*Ketūrasa*
	α Centauri	*Rijl al-Qanṭūrus*	*Kantūrasa-pāda*	
45	Lupus	*al-Sab*^{c}	*Lpālī-mūrtiḥ* ?	*Sūrata-simhaḥ*
46	Ara	*al-Mijmarah*	*Agni-śakaṭī* (fire cart, i.e., portable stove)	*Hasantī* (portable stove)
47	Corona Australis	*al-Iklīl janūbī*	*Mutkuṭa-mūrtiḥ* (figure of the crown)	*Vṛkṣasya Tārāḥ* (stars of the tree ?)
48	Piscis Austrinus	*al-Ḥūt janūbī*	*Dakṣina-matsya-mūrtiḥ* (figure of the southern fish)	*Dakṣiṇa-gola-stha-matsyaḥ* (fish in the southern hemisphere)
	α Piscis Austrini	*Fam al-Ḥūt Janūbī*	*Matsya-mukha* (mouth of the fish)	

H002⦿ CELESTIAL GLOBE BY MUḤAMMAD ṢĀLIḤ, 1074 AH (AD 1663-64) REWORKED WITH SANSKRIT LEGENDS BY NANDARĀMA, 1824 VS (AD 1767-68)

Diameter ca 250 mm, weight of the globe 4.95 kg

London, Nasser D. Khalili Collection of Islamic Art (# SCI 45)

ESS 29



Figure H002.1 – Globe with stand
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 45
Photo courtesy of the Khalili Family Trust © Nour Foundation

This Indo-Persian celestial globe, which was originally made by Muḥammad Ṣāliḥ of Thatta in 1074/1663-64, was reworked about a century later at the instance of the

Hindu astronomer Nandarāma in VS 1824 VS (= AD 1767-68), as recorded in the metrical inscription engraved near the southern poles. The original globe was described in G003. Here the additions made in Sanskrit by Nandarāma will be discussed. These two entries should be read together.

Nandarāma Miśra (*fl.* 1763-1778) was a resident of Kāmyakavana (modern Kāmon town in Rajasthan 27;38,60° N and 77;1,0° E). He was a prolific writer; some 14 astronomical and astrological works composed by him are known.[1274] Important for the present context is the *Yantrasāra* (Essence of Instruments) which he composed in *Śaka* 1693 (= AD 1771-72) and where he describes the construction and use of several instruments, including the astrolabe and the celestial globe.



Figure H002.2 – Vernal equinox (photo by S. R. Sarma)

[1274] Cf. CESS, 3, pp. 128-130; 4, p. 121; 5, pp. 156-158.

Circles

On the ecliptic, Devanagari numerals are added next to the *Abjad* numerals. On the equator, one additional band is engraved in which groups of 6° (as against the original groups of 5°) are numbered serially from 1 to 60, starting from the vernal equinox. The ecliptic is named *krāṃti-valaya* (more correctly, *krānti-valaya,* circle of declination) and the celestial equator *nāḍī-valaya* (circle of *nāḍīs,* i.e., *ghaṭikās*). The north celestial pole and the south celestial pole are named respectively *u[tthara] dhru[va]* and *da[kṣiṇa] dhru[va].* The poles of ecliptic in the north and in the south receive the names *krāṃ[ti]vṛ[tta]ke[ndra] u[ttara]* and *krāṃtivṛttakendra da[kṣiṇa].* The names of the zodiac signs, i.e., the segments of 30° in the ecliptic, are engraved in large letters along the ecliptic.

At the point of the **vernal equinox** is engraved *u[ttara] gola pravṛttiḥ* (the commencement of the sun's progress in the northern hemisphere); at the point of the **autumnal equinox** is written *da[kṣiṇa] gola pravṛttiḥ* (the commencement of the sun's progress in the southern hemisphere). At the point of the **summer solstice**, *u[ttara] pa[rama] krāṃ[tiḥ]. da[kṣiṇa] a[yana] pra[vṛttiḥ]* (maxim declination in the north, commencement of the *Dakṣiṇāyana,* the southern progress of the sun). At the point of the **winter solstice**, opposite the label *mayl kullī,* is engraved *pa[rama] dū [dakṣiṇa ?] krāṃ[tiḥ]. u[ttara] ayana pravṛttiḥ* (maximum declination in the south; commencement of the *Uttarāyaṇa,* the northern progress of the sun).

Constellation Figures and Stars

At the instance of Nandarāma, the Sanskrit names of the constellation figures, those of the junction stars of all the 28 lunar mansions and the names of a small number of prominent stars are engraved on the globe. The names of the constellation figures are followed by the prefix *mūrtiḥ* (figure, *ṣūrat*) or the abbreviation *mū*; sometimes without any suffix at all. It has already been mentioned that Cepheus is named *Jvālā-kṣepaka-naṭa-gaṇaḥ* on the basis of the Arabic attribute *al-Multahab.*

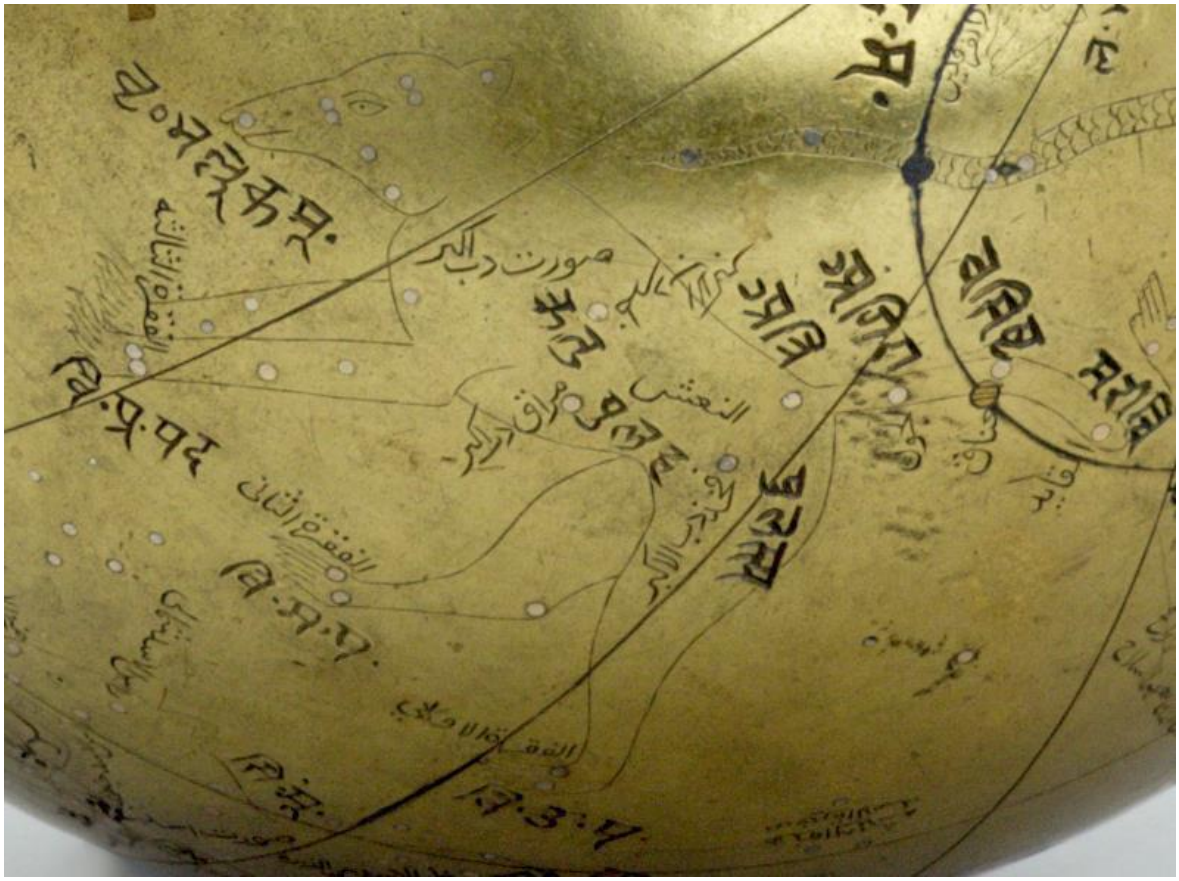


Figure H002.3 – Ursa Major
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 45
Photo courtesy of the Khalili Family Trust © Nour Foundation

A few other unusual names deserve attention. On Sanskrit astrolabes, the star α Hydrae is named *Mahāpuruṣa* (great man) for unknown reasons; this Sanskrit name has no connection whatsoever to the Arabic name *Fard al-Shujāʿ* (the isolated [star] of the serpent). Now on this globe the entire constellation of Hydra is named *Mahāpu[ruṣa]mū[rtiḥ]* (figure of the great man). In Nandarāma's *Yantrasāra,* however, the constellation Serpens is called *Sarpa-mūrtiḥ* (figure of the snake) and the constellation Hydra *Dakṣiṇa-sarpa-mūrtiḥ* (figure of the southern snake).

In the constellation of Orion, the star β is named in Sanskrit as *vāyuḥ* and the star κ as *guṇa.* In Sanskrit *vāyuḥ* denotes the wind and also the god of winds, who is considered to be lord of the northwest and the regent of the lunar mansion *Svāti.* But there is no Sanskrit tradition connecting *Vāyuḥ* to the star β Orionis. The Sanskrit word *guṇa* means quality or attribute and also thread or rope. Again there is no tradition connecting *Guṇa* to κ Orionis. It is not known why Nandarāma named these two stars in this manner.

Figure H002.3 shows Ursa Major with the original Arabic names engraved by Muḥammad Ṣāliḥ and the Sanskrit names added by Nandarāma. Here can be seen the juxtaposition of several astronomical traditions: the Ptolemaic tradition of seven stars forming the figure of a bear, the Sanskrit tradition of the seven stars representing seven great sages, the Bedouin conception of the four stars forming the bier (*al-Naᶜsh*) to carry the dead person and the three stars representing the three mourning daughters (*al-Banāt*) who follow the bier, and another Bedouin conception according to which the paws of the bear represent the marks made by the cloven hooves of a deer chased by the dogs of Bootes. Nandarāma added Sanskrit labels for these three pairs of stars in abbreviated form: *vi pra pada, vi dvi pa* and *vi u pa.* It is not clear what the first abbreviation *vi* represents. Other abbreviations can be expanded thus: *vi* (?) *pra[thama] pada* (first step)*, vi* (?) *dvi[tīya] pa[da]* (second step) and *vi u[ttara] pa[da]* (final step). It may be noted that Nandarāma reversed the sequence of the steps.

On the other hand, Nandarāma makes a highly significant addition near the constellation Eridanus. The star at the end of the river Eridanus (α Eridani) is called *Ākhir al-Nahr* (end of the river) in Arabic; this name is engraved by Muḥammad Ṣāliḥ. It is generally rendered in Sanskrit as *Nadyantaka* (that which is at the end of the river). But this name is not engraved on the present globe; instead there is *vālmīka purāṇe triśaṅkuḥ.* The first word is a miswriting for Vālmīkī, the famous author of the *Rāmāyaṇa; purāṇas* are a class of mythical histories in Sanskrit. The *Rāmāyaṇa* as well as some *purāṇas* narrate the story of king Triśaṅku who wished reach the heaven with his mortal body, but the gods did not let him in; therefore he remains suspended for ever between the heaven and earth. Astronomically, Triśaṅku is identified as the Southern Cross.

The Sanskrit names added to this globe will be listed in the Table H002-1 below.



Figure H002.4 – Horizon ring
The Nasser D. Khalili Collection of Islamic Art, Accession No. SCI 45
Photo courtesy of the Khalili Family Trust © Nour Foundation

STAND

The globe is mounted on a stand, with balustrade legs which rest on a base formed by two thick crossbars. In the horizon ring there are two notches for the meridian ring to pass through. To the underside of the horizon ring is attached a semicircular arc as a support for the meridian ring. The original meridian ring, however, is missing. The horizon ring is divided in 1°and 6° numbered in 6s from 6 to 90 in Devanagari numerals, separately in each quadrant. The outer band is divided in 30° but not labelled. Savage-Smith opines that the stand was made at the same place where the Sanskrit reworking of the globe was done. It is probable, but the engraver of the globe and the engraver of the horizon ring are different persons, for the style of the Devanagari numerals 3 and 9 are clearly different on the globe and on the ring.[1275]

[1275] Maddison & Savage-Smith 1997, I, no. 134, p. 234.

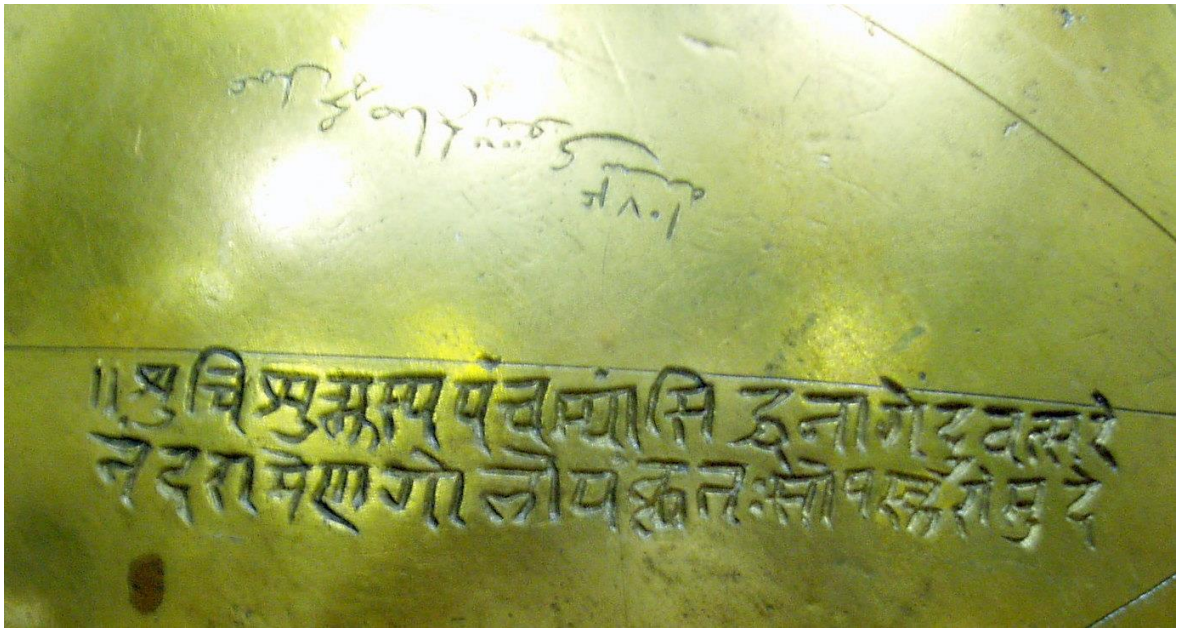


Figure H002.5 – Inscription in Sanskrit (photo by S. R. Sarma

INSCRIPTION

Near the southern poles, the following inscription in *Anuṣṭubh* metre is engraved deeply in two lines:

> *śuci-śuklasya pañcamyāṃ siddhanāgenduvatsare* |
> *nandarāmeṇa golo 'yaṃ kṛtaḥ sopaskaro mude* ||
> 'In the year 1824 (*siddha-nāga+indu-vatsara*), on the fifth day of the bright half of the month of *Āṣāḍha,* this globe was embellished by Nandarāma for [his own] pleasure.'

The year is Vikrama Saṃvat, the month *Āṣāḍha.* The date corresponds to Wednesday, 1 July 1767.

SANSKRIT NAMES OF CONSTELLATIONS AND STARS

The Sanskrit names of constellations and stars added to the globe are listed in the following table; the Sanskrit names of constellations in Nandarma's *Yantrasāra* are given in the last column. As mentioned above, the Sanskrit names of constellations engraved on the globe are followed by the prefix *mūrtiḥ* or the abbreviation *mū;* in the *Yantrasāra,* the names are generally followed by *mūrtiḥ.* These prefixes will not be shown the table.

Table H002-1 Sanskrit Names of Constellations and Stars

	Modern Name	Arabic Name	Sanskrit name engraved on the globe	Sanskrit Name in the *Yantrasāra*
1	Ursa Minor	*Dubb al-Aṣghar*	*La[ghu] bha[llūka]*	*Laghu-bhallūka*
2	Ursa Major	*Dubb al-Akbar*	*Bṛ[had] bha[llūka]*	*Bṛhad-bhallūka*
	α UMa	*Ẓahr Dubb al-Akbar*	*Kratuḥ*	
	β UMa	*Mirāq Dubb al-Akbar*	*Pulahaḥ*	
	γ UMa	*Fakhd Dubb al-Akbar*	*Pulastyaḥ*	
	δ UMa	*Maghriz Dubb al-Akbar*	*Atriḥ*	
	ε UMa	*Jawn*	*Aṅgirāḥ*	
	ζ UMa	*ᶜAnāq*	*Vasiṣṭhaḥ*	
	η UMa	*Qā'id*	*Marīciḥ*	
	νξ UMa	*Qafzah al-Ūlā*	*Vi[?] pra[thama] pa[da]*	
	λμ UMa	*Qafzah al-Thānī*	*Vi[?] dvi[tīya] pa[da]*	
	ικ UMa	*Qafzah al-Thālith*	*Vi[?] u[ttara] pa[da]*	
3	Draco	*al-Tinnīn*	*Ajagara Jahāhir vā* (dragon or water snake)	*Ajagara*
4	Cepheus	*Qīqā'ūs*	*Jvālā-kṣepaka-naṭa-gaṇa*	*Jvālā-kṣepaka-rudra-gana*
5	Bootes	*ᶜAwwā'*	*Dharmi-janāhvāyaka*	*Dharmi-janāhūyaka-puruṣa*

	Modern Name	Arabic Name	Sanskrit name engraved on the globe	Sanskrit Name in the *Yantrasāra*
	α Bootis	*Simāk Rāmiḥ*	*Svāti*	
6	Corona Borealis	*al-Fakkah*	*Mātṛkā-ca[kra]*	*Mātṛkā-maṇḍalam*
7	Hercules	*al-Jāthī*	*Jānūpaviṣṭa*	*Jānū[pa]viṣṭa*
8	Lyra	*al-Shulyāq*	*Sudhā-pātram*	*Pāna-pātram*
	α Lyrae	*Nasr Waqi*^{c}	*Abhijit*	
9	Cygnus	*al-Dajājah*	*Kukkuṭa*	*Kukkuṭa*
10	Cassiopeia	*Dhāt al-Kursī*	*Pīṭhāsanastha-pu[ruṣa]*	*Pīṭhāsanastha*
	β Cassiopeiae	*Kaff al-Khaḍīb*	*Raṃjita-[kara]*	
11	Perseus	*Pershā'ūs*	*Pretayug-gaṇa*	*Pretaśiro-grāhaka*
12	Auriga	*Mumsik al-A*^{c}*innah*	*Yajña-paśu-grāhaka*	*Valgū*(?)*-hasta-puruṣa; Yajña-paśu-grāhaka*
	α Aurigae	^{c}*Ayyūq*	*Bra[hma-]hṛ[daya]*	
	β Aurigae		*Prajāpatiḥ*	
	γ Aurigae = β Tauri	*Ki*^{c}*ab Dhī al-*^{c}*Inān*	*Agni*	
13	Ophiuchus	*al-Ḥawwā*	*Sarpa-dhārī*	*Sarpa-dhāri-puruṣa*
14	Serpens	*al-Ḥayyaḥ*	---	*Sarpa*
15	Sagitta	*al-Sahm*	*Kunta* (lance)	*Bāṇa* (arrow)
16	Aquila	^{c}*Uqāb*	*Uḍḍīyamāna-kākaḥ* (crow in flight)	*Uḍḍīyamāna-śyena* (hawk in flight)

	Modern Name	Arabic Name	Sanskrit name engraved on the globe	Sanskrit Name in the *Yantrasāra*
17	Delphinus	*al-Dulfīn*	*Matsya*	*Samudrapakṣī* (sea-bird)
18	Equuleus	*Qitᶜat al-Faras*	*A[śva]mu[kha]*	*Aśvamukha*
19	Pegasus	*Faras al-ᶜAzam*	*Aśva-skandha* (shoulder of the horse)	*Aśva-skandha*
	β Pegasi		*Pū[rvā] Bhā[drapadā]* (lunar mansion 26)	
	γ Pegasi		*U[ttarā] Bhā[drapadā]* (lunar mansion 27)	
20	Andromeda	*Marᶜah al-Musalsalah*	*Śṛṃkhala-bandha-mū[rtiḥ] Strī*	*Śṛṃkhalā-dhara-puruṣa*
21	Triangulum	*al-Muthallath*	*Trikoṇa*	---
22	Aries	*al-Ḥamal*	*Me[ṣa]*	*Meṣa*
	β Arietis		*Aśvinī* (lunar mansion 1)	
	41 Arietis		*Bharaṇī* (lunar mansion 2)	
23	Taurus	*al-Thawr*	*Vṛ[ṣabha]*	*Vṛṣabha*
	α Tauri		*Rohiṇī* (lunar mansion 4)	
	η Tauri		*Kṛttikā*(lunar mansion 3)	
24	Gemini	*al-Jawzā'*	*Mithuna*	*Mithuna*
	B Gem		*Punarvasu* (lunar mansion 7)	

	Modern Name	Arabic Name	Sanskrit name engraved on the globe	Sanskrit Name in the *Yantrasāra*
25	Cancer	*al-Saraṭān*	*Karka*	*Karka*
	δ Cancri		*Puṣya* (lunar mansion 8)	
	ζ Cancri		*Aśleṣā* (lunar mansion 9)	
26	Leo	*al-Asad*	*Siṃha*	*Siṃha*
	α Leonis		*Maghā* (lunar mansion 10)	
	β Leonis		*U[ttarā] Phā[lgunī]* (lunar mansion 12)	
	δ Leonis		*Pū[rvā] Phā[lgunī]* (lunar mansion 11)	
27	Virgo	*al-Sunbulah*	*Kanyā*	*Kanyā-rāśiḥ*
	α Virginis	*Simāk A^{c}zal*	*Citrā* (lunar mansion 14)	
	δ Virginis		*Āpaḥ*	
	θ Virginis		*Apāṃvatsaḥ*	
28	Libra	*al-Mīzān*	*Tulā*	*Tulā*
	α Librae		*Viśākhā* (lunar mansion 16)	
29	Scorpio	*al-^{c}Aqrab*	*Vṛścika*	*Vṛścika*
	α Scorpii		*Jyeṣṭhā* (lunar mansion 18)	
	δ Scorpii		*Anūrādhā* (lunar mansion 17)	
	λ Scorpii		*Mūla* (lunar mansion 19)	

	Modern Name	Arabic Name	Sanskrit name engraved on the globe	Sanskrit Name in the *Yantrasāra*
30	Sagittarius	*al-Qaws*	*Danur*	*Danur*
	δ Sagittarii		*Pū[rvā]ṣā[ḍhā]* (lunar mansion 20)	
	σ Sagittarii		*U[ttarā]ṣā[ḍhā]* (lunar mansion 21)	
31	Capricorn	*al-Jadī*	*Makara*	*Makara*
32	Aquarius	*al-Dalw*	*Kumbha*	*Kumbha*
	λ Aquarii		*Śatabhiṣā* (lunar mansion 25)	
33	Pisces	*al-Ḥūt*	*Mīna*	*Mīna*
	ζ Piscium		*Revatī* (lunar mansion 28)	
34	Cetus	*al-Qayṭus*	*Samudra-pakṣī*	*Dvitīya-samudra-pakṣī* (second sea-bird)
35	Orion	*al-Jabbār*	*Gadādhārī-pu[ruṣa]*	*Gadādhārī-puruṣa*
	α Orionis	*Yad al-Jawzā' al-Yumnā*	*Ārdrā* (lunar mansion 6)	
	β Orionis	*Rijl al-Jawzā' al-Yusrā*	*Vāyuḥ* ?	
	κ Orionis	*Rijl al-Jawzā' al-Yumnā*	*Guṇa* ?	

	λ Orionis		***Mṛgaśirā* (lunar mansion 5)**	
36	Eridanus	*al-Nahr*	*Kulyā* (canal)	*Kulyā*
	α Eridani	*Ākhir al-Nahr*	*Vālmīka purāṇe Triśaṅkuḥ* (king Tris(king Triśaṅku representing the Southern Cross)	
37	Lepus	*al-Arnab*	*Mṛga[ḥ] śaso vā* (animal or hare)	*Śaśa*
38	Canis Major	*Kalb al-Akbar*	*Vṛ[hat] śvā[na]*	*Bṛhat-śvāna*
	α CMa	*Shiʿrā Yamānī*	*Lubdhaka*	
39	Canis Minor	*Kalb al-Aṣghar*	*La[ghu] śvā[na]*	*Laghu-śvāna*
	α CMi	*Shiʿrā Shāmī*	*Lubdhaka-bandhu*	
40	Argo Navis	*al-Safīnah*	*Nau[kā]*	*Naukā*
	α Carinae	*Suhayl*	*Agastya*	
41	Hydra	*al-Shujāʿ*	*Mahāpu[ruṣa]*	*Sarpa; Dakṣiṇa-sarpa*
42	Crater	*al-Bāṭiyah*	*Bahuguṇapātra*	*Sudhāpānapātram*
43	Corvus	*al-Ghurāb*	*Kāka*	*Kāka*
44	Centaurus	*al-Qanṭūrus*	*Kinnara*	*Kantūrasa-kinnara*
45	Lupus	*al-Sabʿ*	*Vṛka* (wolf)	*Vṛka*
46	Ara	*al-Mijmarah*	*Hasantī*	*Agni-śakaṭī*
47	Corona Australis	*Iklīl Janūbī*	*Mukuṭa* (crown)	*Mukuṭa*
48	Piscis Austrinus	*al-Ḥūt janūbī*	*Matsya*	*Dakṣiṇa-matsya* (southern fish)

BIBLIOGRAPHY

Savage-Smith 1985, no. 29, pp. 231-232.

Maddison & Savage-Smith 1997, I, no. 134, p. 234.

Sarma 2008a, pp. 294-307.

H003 SANSKRIT CELESTIAL GLOBE BY LĀLAH BULHOMAL LĀHORĪ, 1895 VS (AD 1839)[1276]

Diameter 140 mm

PLU; ex-Milan, PC

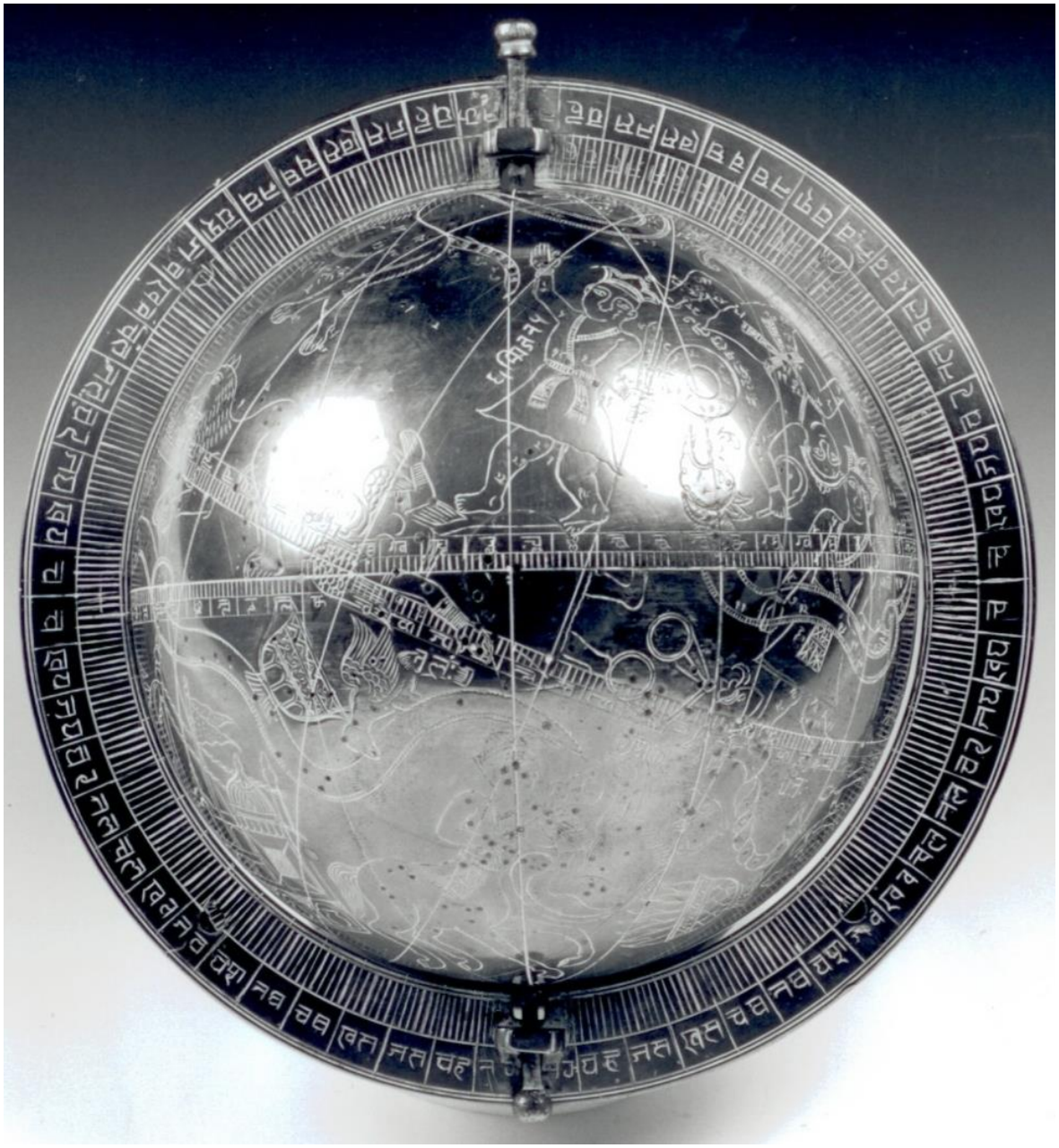


Figure H003.1 – Globe with the horizon ring (photo by Professor G. L'E. Turner)

This globe made by the versatile instrument maker Lālah Bulhomal of Lahore is endowed with two unusual features. The scales on the equator, the ecliptic and the

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[1276] Entry based on the detailed photos kindly provided by the late Professor G. L'E. Turner.

horizon ring are numbered in the Sanskrit alpha-numerical system called *Kaṭapayādi,* which originated in Kerala and was popular there.[1277] Only one other instrument is numbered in this system, namely the astrolabe C015.[1278] The inscription is in verse form, consisting of three verses in Anuṣṭubh metre.[1279] Here the year of manufacture is expressed in the so-called *Bhūtasaṃkhyā* notation.[1280]

Of the six Indo-Persian globes and the two Sanskrit globes signed by or attributable to Bulhomal, detailed photos of constellation figures are available only for G010 and H003. The iconography of human figures on these two is widely different. On the present globe, it is close to the iconography of Ḍiyā' al Dīn Muḥammad; on G010 the style may be called contemporary Punjabi. Obviously these were done by different engravers in Bulhomal's workshop. Again of all the Sanskrit instruments produced in Bulhomal's workshop, the Devanagari calligraphy is not uniform. On this and on the next globe (H004), the Devanagari script shows the influence of Gurmukhi script.

The globe is cast as a single hollow sphere by the lost wax process; a large ovoid plug is visible in the figure of Virgo.

Circles

The ecliptic and the equator, as well as the horizon ring, carry double bands of scales; one band displaying single degrees of arc and the other groups of six degrees. Groups of 6° are numbered serially from 1 to 60 on the equator; on the ecliptic from 6 to 30, separately in each zodiac sign. The names of the zodiac signs are engraved along the ecliptic in larger letters.[1281] Besides the equator and the ecliptic there are drawn six ecliptic latitude circles perpendicular to the ecliptic and six meridians perpendicular to the equator, both at intervals of 30° each; however, the meridian circles do not

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1277 On the *Kaṭapayādi* system of numerical notation, see Preface, p. x above, and also Sarma 2012d.

1278 Sarma 2009b.

1279 The custom of writing inscriptions in metrical form in Sanskrit was introduced by Sawai Jai Singh's son, Sawai Madho Singh. Bulhomal was an avid practitioner of this custom; all his signed instruments carry metrical inscriptions; cf. Sarma 2010, esp. pp. 90-92.

1280 On the *Bhūtasaṃkhyā* system of numerical notation, see Preface, p. x above, and also Sarma 2009b.

1281 The names of Virgo and Libra are treated incorrectly as masculine; thus Virgo is named *Kanyaḥ* instead of *Kanyā* and Libra *Tulah* instead of *Tulā.*

commence at the vernal equinox, but 6° westwards, as in the Indo-Persian globes signed by Bulhomal or attributable to him (G006 - G012). There are no tropics or polar circles.

Constellation figures and Stars

The globe carries the full complement of the 48 constellation figures. On each of these figures, their names are written in Sanskrit language and Devanagari script, followed by the serial number. However, names are engraved only of the northern constellations, but not of the southern constellations. Along the ecliptic are engraved the names of the zodiac signs, i.e., the zodiac houses of 30° intervals, but the names of the constellation figures of the zodiac signs are not engraved. Moreover, in all the 48 constellations, the positions of different stars are marked by inlaid silver points. In the northern constellations, the stars within each constellation are numbered serially; but this was done only in Aries and Taurus among the zodiac figures, and only in Cetus among the southern constellations. Thus the engraving of names and numbering of stars in each constellation seems to have been left incomplete for some unknown reason.

The names of the constellation figures engraved on this globe will be listed together with those engraved on globe H004 in the Table H001-1. The names on both the globes generally follow the nomenclature of Nandarāma as engraved on H002.

The focus here will be on the iconography of the figures. We begin with the human figures; their iconography, i.e. clothing, ornaments and postures, generally follow the iconography of Ḍiyā' al-Dīn Muḥammad, but the faces and the head-gear reflects the engraver's personal style. Interestingly, all human figures wear sashes around their waists, and the loose ends with geographical patterns are arranged exactly as on the globes of Ḍiyā' al-Dīn Muḥammad. The three female figures Andromeda, Cassiopeia and Virgo are shown with series of bracelets on the wrists and armlets on the upper arms as in Ḍiyā' al-Dīn's figures.



Figure H003.2 – Andromeda (photo by Professor G. L'E. Turner)

Andromeda is clothed in an ankle-length gown with a sash tied very tightly around the waist. The loose ends of the sash fall down together. In the upper half are marked the V-neck of the gown and the breasts. There are series of parallel lines on her arms indicating rows of bracelets and armlets. A chain is tied to her two legs. The figure is entitled *Śṛṃkhalā-dhara* (bearing chains).

Cassiopeia sits regally on a highly decorated chair, wearing an ankle-length gown; the folds of the gown below the sash are indicated by a series of parallel lines. The loose ends of her sash are very long reaching up to the hemline of the gown. She wears a long necklace; series of parallel lines indicate rows of bracelets on her wrists, rows of armlets on the upper arms and rows of anklets on her feet. Her head is adorned by a crown with three peaks; there is a finial above the middle peak. The legs of her chair are shaped like hour-glasses and the high back rest is decorated with geometrical patterns. The title reads *Pīṭhāsanastha* (seated on a chair) and the script is remarkably close to the Gurmukhi script.

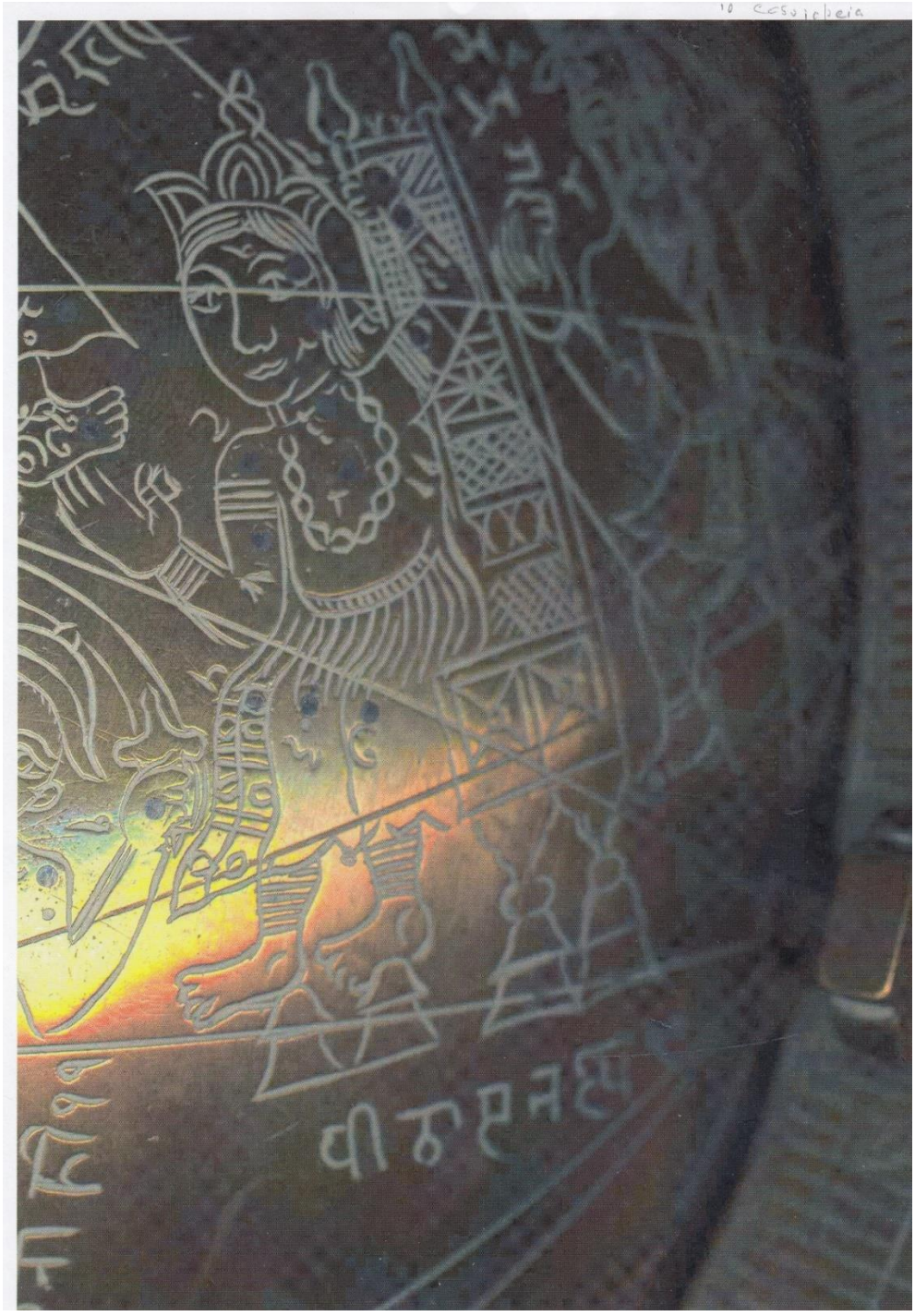


Figure H003.3 – Cassiopeia (photo by Professor G. L'E. Turner)

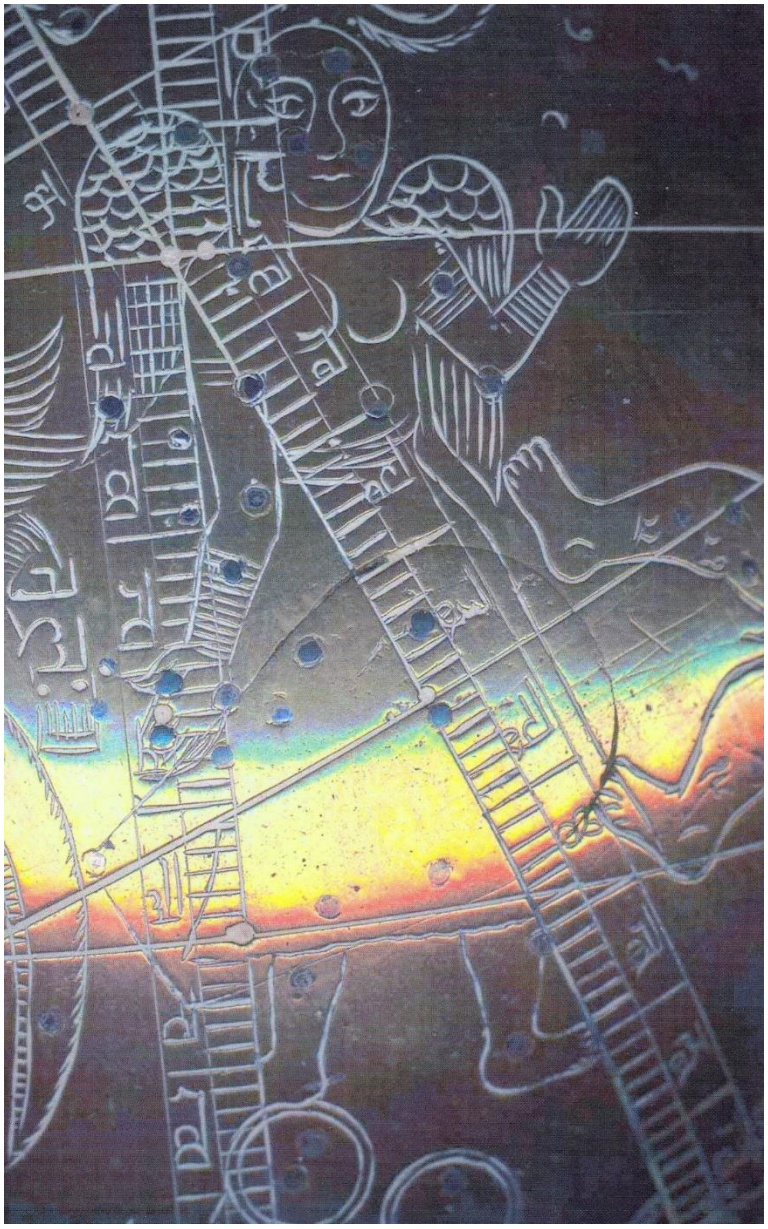


Figure H003.4 – Virgo (photo by Professor G. L'E. Turner)

A large plug covers the middle part of the figure of **Virgo**, but the engraving was not continued on the plug. Consequently nothing can be discerned about her clothing. Like Andromeda and Cassiopeia, she is also adorned with rows of bracelets and armlets. Her face is given a very circular shape. Her breasts are indicated by two semicircles. The two wings are drawn elaborately.

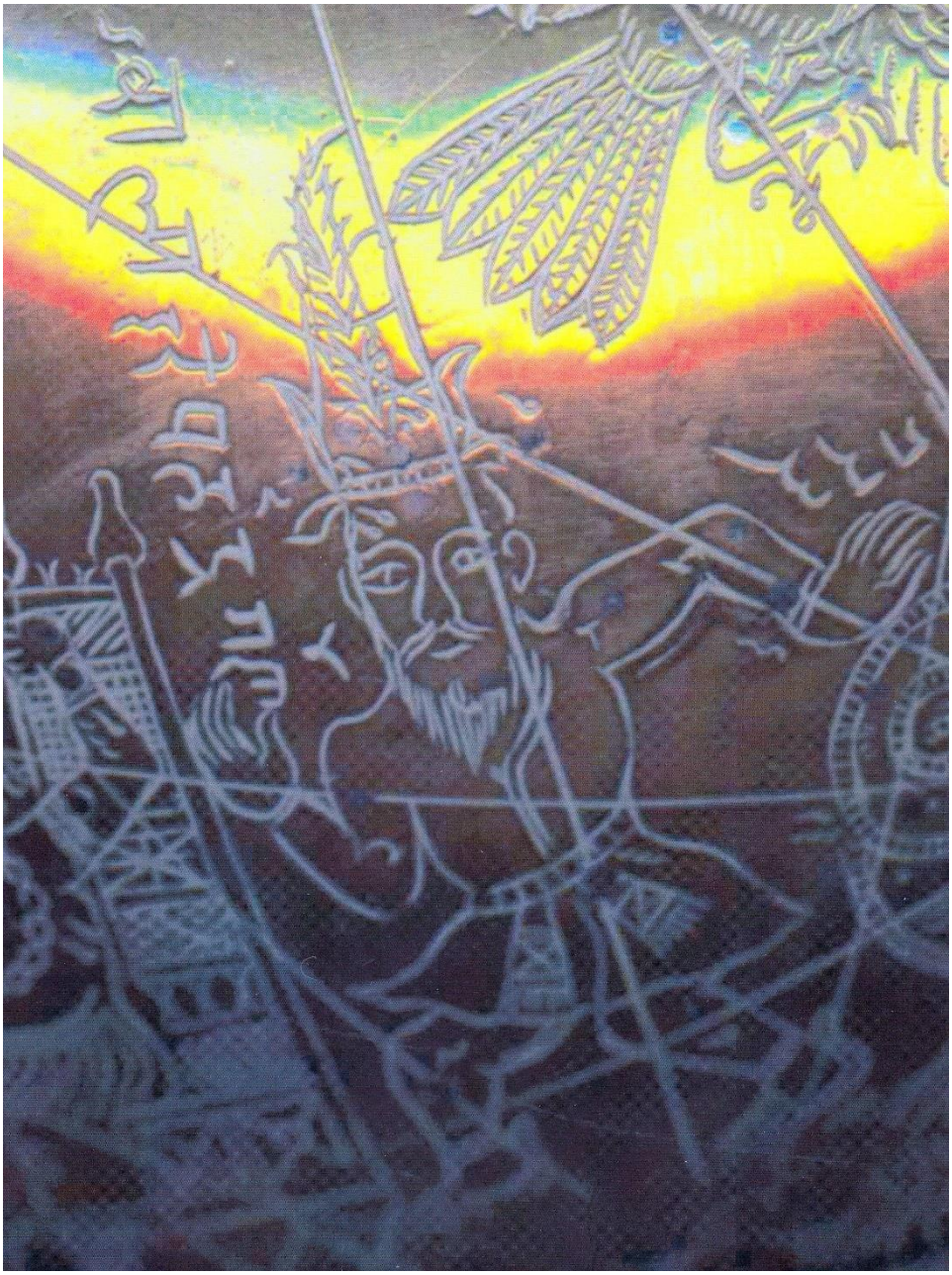


Figure H003.5 – Cepheus (photo by Professor G. L'E. Turner)

Cepheus wears a very high and very complex crown. His facial features are drawn very clearly with moustaches and pointed beard. His tunic stop above his knees. A sash is worn around the waist, the two loose ends, decorated with geometrical patterns fall down in the form of the inverted letter V. The title of figure reads *Jyālā-kṣepa[ka]-rudra-gaṇa,* followed by the serial number 4. The title is obviously borrowed from Nandarāma, or from a common source, and means 'Śiva's attendant who throws flames'.



Figure H003.6 – Perseus and Auriga (photo by Professor G. L'E. Turner)

Perseus is also bearded and dressed in similar attire of a small tunic and a sash, the ends of which carry geometrical patterns. But his head-gear is totally different; it is a tightly fitting cap with a small round pom-pom at the top. Ḍiyā' al-Dīn draws such caps on his globes frequently; for example, in his globe of 1653 at Aligarh, Perseus wears a similar cap (Figure F013.29), as also Andromeda (Figure F013.37) and Hercules and Ophiuchus (Figure F013.30). The figure is entitled *Pretaśirogrāhī 11,* 'one who holds the head of a corpse'.

In contrast to Perseus, **Auriga** is clean-shaven and wears a turban, one end of which is pulled out at the top like a peak. The title reads *Vallaha 12;* it should be *Vallava* or *Ballava*, meaning 'cowherd'.

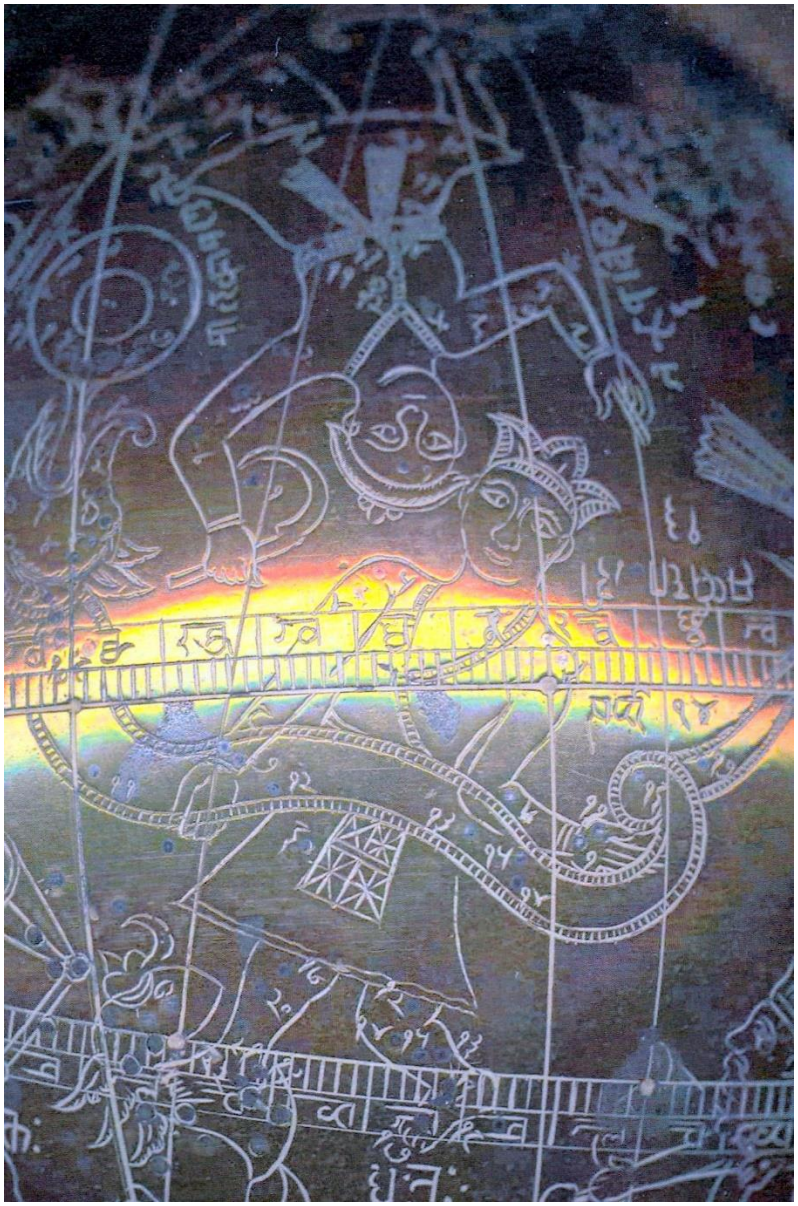


Figure H003.7 – Ophiuchus and Hercules (photo by Professor G. L'E. Turner)

Figure H003.7 shows Ophiuchus and Hercules placed in opposite directions. Like Ḍiyā' al-Dīn, Bulhomal also tries to introduce variety in these figures. Both Ophiuchus and Hercules wear knee-length tunics, but the collars and the sashes are drawn differently. More particularly, the head-gears vary. While Ophiuchus is adorned with a crown with a triple peak, Hercules has a simple cap like the one worn by Perseus. Ophiuchus is labelled *Sarpa-dhārī 13,* 'snake-bearer 13', Hercules is named *Jānūpaviṣṭa 6,* 'seated on his knees'; the serial number 6 is wrong; it should be 7.

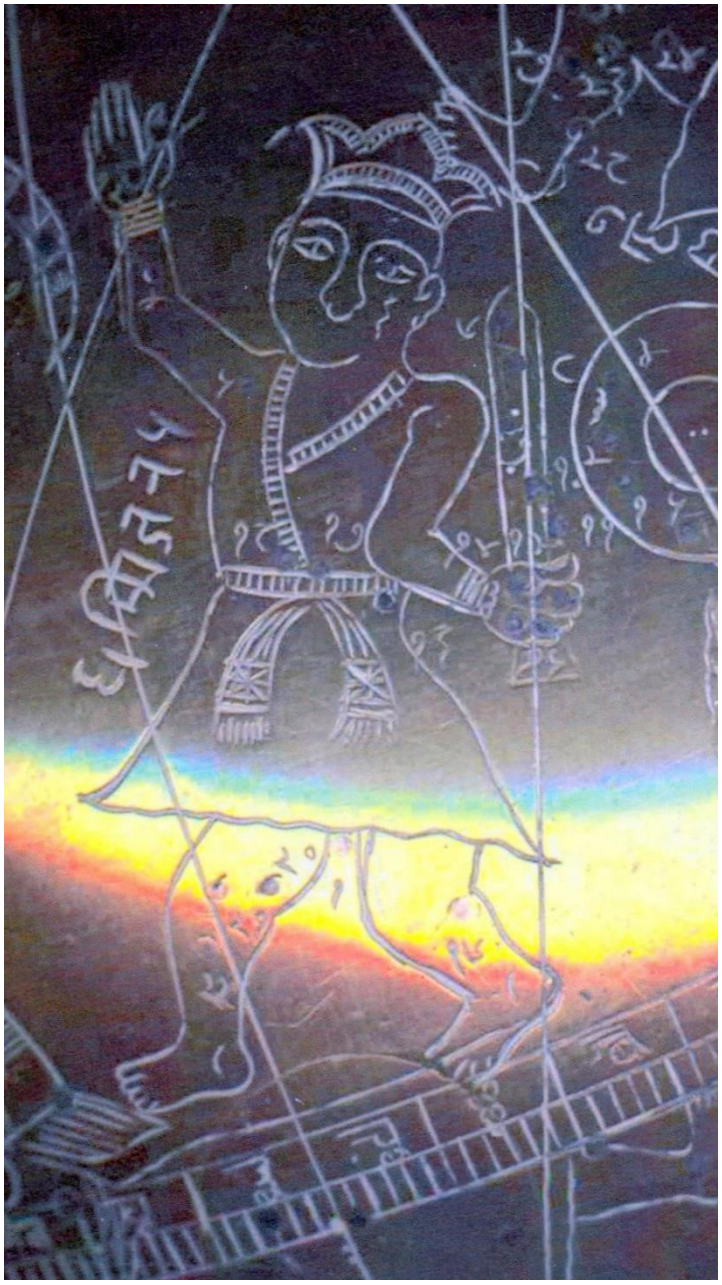


Figure H003.8 – Bootes (photo by Professor G. L'E. Turner)

Bootes is also depicted like Ophiuchus, with a three-peaked crown, short tunic that stops above the knees, with the same type of collar. But the two loose ends of the sash fall down differently. The engraver forgot to add the mouth. The title reads *Dharmmi-jana 5.* It is an abbreviation of *Dharmi-janāhūyamāna* (one who calls pious people [to the prayers]) and is obviously borrowed from Nandarāma.

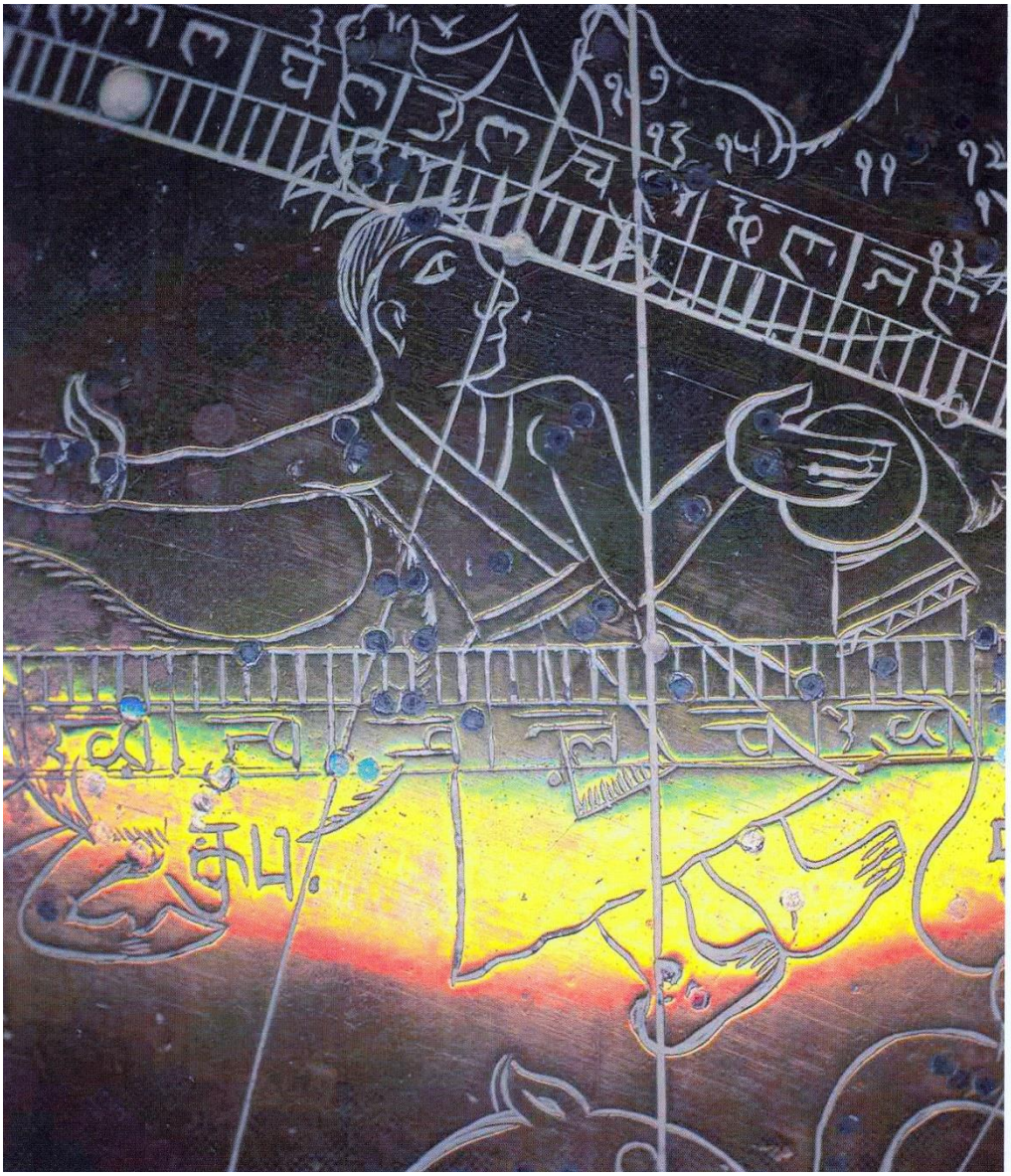


Figure H003.9 – Aquarius (photo by Professor G. L'E. Turner)

The posture and the ankle-length tunic of **Aquarius** are as in the figures drawn by Ḍiyā' al-Dīn, but here he is given youthful looks with short cropped hair and a prominent nose. Many star positions are marked by inlaid silver nails, but these are not numbered. On the left is engraved *Kuṃbha* (Aquarius), but that is the name of the zodiac house and not of the constellation figure.

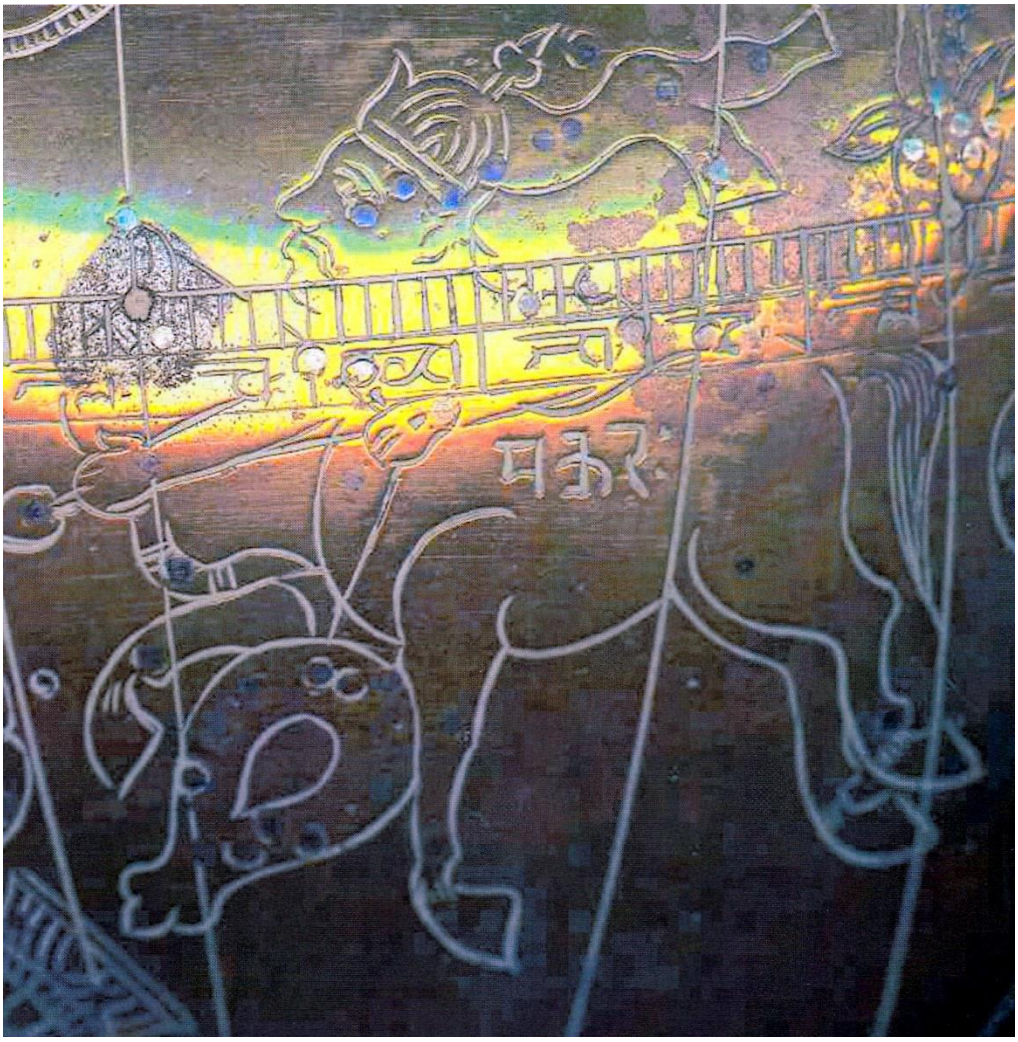


Figure H003.10 – Sagittarius (photo by Professor G. L'E. Turner)

The depiction of Sagittarius also generally follows Ḍiyā' al-Dīn's iconography; here the figure wears a large crown with a trifoliate finial. The face in profile is impressive. On the body is engraved *Makara* (Capricorn); that is the name of the zodiac house, but the title of the figure is not engraved. Likewise, the star pointers are not numbered.



Figure H003.11 – Centaurus and Lupus (photo by Professor G. L'E. Turner)

The constellation figure of **Centaurus** is done well. The tunic, collar, loose ends of the sash flying westwards, all this is reminiscent of Ḍiyā' al Dīn's figures, in particular the one on his globe at the Hermitage (Figure F009.13). Lupus is rendered as a lion cub. The twig of vine in Centaurus's hand has an unusual form. There is no title, and no star numbers.



Figure H003.12 – Cetus (photo by Professor G. L'E. Turner)

Bulhomal took great pains to draw the hybrid creature Cetus, with the body of a bird and the tail of a fish. Here the fish tail and bird's body are drawn well; in particular, the large wing on the bird's body is drawn with great detail, in the same manner as the two wings of Virgo are depicted. But in drawing the head, the engraver mixes up the dog's head and bird's head. The front of the head is like that of a bird with a large open beak open; but the back of the head is rather strange; it looks more like a cap with a curved pom-pom. The image is exactly like that on Ḍiya al-Din's globe of 1647 at the Hermitage (see Figure F009.12).



Figure H003.13 – Argo Navis (photo by Professor G. L'E. Turner)

Argo Navis also closely resembles Argo Navis drawn by Diya on his globe at the Hermitage (Figure F009.14), with a parrot in figurehead, dotted pennants, vases in the arched windows of the gallery and so on.

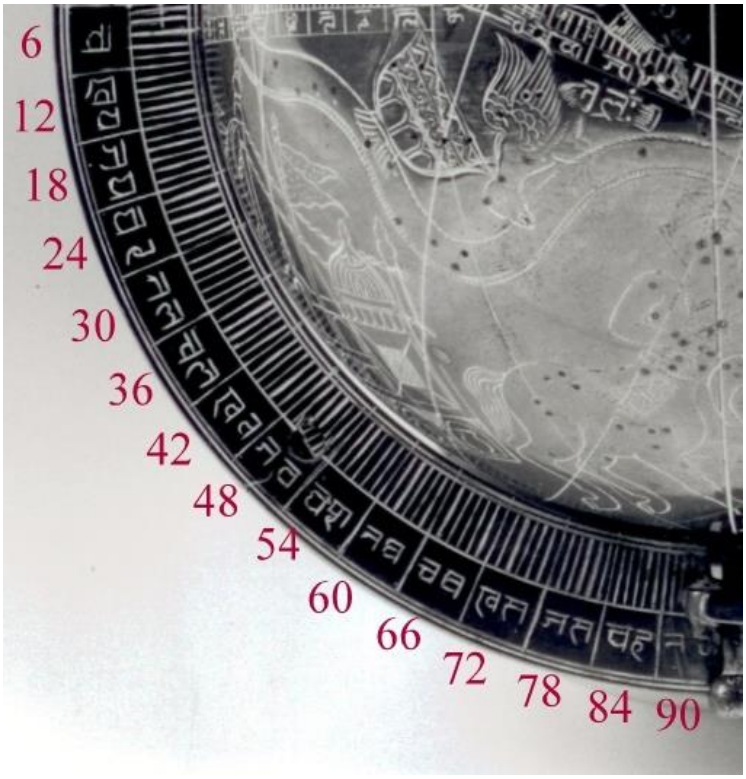


Figure H003.14 – Detail of the meridian ring (photo by Professor G. L'E. Turner)

STAND

No photos of the stand are available, except that of the horizon ring. The stand is said to be 277 mm high. The horizon ring has a diameter of 170 mm. It is graduated in single degrees and in groups of 6°. The latter are labelled in the *Kaṭapayādi* notation thus: *ca* (6), *khaya* (12), *jaya* (18), *ghara* (24), *nala* (30), *cala* (36), *khava* (42), *java* (48), *vaśa* (54), *naṣa* (60), *caṣa* (66), *khasa* (72), *jasa* (78), *vaha* (84), *najha* (90). This is repeated in each quadrant.

On the globe itself, both the ecliptic and the equator scales are likewise labelled in the *Kaṭapayādi* notation. For economy of space, two consonants are conjoined here, but both have numerical values. Thus *pla* (31), *phla* (32), *bla* (33), *bhla* (34), *mla* (35) …. *kva* (41), *khva* (42), *gva* (43), *ghva* (44), *ṅva* (45), *cva* (46), *chva* (47), *jva* (48) …

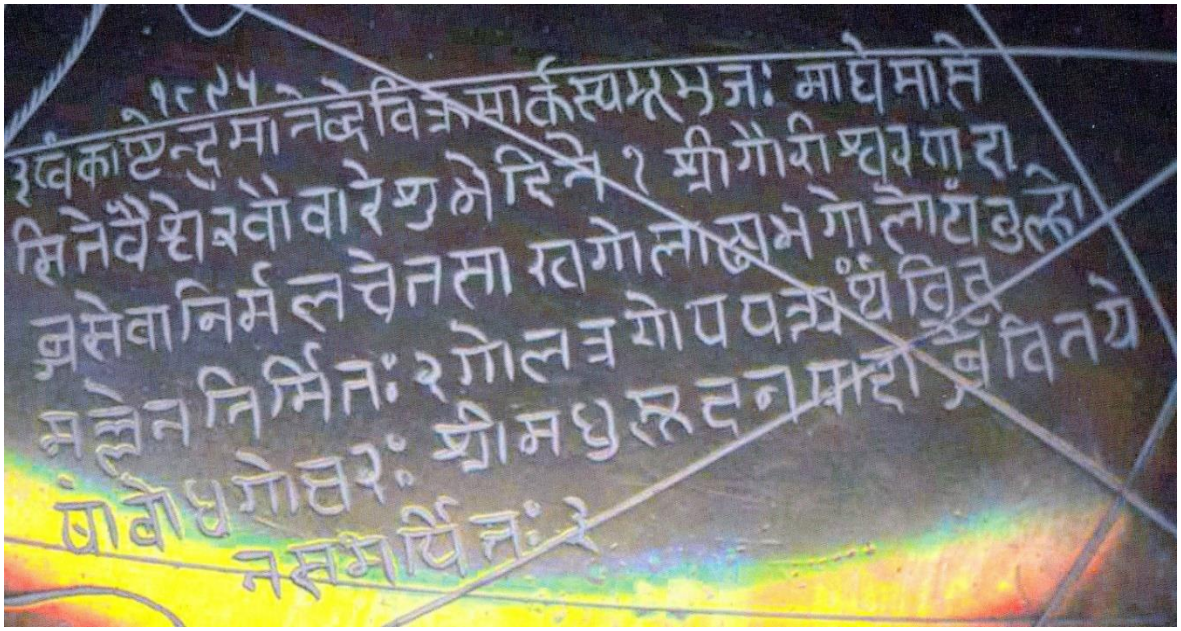


Figure H003.15 – Inscription (photo by Professor Gerard Turner)

INSCRIPTION

In the lower half of the segment of Pisces, under the tail feathers of Cetus, is engraved the following inscription in six lines, consisting of three verses in *Anuṣṭubh* metre:

iṣvaṅkāṣṭendu-māne 1895 'bde vikramārkasya bhūbhujaḥ |
māghe māse site vaiśve ravau vāre śubhe tithau ||1||
śrīgaurīśvara-pādābja-sevā-nirmalacetasā |
khagolāḍhya-bhagolo 'yam vulhomallena nirmitaḥ ||2||
golatrayopapattyartham viduṣām bodhagocaraḥ |
śrī-madhusūdana-pādābje vinayena samarpittaḥ ||3||

'In the year 1895 of king Vikrama, in the bright [half] of the month Māgha, on Sunday, the auspicious lunar day *vaiśva*, this celestial globe (*bhagola*) inclusive of sphere of the sky (*khagola-āḍhya*) was constructed by Bulhomal (*vulhomalla*) whose mind is cleansed of all impurities owing to [his] worship of the lotus feet of the glorious Pārvatī and Śiva, for the demonstration of three kinds of spheres (*gola-traya-upapatti-artham*)[1282]; [this globe which

[1282] The three kinds of spheres are the *bha-gola* (the sphere of the fixed stars), *kha-gola* (the sphere of the sky) and *graha-gola* (the sphere of the planets).

is] intelligible to the learned (*viduṣāṃ bodha-gocaraḥ*), is dedicated with humility to the lotus feet of the glorious Madhusūdana.'

In the date, the number of the lunar day is expressed by the term *vaiśva,* 'related to *viśva*'. In the *Bhutasaṃkhyā* system, *viśva* stands for 14. The 14th lunar day in the bright half of the month of Māgha in the year VS 1895 corresponds to 29 January 1839, but this is a Tuesday. On the other hand, the bright half in this month commences on 16 January and goes on up to 30 Wednesday. During this period, Sunday falls on 20 and 27. Therefore, the intended date appears to be 20 or 27 January 1839. Nothing is known about Madhusūdana; perhaps he was a teacher of Bulhomal.

PROVENANCE

The globe was in a private collection in Milan in 2005 when Professor G. L'E. Turner sent me the photos. I understand that subsequently the collection was acquired by the Ahuan Gallery of Islamic Art, London; it is not known whether the globe is still with this Gallery.

BIBLIOGRAPHY

Sarma 1999b
Sarma 2010
Sarma 2012d
Sarma 2015b, no. 17, pp. 275-277.

H004 SANSKRIT CELESTIAL GLOBE, ATTRIBUTABLE TO LĀLAH BULHOMAL LĀHORĪ

Not dated; mid-19th Century

Diameter 205 mm

New York, Columbia University, Butler Library, D. E. Smith Collection (# 27-244)

ESS 54



Figure H004.1 – Globe with stand (courtesy Butler Library, Columbia University)

This globe is not signed, nor dated, but its similarity to the Indo-Persian globes G008 - G015 is so striking that there cannot be any doubt about its being made by Lālah Bulhomal Lāhorī in the middle of the nineteenth century. However, the Devanagari script in which the names of the constellations are engraved shows slight influence of Gurmukhi script; probably these were engraved, not by Bulhomal, but by an assistant who was more at home with Gurmukhi script.

The globe is cast as a single hollow sphere by lost wax method; two large circular plugs are visible, one in the constellation of Ursa Major in the northern hemisphere and the other in the houses of Aquarius and Pisces in the southern hemisphere.

Circles

The equator and the ecliptic are divided in 1° and 6°; the equator is numbered from 6 to 360 continuously from the vernal equinox; the ecliptic from 6 to 30, separately in each zodiac sign. The names of the zodiac signs are engraved along the ecliptic. Six great circles are drawn perpendicular to the ecliptic at intervals of 30°. Also six meridians, i.e. great circles perpendicular to equator, are drawn; however, these do not commence at the vernal equinox, but 6° westwards, as in the Indo-Persian globes signed by Bulhomal or attributable to him (G006 - G012). Equatorial tropics, circles at 12° and 20°, and polar circles are drawn on either side of the equator. The north and south celestial poles are labelled respectively as *uttara-dhruva* and *dakṣiṇa-dhruva.*

Constellation Figures and Stands

The full set of 48 classical constellation figures are drawn and the position of about 1020 stars are marked with inlaid silver pins. Figure H004.2 shows the constellation figure of Ursa Major followed by Bootes. It is amusing that the figure of the bear is filled with thick oblique stripes and the tunic of Bootes is also patterned with matching oblique stripes. The Sanskrit names of the constellations are engraved next to the figures followed by their serial numbers. The stars in each constellation are numbered serially, but no star names are engraved.



Figure H004.2 – Another view of globe showing Ursa Major and Bootes
(© Butler Library, Columbia University)

STAND

The highly ornate horizon ring is made up of two rings welded together. The outer edge of each ring is decorated by a floral motif. In the lower ring, notches are made into which the tops of the three legs are inserted and tightened by winged bolts. The legs are curved like the Roman letter *S* and decorated on the outer surface by a leaf pattern; they rest on high 'knopped' feet. To the underside of the horizon ring is attached, at its east and west points, a semi-circular arc with an ornate crest at its centre to support the meridian ring.

Notches are made in the horizon ring at the four cardinal points. Those at the east and west points are for the zenith ring which is now missing; the meridian ring passes through the notches at the north and south points. The horizon ring is divided in 1° and 6° and numbered from 6 to 90, separately in each quadrant; these numbers commence from east and west points and end at the north and south points.

As in globes nos. F008, G010 and G011, the thickness in one half of the meridian ring is reduced in order to permit a small sleeve of 6° width to slide on this half. The sleeve is graduated in single degrees. An arc of 90° is to be attached to this sleeve for

measuring altitudes, but it is missing now. The outer edge of the meridian ring is divided in 1° and 6° and numbered from 6 to 90, separately in each quadrant; the numbers commence from the poles and end at points opposite the celestial equator engraved on the globe.

Provenance

This globe is from the personal collection of David Eugene Smith, the author of the well known *History of Mathematics.* Smith collected a large number of manuscripts and scientific instruments belonging to different cultures and ages, and reproduced images of many of these in his book. A fine image of the present globe is reproduced in on p. 365 in volume 2 (and also on the covers of the both the volumes). The caption on p. 365 reads as follows: 'Hindu Celestial Sphere. This piece is of bronze, the stars being inlaid in silver. It was made *c.* 1600 [sic!]. From the author's collection.'

Sanskrit Names of Constellation Figures

The Sanskrit names of the constellation figures engraved on the previous globe (H003) and on the present one are listed in the table below, omitting the serial numbers. It will be seen that the two globes accept broadly the new nomenclature introduced by Nandarāma on H002 and in his *Yantrasāra.* Generally Cetus is called *Samudra-pakṣī.* Here this name is given also to Delphinus.

Table H004-1 Sanskrit Name on H003 and H004

	Modern name	Arabic name	Sanskrit Name on H003	Sanskrit Name on H004
1	Ursa Minor	*Dubb al-Aṣghar*	*Laghu-bhalluka*	*Laghu-bhallūkaḥ*
2	Ursa Major	*Dubb al-Akbar*	*Bṛha[d]-bhallūka*	*Vṛhat-bhallūkaḥ*
3	Draco	*al-Tinnīn*	*Ajagara*	*Ajagara-mūrtiḥ*
4	Cepheus	*Qīqā'us*	*Jvālākṣpa[ka]-rudra-gaṇa*	*Jvāla-kṣepaka-ganā-mūrti*
5	Bootes	*al-ᶜAwwā'*	*Dharmi-jana*	*Dharmma-jaṇa-āhū-praramā* (sic! *Dharmi-jana-āhūyamāna*)

	Modern name	Arabic name	Sanskrit Name on H003	Sanskrit Name on H004
6	Corona Borealis	*al-Fakkah*	*Mātṛkā-maṇḍala*	*Pātrakamaṇḍala* (sic! *Matṛkā-maṇḍala*)
7	Hercules	*al-Jathī*	*Jānūpaviṣṭa*	*Jānūpaviṣṭa*
8	Lyra	*al-Shulyāq*	*Pānapātra*	*Pānapātra*
9	Cygnus	*al-Dajājah*		*Kuk[k]uṭa-mūrti*
10	Cassiopeia	*Dhāt al-Kursī*	*Pīṭhāsanastha*	*Pīṭhāhā manuṣya mūrti* (sic! *Pīṭhāsanastha-manuṣya-mūrti*)
11	Perseus	*Barsā'ūs*	*Pretaśirogrāhī*	*Pretaśirogrāhaka -mūrti*
12	Auriga	*Mumsik al-Aᶜinnah*	*Vallahaka* (?)	*Balā-hasta-prama-mūrti* (?)
13	Ophiuchus	*al-Ḥawwā*	*Sarpa-dhārī*	*Sarpadhārī-puruṣa-mūrti*
14	Serpens	*Ḥayyat al-Ḥawwā*	*Sarpa*	*Sarpa-mūrti*
15	Sagitta	*al-Sahm*		*Bāṇa-mūrti*
16	Aquila	*ᶜUqāb*		
17	Delphinus	*al-Dulfīn*	*Samudra-pakṣī*	*Samudra pali mūrti* (sic! *samudra-pakṣī-mūrtiḥ*)
18	Equulus	*Qitᶜat al-Faras*		
19	Pegasus	*Faras Aᶜzam*	*Bṛhad-aśva* (great horse)	*Aśvamukha* (mouth of the horse)
20	Andromeda	*al-Marʻah al-Musalsalah*	*Śṛṃkhalā-dhara*	*Śṛṃkhalā para ? puruṣa-mū[rti]* (sic! *Śṛṅkhala-dhara-puruṣa-mūrti*)

	Modern name	Arabic name	Sanskrit Name on H003	Sanskrit Name on H004
21	Triangulum	*al-Muthallah*	*Tryasra*	*Tryasra-mūrti*
22	Aries	*al-Ḥamal*		*Meṣaḥ*
23	Taurus	*al-Thawr*		*Vṛṣaḥ*
24	Gemini	*al-Jawjā'*		*Mithunaḥ*
25	Cancer	*al-Saraṭān*		*Kulīraḥ*
26	Leo	*al-Asad*		*Siṃhaḥ*
27	Virgo	*al-Sunbulah*		*Kanyā*
28	Libra	*al-Mīzān*		*Tulā*
29	Scorpio	*al-ᶜAqrab*		*Vṛścika*
30	Sagittarius	*al-Qaws*		*Dhanuḥ*
31	Capricorn	*al-Jadī*		*Makaraḥ*
32	Aquarius	*al-Dalw*		*Kumbhaḥ*
33	Pisces	*al-Ḥūt*		*Mīnaḥ*
34	Cetus	*al-Qayṭus*		*Samudra-pakṣī-mū[rtiḥ]*
35	Orion	*al-Jabbār*		*Gadādhārī-puruṣa*
36	Eridanus	*al-Nahr*		*Kulyā-mūrti*
37	Lepus	*al-Arnab*		*Śaśa-mūrti*
38	Canis Major	*Kalb al-Akbar*		*Vṛhat-śvāna-mūrtiḥ*
39	Canis Minor	*Kalb al-As ghar*		*Laghu-svāna-mūrti*
40	Argo Navis	*al-Safīnah*		*Naukā-mūrti*
41	Hydra	*al-Shujāᶜ*		*Sarpa-mūrti*

	Modern name	Arabic name	Sanskrit Name on H003	Sanskrit Name on H004
42	Crater	*al-Bāṭiyah*		*Sabhā-pāna-mūrti* (sic! *Sudhā-pāna-mūrtiḥ*)
43	Corvus	*al-Ghurāb*		*Kāka-mūrti*
44	Centaurus	*al-Qanṭūrus*		*Kinnara-sakinnara-mūrti* (sic! *Kinnara-mūrtiḥ*)
45	Lupus	*al-Sabᶜ*		*Vṛka-mūrti*
46	Ara	*al-Mijmarah*		*Āviṣa-kaṭī-mūrti* (?)
47	Corona Australis	*Iklīl janūbī*		*Mukuṭa-mūrti*
48	Piscis Austrinus	*Ḥūt janūbī*		*Dakṣiṇa-matsya-mūrti*

Bibliography

David Eugene Smith, *History of Mathematics,* Dover edition, undated reprint of the 1958 edition.

Savage-Smith 1985, no. 54, p. 245, fig. 25 on p. 54.

Savage-Smith 1992a, p. 49, Fig. 2.31.

Sarma 2015b, no. 18, pp. 277-278.

H005 SANSKRIT CELESTIAL GLOBE, NOT SIGNED, NOT DATED[1283]

19th century

Diameter 210 mm

PLU; ex-Skinner, Bolton, MA



Figure H005.1 – Globe with the meridian ring (courtesy Professor David Pingree)

This large celestial globe appears to have been cast as a single hollow sphere; it was produced in Rajasthan

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[1283] Entry based on a photo and the notes kindly provided by Professor David Pingree who read the globe for the auction house of Skinner.

CIRCLES

The equator and the ecliptic are represented by double bands. One band of the equator is blank and the other is divided in 6° and these divisions are numbered serially from 1 to 60 anticlockwise. In the ecliptic, one band is divided unevenly in 1°; in the other band, intervals of 6° are numbered from 6 to 30 anticlockwise, separately in each zodiac sign. Six great circles are perpendicular to the ecliptic in intervals of 30°. Very unusually, meridian circles are drawn perpendicular to the equator at intervals of 6°. Polar circles of the equator are drawn, but not the tropics.

The equator is named *nāḍī-valaya* (lit. circle of *nāḍīs* or *ghaṭikās*) and ecliptic *rāśī-valaya* (lit. circle of zodiac signs). The names of the zodiac signs are engraved along the ecliptic: *Meṣa* (Aries), *Vṛṣa* (Taurus), *Mithuna* (Gemini) , *Karka* (Cancer), *Siṃha* (Leo), *Kanyā* (Virgo), *Tulā* (Libra), *Vṛścika* (Scorpio), *Dhana* (sic! *Dhanuḥ*, Sagittarius), *Makara* (Capricorn), *Kuṃbha* (Aquarius), *Mīna* (Pisces). The celestial poles are named *Uttara-dhruva* (North Pole) and *Dakṣiṇa-dhruva* (South Pole). The ecliptic latitude circles are named *kadamba-vṛtta* (circle passing through the poles of the ecliptic)

STARS

The positions of 55 major stars are marked with small circles and the star names are engraved next to them; these include the junction stars of all the *nakṣatras* or lunar mansions, except the very last one. The stars are arranged below according to their location in different zodiac houses, in each house from north to south. The serial numbers of the lunar mansions are enclosed in parentheses after their names.

Table H005-1 Star Names on the Globe

	Star Name in Sanskrit	Star Name in Arabic	Identification
	Aries		
1	*Aśvanābhi*	*Surrat al-Faras*	δ Pegasi = α Andromedae
2	*Uttarā Bhādrapadā* (27)	*Janāḥ al-Faras*	γ Pegasi
3	*Matsyodara*	*Baṭn al-Ḥūt*	β Andromedae

	Star Name in Sanskrit	Star Name in Arabic	Identification
4	*Aśvinī* (1)		β Arietis
5	*Nadyantaka*	*Ākhir al-Nahr*	θ Eridani
	Taurus		
6	*Raṃjitakara*	*Kaff al-Khaḍīb*	β Cassiopeiae
7	*Matsyodarapāda*	*Rijl al-Musalsalah*	γ Andromedae
8	*Pretaśira*	*Rās al-Ghūl*	β Persei
9	*Bharaṇī* (2)		41 Arietis
10	*Kṛttikā* (3)		η Tauri
	Gemini		
11	*Brahmahṛdaya*	*ᶜAyyūq*	α Aurigae
12	*Prajāpati*		δ Aurigae
13	*Rohiṇī* (4)	*ᶜAyn al-Thawr / Dabarān*	α Tauri
14	*Mi[thuna-] vāma-hasta*	*Yad al-Jawzā' al-Yusrā*	γ Orionis
15	*Mrgaśira* (5)		λ Orionis
16	*Ārdrā* (6)	*Yad al-Jawzā' al-Yumnā*	α Orionis
17	*Mi[thuna-] vā[ma-] pāda*	*Rijl al-Jawzā' al-Yusrā*	β Orionis
18	*Mi[thuna-] da[kṣiṇa-] pāda*	*Rijl al-Jawzā' al-Yumnā*	κ Orionis
	Cancer		
19	*Punarvasu* (7)	*Rās al-Taw'am al-Mu'akhkhar*	β Geminorum

	Star Name in Sanskrit	Star Name in Arabic	Identification
20	*Ludyakavandhu*[1284]	*Shiᶜrā Shāmī*	α Canis Minoris
21	*Lubdhaka*	*Shiᶜrā Yamānī*	α Canis Majoris
22	*Agasti*	*Suhayl*	α Carinae
	Leo		
23	*Kravimākṛti* ?		
24	*Kratu*	*Ẓahr al-Dubb al-Akbar*	α Ursae Majoris
25	*Avī* ?		
26	*Pulasya*	*Fakhdh al-Dubb Akbar*	γ Ursae Majoris
27	*Pulaha*	*Mirāq al-Dubb Akbar*	β Ursae Majoris
28	*Puṣya (*8)		δ Cancri
29	*Maghā (*10)	*Qalb al-Asad*	α Leonis
30	*Āśleṣā (*9)		ζ Cancri
31	*Mahāpuruṣa*	*Fard al-Shujāᶜ*	α Hydrae
	Virgo		
32	*Marīci*	*al-Qaid*	η Ursae Majoris
33	*Vaśiṣṭha*	*al-ᶜAnaq*	ζ Ursae Majoris
34	*Āgārā* ?		
35	*Pūrvā Phālgunī* (11)		δ Leonis
36	*Uttarā Phālgunī* (12)		β Leonis

[1284] Sic! read *Lubdhaka-bandhu.*

	Star Name in Sanskrit	Star Name in Arabic	Identification
	Libra		
37	*Svāti* (15)	*Simāk Rāmiḥ*	α Bootis
38	*Citrā* (14)	*Simāk A^{c}zal*	α Virginis
39	*Hasta* (13)		δ Corvi
	Scorpio		
40	*Anurādhā* (17)		δ Scorpii
41	*Viśākhā* (16)		α Librae
42	*Kanturasapāda*	*Rijl Qanṭūrus*	α Centauri
	Sagittarius		
43	*Sarpadhārīśira*	*Rās al-Ḥawwā*	α Ophiuchi
44	*Jyeṣṭā (*18)	*Qalb al-^{c}Aqrab*	α Scorpii
45	*Mūlā* (19)		λ Scorpii
46	*Pūrvāṣāḍhā* (20)		δ Sagittarii
	Capricorn		
47	*Abhijit* (22)	*Nasr Wāqi^{c}*	α Lyrae
48	*Śravaṇa* (23)	*Nasr Ṭā'ir*	α Aquilae
49	*Uttarāṣāḍha* (21)		σ Sagittarii
	Aquarius		
50	*Dhaniṣṭā* (24)		β Delphini
51	*Aśvamukha*	*Fam al-Faras*	ε Pegasi
52	*Mashamuṣa* ?		
	Pisces		

	Star Name in Sanskrit	Star Name in Arabic	Identification
53	*Kurkaṭapucha*[1285]	*Dhanab al-Dajājah*	α Cygni
54	*Pūrvī Bhādrapada* (26)	*Mankib al-Faras*	β Pegasi
55	*Śatabhiṣā* (25)		λ Aquarii

STAND

Of the original stand, only the meridian ring survives which is attached to the globe at its celestial poles. The ring is graduated in 1° and 6° and numbered from 6 to 90, separately in each quadrant, starting from the points of attachment and ending at points opposite the equator on the globe. At present, the globe is mounted on a modern 762 mm high mahogany stand.

BIBLIOGRAPHY

Skinner 2002, lot 224, p. 36.

[1285] Sic! read *Kukkuṭa-puccha.*

H006 SANSKRIT CELESTIAL GLOBE, NOT SIGNED, NOT DATED[1286]

19th century

Diameter ?

PLU



Figure H006.1 – Globe with stand (courtesy Museum of the History of Science, Oxford)

[1286] Entry based on two photos in the archives of the Museum of the History of Science, Oxford.

This globe shows many similarities with the previous globe, in particular the meridian circles drawn at intervals of 6°. It must have been produced in the same milieu somewhere in Rajasthan.

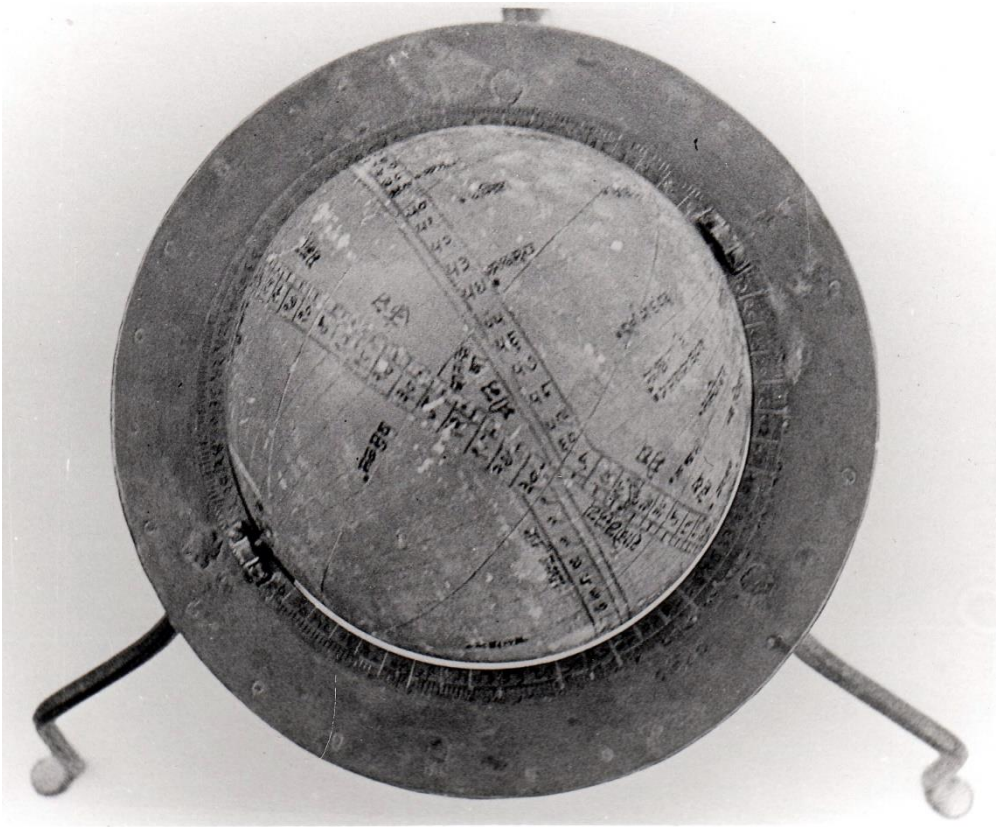


Figure H006.2 – Globe with the meridian ring
(courtesy Museum of the History of Science, Oxford)

CIRCLES

The circles drawn on this globe are exactly as on the previous globe H005. The equator and the ecliptic are represented by double bands. On band of the equator is blank and the other is divided in 6° and these divisions are numbered serially from 1 to 60 anticlockwise. In the ecliptic, one band is divided unevenly in 1°; in the other band, intervals of 6° are numbered from 6 to 30 anticlockwise, separately in each zodiac sign. Six great circles are drawn perpendicular to the ecliptic in intervals of 30°. Very unusually, meridian circles are drawn perpendicular to the equator at intervals of 6°; these are rather faint now. Polar circles of the equator are drawn, but not the tropics. The names of the zodiac signs are written in large letters along the ecliptic, which is named *Rāśīvalaya*. The north pole is named *Uttara-dhruva.*

STARS

The positions of several stars are marked with thick dots. The following names can be deciphered in the two available photos.

Table H006-1 Star Names on the Globe

	Star Name in Sanskrit	Star Name in Arabic	Identification
1	*Aśvinī*		β Arietis
2	*Bharaṇī*	Lunar mansion 2	41 Arietis
3	*Kṛttikā*	Lunar mansion 3	η Tauri
4	*Matsyodara*	*Baṭn al-Ḥūt*	β Andromedae
5	*Matsyodarapāda*	*Rijl al-Musalsalah*	γ Andromedae
6	*Pretaśira*	*Rās al-Ghūl*	β Persei
7	*Raṃjitakara*	*Kaff al-Khaḍīb*	β Cassiopeiae

STAND

The stand consists of a very wide and very thick horizon ring supported by three very long legs. There is a semi-circular arc attached to the underside of the horizon ring, but it does not support the meridian ring. Consequently, the meridian ring is not correctly in position; it lies flat on the horizon ring in the same plane. As in the previous specimen, the meridian ring is divided in 1° and 6° and numbered from 6 to 90, separately in each quadrant; the numbers commence at the points where the ring is attached to the globe and end at points opposite the equator on the globe.

I. SANSKRIT ARMILLARY SPHERES (GOLA-YANTRA)

INTRODUCTION

1. The Armillary Sphere in Greek Antiquity

The armillary sphere is an assemblage of rings (armilla) representing some great circles with the Earth as the centre and smaller circles with other centres, for graphically demonstrating the orbits and positions of celestial bodies. When the rings are graduated and equipped with sighting plates, planetary positions can also be measured. The instrument was known to the Greek antiquity. Ptolemy calls it *astrolabon* and describes its construction in his *Almagest.* His armillary sphere consists of six rings. There is a fixed meridian ring inside which the ecliptic ring and the solstitial colure are pivoted. Two latitude rings are attached, one outside the solstitial colure and the other inside it. Inside the inner ring is added another ring which is equipped with two sighting plates at diametrically opposite points.[1287]

2. The Armillary Sphere in Europe

Armillary spheres made according to Ptolemy's basic model with minor additions can be seen in nearly every museum in Europe. There exist also some large and highly ornate armillary spheres,[1288] and specimens representing the Copernican heliocentric model with the sun at the centre.

3. The Armillary Sphere in the Islamic world

The armillary sphere was known in the Islamic world as *Dhat al-Ḥalaq* (that which has rings) and followed Ptolemy's basic design, with certain changes for improving the observation. Mu'ayyad al-Dīn al-ᶜUrḍī replaced Ptolemy's sixth ring (i.e., inner latitude ring) with an alidade, arguing that the alidade is more suitable for observation, and constructed an armillary sphere with five rings at the Marāgha Observatory in 1259.[1289]

1287 Ptolemy, Book V, ch. 1, pp. 217-219, Fig. F on p. 218; see also Seemann 1929, Fig. 8 on p. 34.

1288 The largest armillary sphere in the world is the one made by Antonio Santucci between 1588 and 1593 with a diameter of *ca.* 2000 mm, height of *ca.* 3700 mm and width of *ca.* 2450 mm; this magnificent armillary sphere is on display in the Museo Galileo in Florence.

1289 Cf. Seemann 1929, pp. 33-53, esp. 46-47.

Otherwise the armillary sphere did not attract much interest in the Islamic world. The *Yantraprakāra,* attributed to Sawai Jai Singh, describes an armillary sphere with five rings and another of six rings, both under the Arabic name *Dhāt al-Ḥalaq*.[1290] In Jai Singh's Observatory at Jaipur, there exists a loose copper plaque on which is engraved *jātula halaka yaṃtra vṛtta sāt kī* (instrument named *Dhāt al-Ḥalaq,* with 7 rings) (see Figure T2). It indicates that Jai Singh's collection of portable instruments included an Indo-Persian or Arabic armillary sphere with 7 rings. But there is no trace of it now in Jai Singh's observatory. It was mentioned neither by Garrett & Guleri 1902, nor by Kaye 1918. Otherwise, no other armillary sphere with either Arabic or Persian inscriptions is known to be extant anywhere in the world.[1291] It appears in some Mughal miniatures, but these were clearly inspired by European models.[1292]

4. The Armillary Sphere in Sanskrit Astronomy[1293]

The armillary sphere is called *Gola-yantra* in Sanskrit and is quite different from Ptolemy's model. As Ôhashi remarks, the main purpose of the *Gola-yantra* is to ascertain the equatorial coordinates, while Ptolemy's armillary seeks to determine ecliptic coordinates.[1294] It is also much more elaborate than Ptolemy's armillary sphere. For example, in the *Gola-yantra* envisaged by Brahmagupta there are as many as 51 movable rings, besides several fixed rings.[1295]

Moreover, in Sanskrit texts, the *Gola-yantra* is treated in exclusive chapters, separate from those where other instruments are discussed. Thus Brahmagupta

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1290 Sarma 1986-87b, pp. 16-18 (text); pp. 54-58 (translation and commentary).

1291 The auction catalogue of Christie's, London, lot 18, p. 12, speaks of an Indo-Persian armillary sphere thus: 'An Indo-Persian brass armillary sphere, 13-inches (33 cm.) diameter, with six engraved circles, one fixed, five pivoting on the central axis, each engraved with characters, scales and divided in degrees, with central sun ball, the earth ball mounted on the outer circle on two columns, raised on a tapering pillar support and stepped base – *21in. (53.4) high.*' The fact that there is a sun ball at the centre and that the earth ball is placed on the outer circles shows that this specimen follows Copernican model and must be of recent manufacture.

1292 Ramaswamy 2014, pp. 33-34.

1293 Cf. Subbarayappa & Sarma 1985, Ch. 8. Golabandhaḥ: Armillary Sphere, pp. 74-80 (several extracts from Sanskrit texts with translation); Rai 1986, pp. 308-312; see also Das 1928, pp. 265-269; Dikshit 1981, pp. 224-225.

1294 Cf. Ôhashi 1994, p. 272.

1295 Brahmagupta, 21.69: *calavṛttāny ekapañcāśat* (of movable rings [there are] one-and-fifty).

discusses the *Gola-yantra* exclusively in the twenty-first chapter of his *Brāhmasphuṭa-siddhānta* (628) and the other instruments in the twenty-second chapter. Lalla (8th-9th centuries) devotes the fifteenth chapter of his *Śiṣyadhīvṛddhida* to the armillary sphere and the twenty-first chapter to the other instruments. Śrīpati, in his *Siddhānta-śekhara* (1139), discusses the armillary sphere in the sixteenth chapter and the other instruments in the nineteenth. Likewise, Bhāskara II, in the *Golādhyāya* of his *Siddhānta-śiromaṇi* (1150) has separate chapters for the armillary sphere and for other instruments.

The reason for this exclusive and separate treatment of the *Gola-yantra* is that this instrument is considered an essential part of the *Gola* (Spherics) which deals with a host of imaginary circles in the heavens such as the celestial equator, the ecliptic and so on, and teaches methods to determine the linear and angular distances between them. By arranging these imaginary circles as physical entities in the armillary sphere, the student can clearly grasp the purpose and function of these imaginary circles. Therefore, *gola-bandha,* i.e., putting together different rings to constitute the armillary sphere, is a primary task in understanding the *Gola.* Nṛsiṃha Daivajña, in his commentary on Bhāskara II's *Siddhānta-śiromaṇi,* observes that because the armillary sphere forms the basis of all astronomical instruments, it was mentioned first by Bhāskara.[1296]

It is for this reason that Bhāskara I, who is Brahmagupta's contemporary, discusses the construction of the armillary sphere in great detail at the beginning of his commentary on the *Gola-pāda* of the *Āryabhaṭīya.*[1297] Brahmagupta, on the other hand, defines the various circles and their mutual relationships, but does not dwell on the practical aspects of the construction, which is done by Lalla (8th-9th centuries) in his *Śiṣyadhīvṛddhida*.

Lalla arranges the various rings in three groups called *kha-gola* (sphere of the sky), *bha-gola* (sphere of the fixed stars) and *graha-gola* (sphere of the planets). Each group or assemblage of rings constitutes a separate shell or sphere and these are arranged one

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1296 Nṛsiṃha, p. 438; *sarveṣāṃ yantrāṇāṃ gola-mūlakatvāt pūrvaṃ goloddeśaḥ kṛtaḥ [bhāskareṇa].*

1297 Here Bhāskara I also describes minutely how to prepare the various rings out of wood and even mentions three types of joining the wooden rings; such detailed description of constructional methods is common in Arabic texts (e.g. al-ᶜUrḍī's description of the armillary sphere), but most unusual in Sanskrit texts. Bhāskara I's treatment is analysed and illustrated very competently by Peng Lu 2015.

inside the other at three slightly different levels on the polar axis (*dhruva-yaṣṭi*). The *kha-gola* represents the horizontal system of coordinates. It consists of six rings which stand for the prime vertical (*sama-maṇḍala*), the prime meridian (*yāmyottara-maṇḍala*), the horizon (*kṣitija-maṇḍala*), two *koṇa*-circles (two great circles, one passing through the zenith, the north-east and the south-west points, and the other through the zenith, the north-west and the south-east points), and the six o'clock circle (*un-maṇḍala*). All these rings are marked with 360 degrees.

The *bha-gola* (sphere of the fixed stars) represents the equatorial and ecliptic coordinates. It consists of the equator (*viṣuvad-vṛtta,* also called *nāḍī-vṛtta*) which is divided into 60 *ghaṭikās*, the solstitial colure, ecliptic (*apa-maṇḍala*) and six *dyu-maṇḍalas* (diurnal circles), three each on either side of the equator, corresponding to the six pairs of signs. The *graha-gola* is the sphere of the planets where diverse rings are fixed for each planet.[1298]

Bhāskara II, popularly known as Bhāskarācārya, in his *Siddhānta-śiromaṇi* of 1150, introduced a *dṛg-gola,* in addition to *bha-gola* and *kha-gola* of Lalla. Instead of having a separate *bha-gola* for each planet, Bhāskarācārya prescribes for all planets only one *bha-gola*, which consists of the ecliptic, equinoctial, diurnal circles, etc., all of which are movable. It is fixed to the polar axis so that it may move freely by moving the axis. Beyond this sphere is fixed the *kha-gola* or the celestial sphere; it consists of the prime vertical, meridian, horizon etc., which remain fixed in a given latitude. Beyond these two is the *dṛg-gola* in which the circles forming both the spheres *kha-gola* and *bha-gola* are combined. [1299] Having discussed the construction and use of the *Gola-yantra* in the *Golabandhādhikāra,* Bhāskara teaches how to determine the ascendant (*lagna*) with the help of the *Gola-yantra* at the beginning of the *Yantrādhyāya.*[1300]

[1298] Lalla, I, pp. 200-205; II, pp. 232-237; cf. Ôhashi 1994, pp. 268-269; Sarma (forthcoming).

[1299] Bhāskarācārya, *Golādhyāya, Golabandhādhikāra*; cf. Sarma (forthcoming).

[1300] Bhāskarācārya, *Golādhyāya*, *Yantrādhyāya,* 3-5*ab.*

Extant Specimens of Sanskrit Armillary Spheres

Since the time of Brahmagupta, if not earlier, teachers of astronomy must have taught their pupils how to prepare a *Gola-yantra* with strips of bamboo. None of these have survived, probably because they were made of perishable material.

Śaṅkaranārāyaṇa, in his commentary of 869 on Bhāskara I's *Laghubhāskarīya,* mentions[1301] that a large *Gola-yantra* was erected at Mahodayapura[1302] on the Kerala coast at the instance of King Ravivarman Kulaśekhara. But it is no more extant.

In his *Zīj-i Muḥammad Shāhī,* Sawai Jai Singh states that he got constructed at Delhi a '*Zatul-huluck,* in brass, in diameter three *guz* of the measure now in use.'[1303] It is not extant any more, but a small specimen with 8 rings constructed by Jai Singh's son Madho Singh is extant at Jaipur (I001).

In an article of 1834, Lancelot Wilkinson reports as follows:

> 'I take this opportunity of informing the public of the existence of a native observatory at Kotah, or rather of a valuable collection of astronomical apparatus, made by the late Mahárâo UHMAID SINGH ; and posited on the bastions of the citadel, fitted up for their reception. The apparatus consists of a very splendid and large armillary sphere ; of the celestial and terrestrial globes, dials, gnomons, and also the Ráj Yantra [sic! *Yantra-rāja*], or astrolabe, borrowed from the Musalmáns about 250 or 300 years ago. […]
>
> 'The Mahárâo's collection contains also a Turíya Yantrá, or quadrant, with a radius on one side of 30 digits, and linear rectangular intersections, rising from each digit, representing their canon of sines, cosines, and versed sines adapted to this radius.'[1304]

Wilkinson must have been told that these instruments were commissioned by Maharao Umaid Singh. This prince ruled Kota from 1771 to 1819. Some of these instruments are described by Virendra Nath Sharma; he mentions that the place where

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1301 Cf. Subbarayappa & Sarma 1985, p. 81; SarmaKV 1990, pp. 41-42.

1302 This ancient Mahodayapura is said to be identical with the modern locality Makotai, near Kodangallur (10;25° N; 76;15° E).

1303 Hunter 1799, p. 183.

1304 Wilkinson 1834, p. 515.

the instruments were originally set up for observational purposes is known as *Jantar Burj* (instruments tower).[1305] The instruments are now removed from this tower and displayed in the Rao Madho Singh Museum which was set up in the fort in 1974. In this museum, Sharma found an armillary sphere (I003), an ensemble of water clock and gong (R011) and two sundials of the type *Palabhā-yantra* (N011, N012). It is not known what happened to the celestial and terrestrial globes, to the gnomons and to the sine quadrant (*Turīya-yantra*) which were seen by Wilkinson shortly before 1834.

Besides the two armillary spheres at Jaipur and Kota, just five other specimens are known. There is one each at the Royal Scottish Museum, Edinburgh, Scotland (I002); at the Linden Museum, Stuttgart, Germany (I004); at the Maharaja's Sanskrit College, Mysore (now renamed Mysuru) (I006) and at the Sanskrit Mahavidyalaya of University Baroda (now renamed Vadodara). At the last mentioned place, it was said that a huge armillary sphere made of bamboo was set up at the top of the building. But it was not found there during my visit in October 2008. What I found was a small armillary sphere made of iron and consisting of just one sphere of rings (I007). Moreover, one armillary sphere was presented by the Maharaja of Benares to the Prince of Wales in 1876 (I005). These seven extant specimens will be described separately in the following pages.

[1305] Sharma 2000.

I001 ⊙ SANSKRIT ARMILLARY SPHERE, NOT SIGNED, NOT DATED

Second half the 18th century

Diameter 525, height 585

Jaipur, Jai Singh's Observatory



Figure I001.1 – Armillary Sphere (photo by Dr Jean-Michel Delire)

According to Garrett, this armillary sphere was made for Sawai Madho Singh (r. 1750-1767), the son of Sawai Jai Singh of Jaipur.[1306] It consists of eight brass rings, each with a rectangular cross-section, mounted on an elegant low stand with four horizontal legs.

The horizon ring is graduated in 1° and 6°; groups of 6° are numbered from 6 to 90, separately in each quadrant. Two mutually perpendicular vertical rings are attached to the horizon ring. These are also graduated and numbered in the same manner as the horizon ring. One of these is the prime vertical and other is the meridian ring. These three rings are firmly fixed. The polar axis made in the form of a slender rod passes through the celestial poles situated on the meridian ring. In the middle of the polar axis is a small ball representing the earth.

Inside the frame of the three fixed rings are pivoted the two rings representing the equator and the ecliptic; these intersect each other at an angle tantamount to the obliquity. Both the rings are graduated in 1° and 6°. On the ecliptic ring, groups of 6° are numbered in Devanagari from 6 to 30, separately for each zodiac sign and the boundaries between the signs are marked with a special symbol.

A ring representing the solstitial colure passes through the solstitial points on the ecliptic at right angles and through the celestial poles. Another ring representing the equinoctial colure is pivoted to the celestial poles. It is graduated in 1° and 6°, but carries no numbers. The names of the lunar mansions are engraved on it on both sides. The eighth ring is parallel to the prime vertical and passes through the Zenith and Nadir.

[1306] Garrett & Guleri 1902, pp. 64-65.

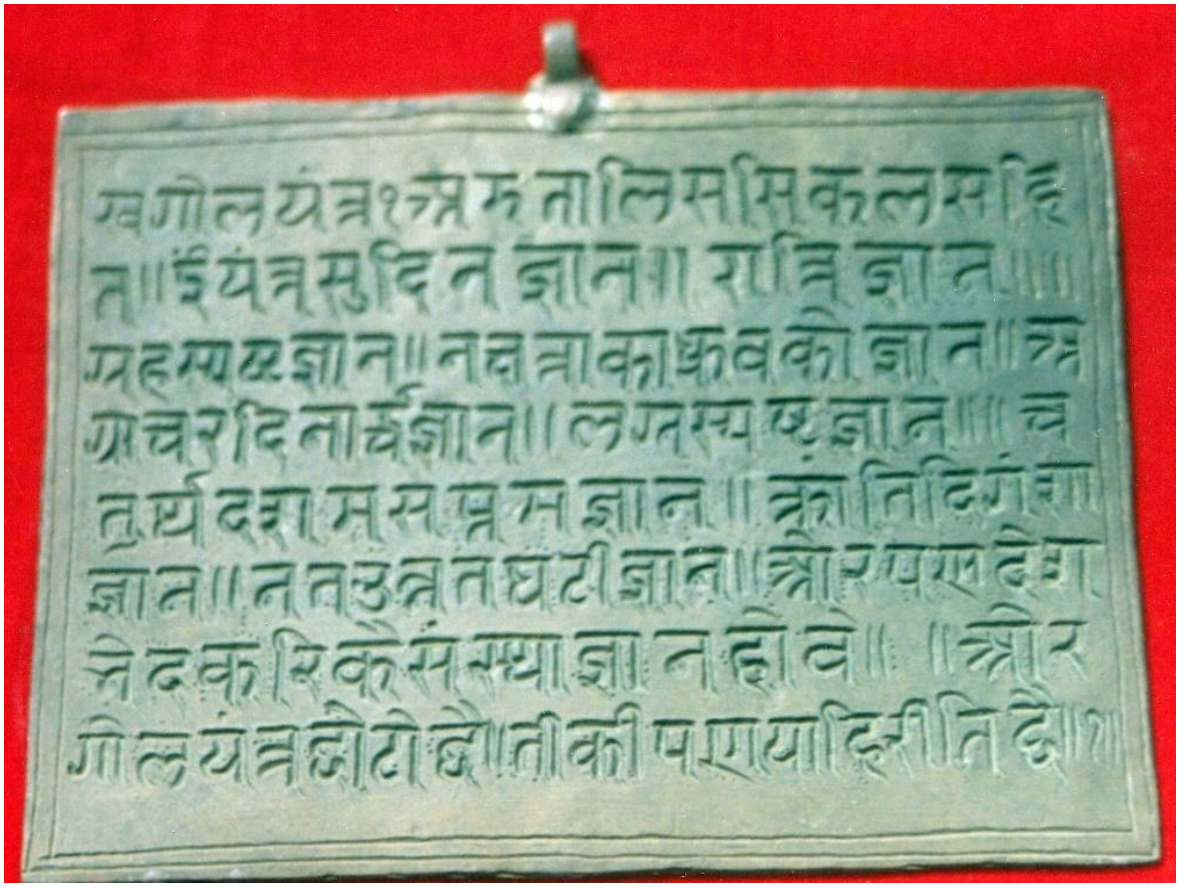


Figure I001.2 – Plaque attached to the armillary sphere (photo by S. R. Sarma)

A large copper plaque (133 x 111 mm) was prepared, apparently at the instance of Sawai Madho Singh, on which the various functions of the armillary sphere are enumerated in the local Rajasthani dialect, in eight lines, thus:

khagola yaṃtra 1 abha (?) tāli sasi kala sahi-
ta ‖ ī yaṃtra sudina jñāna ‖ rātri jñāna ‖
graha spaṣṭa jñāna ‖ nakṣatrā kā dhruva ko jñāna ‖ a-
grā cara dinārddha jñāna ‖ lagna spaṣṭa jñāna ‖ ca-
turtha daśama saptama jñāna ‖ krāṃti digaṃśa
jñāna ‖ nata unnata ghaṭī jñāna ‖ or paṇa deśa
bheda kārikai (?) saṃsthā jñāna hove ‖ or
gola yaṃtra choṭo chai | tī kī paṇayā hi rīti chai ‖1‖

‘One armillary sphere (*khagola-yantra*). Equipped with … (?). This instrument [provides] knowledge of the day [and] knowledge of the night (i.e., with this instrument time can be measured in the day and at night); knowledge of the true [longitudes of the] planets; knowledge of the polar longitudes (*dhruvaka*) of stars; knowledge of the amplitude (*agrā*),

ascensional difference (*cara*) and the half duration of daylight (*dinārdha*); knowledge of the true or accurate ascendant (*lagna spaṣṭa*); knowledge of the fourth, tenth and seventh houses of the zodiac (i.e. the points the ecliptic which are respectively on the lower meridian, on the western horizon and on the upper midheaven at the given moment); knowledge of the declination (*krānti*) and azimuth (*digaṃśa*); knowledge of the meridian distance (*nata*) and altitude (*unnata*) in terms of *ghaṭīs* (i.e., time to elapse up to midday and the time that has elapsed since sunrise); and again the longitudinal difference (*deśa bheda*) … (?). [This is] the small armillary sphere. … (?).

There are some obscure expressions in the first, seventh and eighth lines.

I002 SANSKRIT ARMILLARY SPHERE, NOT SIGNED, NOT DATED[1307]

Early 19th century

Diameter 1200 mm

Kota, Rajasthan, Rao Madho Singh Museum



Figure I002.1 – Armillary sphere (photo by Dr Alexander Walland)

Lancelot Wilkinson states that this 'splendid and large armillary sphere' was commissioned by Maharao Umaid Singh.[1308] This prince ruled Kota from 1771 to 1819; therefore, this armillary sphere must have been made in the early nineteenth century. It was originally set up with its axis pointing towards the north celestial pole, along with several other astronomical instruments, on the top of a tower called *Jantar Buruj* (instruments' tower) which was used as a kind of observatory. In 1974, this and other instruments were removed from the top of the tower and placed inside the museum set up in that year inside the fort.

1307 Entry based on the description in Sharma 2000 and the photo kindly provided by Dr Alexander Walland.

1308 Wilkinson 1834, p. 515.

The instrument consists of three shells, arranged one inside the other, at three slightly different levels on the polar axis, as prescribed by Lalla. The shaft which constitutes the polar axis is 1750 mm long with diameter of 45 mm. The three shells have the diameters of roughly 1200 mm, 1110 mm and 995 mm respectively. The brass rings have a square cross-section of 7.5 mm to 10 mm on the side and are graduated in 1°. Some of the rings are engraved with labels in Devanagari.

BIBLIOGRAPHY

Wilkinson 1834, p. 515.
Sharma 2000.

I003 ⊙ SANSKRIT ARMILLARY SPHERE, NOT SIGNED, NOT DATED

19th century

Diameter 998 mm

Edinburgh, Royal Scottish Museum



Figure I003.1 – Armillary Sphere (photo by S. R. Sarma)

This armillary sphere was acquired by the Royal Scottish Museum in 1988 in an auction at Christie's of London. The photo in the auction catalogue (Figure I003.5)

shows just an assemblage of rings without a shaft. Apparently, the Royal Scottish Museum added a stainless steel shaft through the two ecliptic poles, mounted the sphere on an aluminium frame and enclosed the whole ensemble inside a glass case.

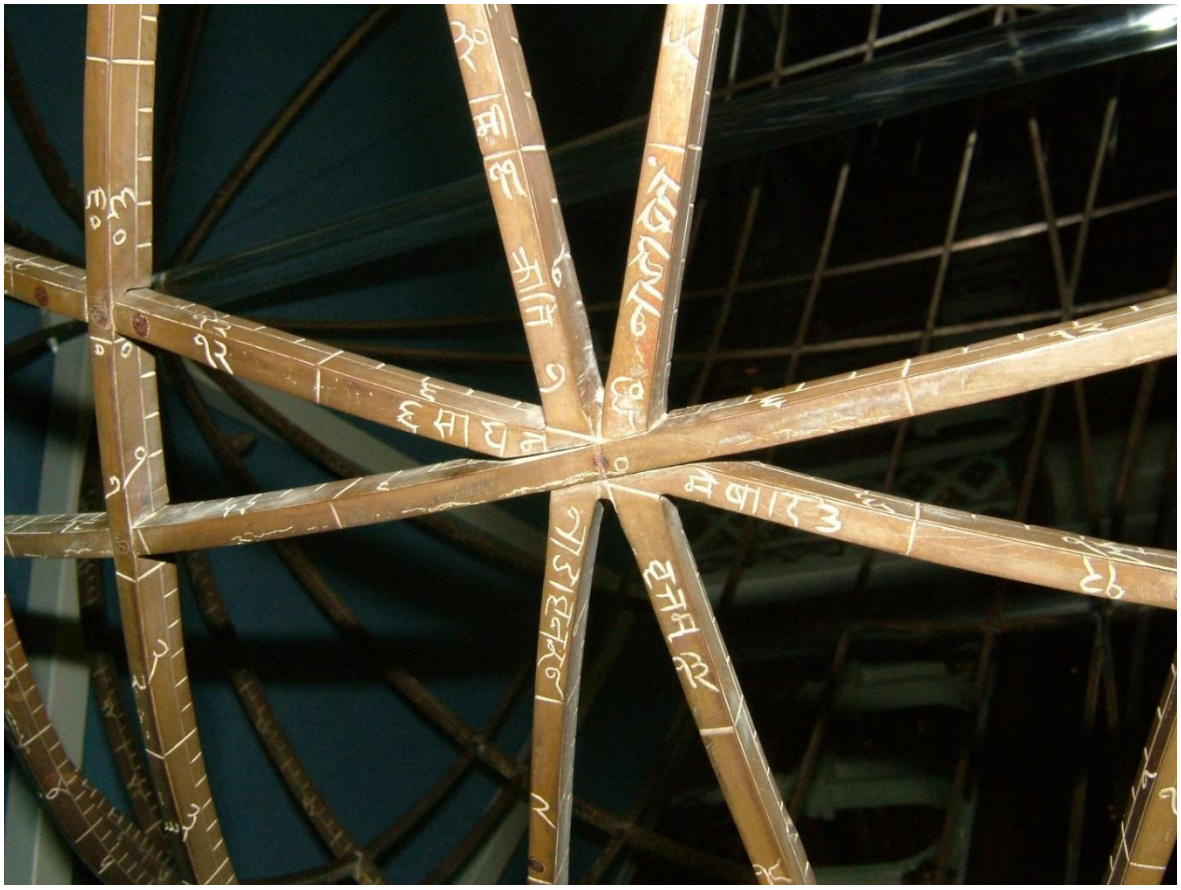


Figure I003.2 – Intersection at the vernal equinox of the equator (*nāḍī-vṛttam*), ecliptic (*krānti-vṛttam*), the equinoctial colure perpendicular to the equator and an ecliptic latitude circle perpendicular to the ecliptic (courtesy Royal Scottish Museum, Edinburgh)

The sphere is composed of about twenty brass rings, all divided in 1° and numbered in 6s, and arranged inside the meridian ring which is divided in 1° and numbered from 6 to 90, separately in each quadrant. Besides the equator, ecliptic and the tropics, there are twelve ecliptic latitude measuring rings which intersect the ecliptic ring at right angles at intervals of 30° and converge at the ecliptic poles.

The positions of the 28 lunar mansions (*nakṣatra*) and some other fixed stars are marked by leaf-shaped pointers attached to the rings. In the photos provided by the Museum, I could decipher the names of 17 lunar mansions and 2 other stars, which are listed in the table below. The remaining star pointers are broken and lost.



Figure I003.3 – Star Pointers of *Anūrādhā* (δ Scorpii) and *Viṣākhā* (α Librae)
(courtesy Royal Scottish Museum, Edinburgh)



Figure I003.4 – Star pointer of *Hastaḥ* (δ Corvi)
(courtesy Royal Scottish Museum, Edinburgh)

Table I003-1 Stars marked on the Armillary Sphere
The stars whose pointers are missing are omitted.

	Lunar mansions and other stars	Identification
1	*Aśvinī*	β Arietis
3	*Kṛttikā*	η Tauri
5	*Mṛgaḥ* (*Mṛgaśirā*)	λ Orionis
6	*Ārdrā*	α Orionis
7	*Punarvasu*	β Geminorum
9	*A[śleṣā]*	ζ Cancri
11	*Pū[rva-] phā[lgunī]*	δ Leonis
12	*U[ttara-] phālgunī*	β Leonis
13	*Hastaḥ*	δ Corvi
14	*Citrā*	α Virginis
16	*Viṣākhā* (sic! *Viśākhā*)	α Librae
17	*Anurādhā*	δ Scorpii
19	*Mūla*	λ Scorpii
20	*Pū[rvā]ṣā[ḍhā]*	δ Sagittarii
21	*U[ttarā]ṣā[ḍhā]*	σ Sagittarii
22	*Abhijit*	α Lyrae
23	*Śravaṇa*	α Aquilae
	Brahma-hṛdaya	α Aurigae
	Prajāpati	δ Aurigae

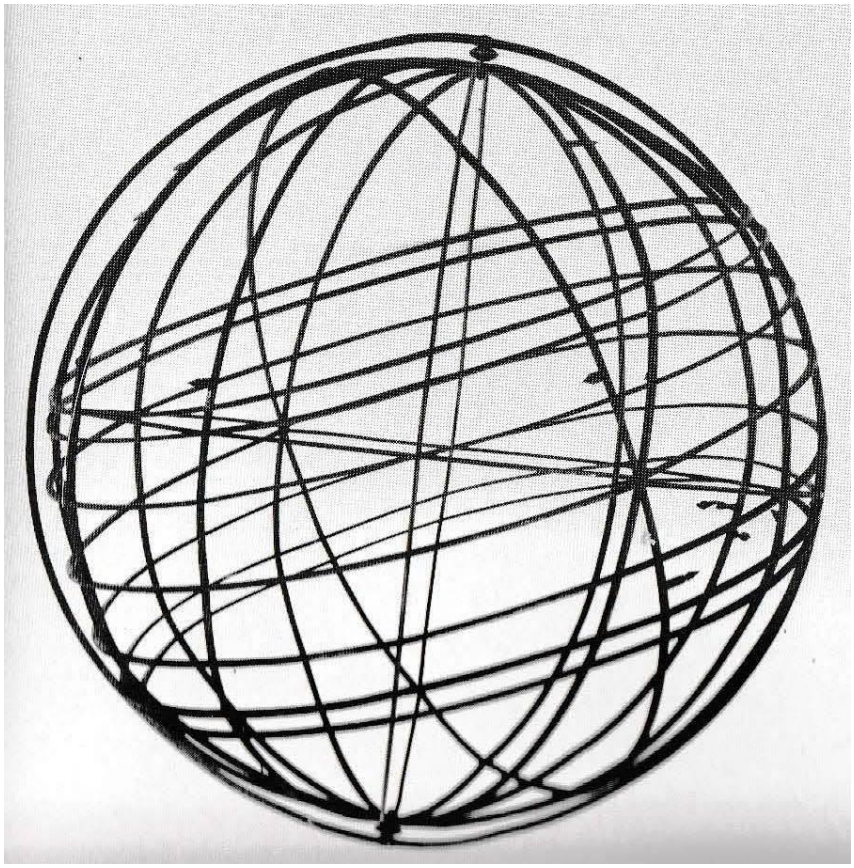


Figure I003.5 – Armillary sphere (from Christie's catalogue)

PROVENANCE

This armillary sphere was manufactured somewhere in Rajasthan; it is difficult to determine precisely where and when. It was formerly in the collection of the Time Museum, Rockford, Ill., USA. It was sold off along with many other instruments of this museum by Christie's of London, in an auction of 14 April 1988. In this auction, it was acquired by the Royal Scottish Museum, Edinburgh.

BIBLIOGRAPHY

Christie's, London, *Measuring Instruments from the Time Museum,* auction catalogue of 14 April 1988, lot 144, p. 79.

Turner 1990, no. 95, p. 76.

I004 ⊙ SANSKRIT ARMILLARY SPHERE, NOT SIGNED, NOT DATED

19th century

Diameter 570 mm

Stuttgart, Linden Museum

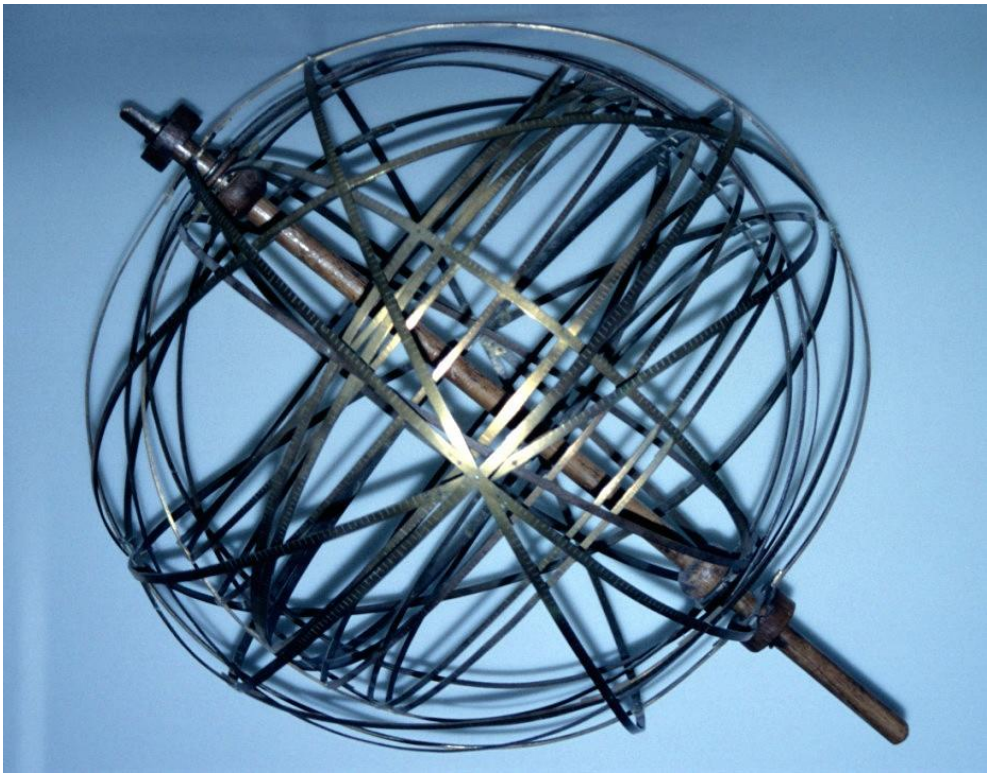


Figure I004.1 – Armillary sphere (photo by S. R. Sarma)

This armillary sphere is said to be from the collection of the Maharaja of Gwalior. In this specimen, there are two sets of rings, one inside the other, around a wooden staff 805 mm long. These two sets correspond to Lalla's *kha-gola* (sphere of the sky) and *bha-gola* (sphere of the fixed stars). The outer ring has a diameter of 570 mm and the inner ring of 506 mm. Some of the rings in shining brass appear to be quite recent, others in rusty iron are old. The brass rings are graduated in single degrees and in groups of 5° and 10°. In the outer set can be seen one ring representing the celestial equator and another the ecliptic. Two other rings are attached perpendicularly to these two. There are also several smaller rings parallel to the equator and the ecliptic.

There is no signature of the maker, nor the date of manufacture. But it was probably made in the nineteenth century.

BIBLIOGRAPHY

Sarma 2008d, pp. 7-8.

I005 SANSKRIT ARMILLARY SPHERE PRESENTED BY MAHARAJA OF BENARES TO THE PRINCE OF WALES, 1876

Dimensions ?

PLU

During his tour of India in 1875-76, the Prince of Wales (the future Edward VII) was presented a set of astronomical instruments by the Maharaja of Benares, Sir Ishwari Prasad Narayan Singh, GCSI, on 5 January 1876. An account of this tour was published by William Howard Russel in his *The Prince of Wales' Tour.* A detailed list of the presented instruments is added at the end of the book (pp. 616-617).

The list was apparently prepared by Bapu Deva Sastri, the well-known scholar of Indian astronomy who did pioneering work in interpreting Sanskrit astronomy for modern readers. He was at that time Professor of Astronomy at the Queen's College, also known as Sanskrit College of Benares.[1309] It is quite likely that the instruments were prepared under his direction. The list has the following entry on the armillary sphere presented to the Prince of Wales:

> 'The Armillary Sphere represents the following circles:--- namely, the Prime Vertical, Meridian, Horizon, Equinoctial, Ecliptic, &c., and by the threads that are fastened within the globe Hindu Astronomers determine the parts of any spherical triangle on the globe.
>
> 'The detailed account of this sphere may be found in the translation of the Siddhánta-śiromani, by Lancelot Wilkinson, Esq. ('Bibliotheca Indica,' pp. 151-176.)'

These instruments are not with any public museum in UK; they may be in some uncatalogued collection of the British royal family.

[1309] Cf. Sarma 1996c.

BIBLIOGRAPHY

William Howard Russel, *The Prince of Wales' Tour: A Diary in India; with some account of the visits of His Royal Highness to the courts of Greece, Egypt, Spain, and Portugal*, with illustrations by Sydney F. Hall, M.A., Artist in the Suite of H.R.H. The Prince of Wales, second edition, Sampson Low, Marston, Searle & Rivington, London 1877 pp. 389-91; 616-17.
https://archive.org/details/princeofwalestou00russuoft
[also https://goo.gl/V8sHM3, last accessed in June 2017].

Sarma 1996c.

Sarma 2014b.

I006 SANSKRIT ARMILLARY SPHERE DESIGNED BY KARUR SESHACHARIAR[1310]

20th Century

Diameter ?

Mysuru, Maharaja's Sanskrit College

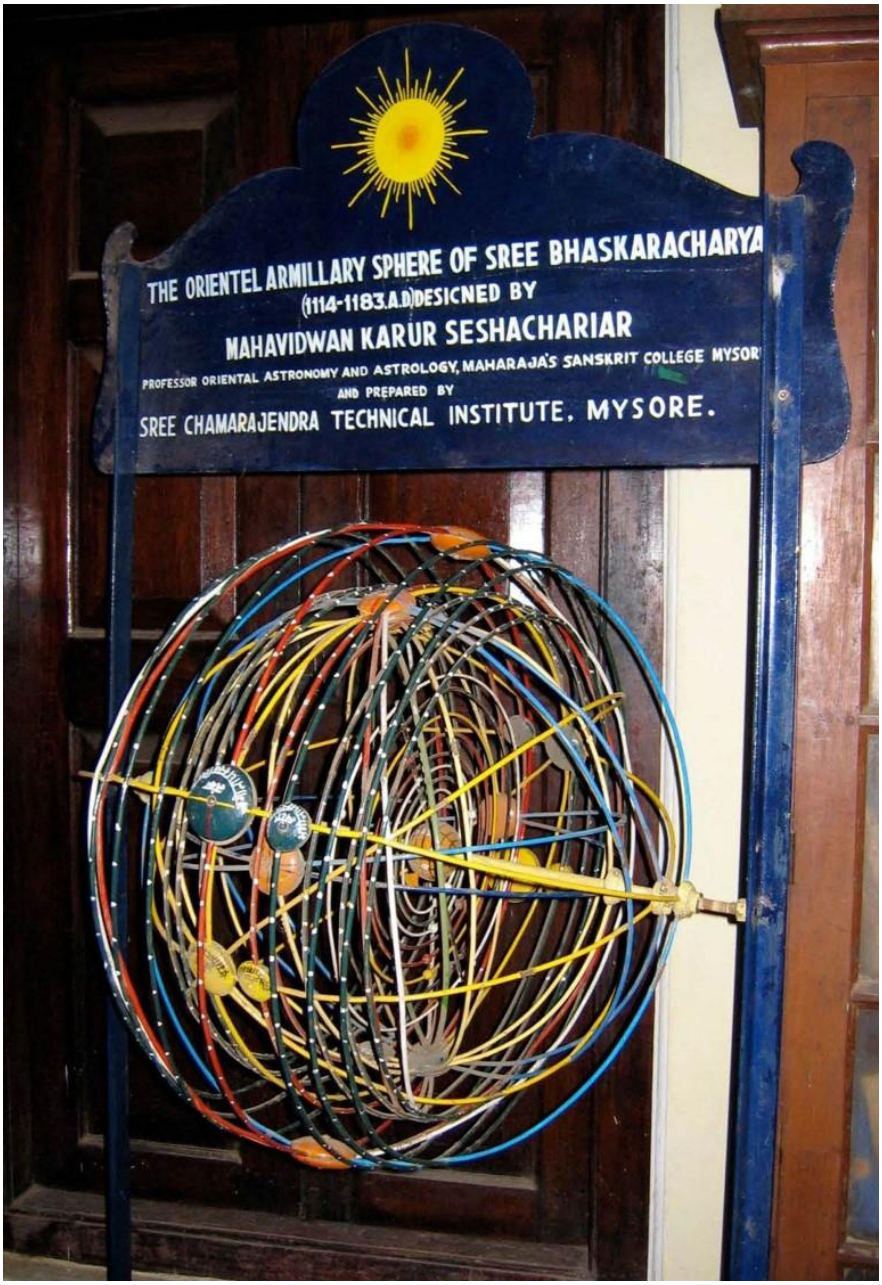


Figure I006.1 – Armillary sphere (photo by Dr James McHugh)

[1310] Entry based on the photo kindly provided by Dr James McHugh.

This large and complex armillary sphere was prepared according to the prescriptions given by Bhāskarācārya in his *Siddhānta-śiromaṇi* of 1150 (see the Introduction). The specimen was designed by Mahāvidvān Karur Seshachariar, Professor of Oriental Astronomy and Astrology at the Maharaja's Sanskrit College, Mysuru, and was fabricated by the Sree Chamarajendra Technical Institute, Mysuru, sometime at the beginning of the twentieth century. The exact dimensions are not available.

I007 ⊙ SANSKRIT ARMILLARY SPHERE, NOT SIGNED, NOT DATED

Early 20th Century

Diameter *ca.* 334 mm

Vadodara, M. S. University of Baroda, Sanskrit Mahavidyalaya



Figure I007.1 – Armillary Sphere (photo by S. R. Sarma)

This armillary sphere was constructed in the early 20th century as a teaching aid for the students of Sanskrit astronomy (*Jyotiḥ-śāstra*) in the Sanskrit Mahavidyalaya. It consists of seven rings, each with a circumference of about 1050 mm. These constitute the various great circles of the armillary sphere, such as the celestial equator, the ecliptic, the equinoctial colure placed perpendicular to the celestial equator and passing through the celestial poles and the ecliptic latitude circle at right angles to the ecliptic

and passing through the equinoxes. The intersection of these four rings can be seen in the centre of the Figure. The fifth ring is the solstitial colure, passing through the two solstitial points on the ecliptic and through the celestial poles. The last two rings also pass through the solstitial points on the ecliptic.

On each of the rings, two scales are engraved on one of the edges. The outer scale is divided into single degrees of arc and the inner scale into groups of 6°, but not labelled. The seven rings are mounted on a shaft of about 500 mm, which is the polar axis joining the two celestial poles. In the middle of the axis, there is a large globe representing the earth. At the North Pole of the earth globe, there is a small tube and a screw with which the globe is fixed tightly to the shaft.

This armillary sphere must have been originally mounted on a stand, but this stand is now missing. The rings have become somewhat rusty.

J. INDO-PERSIAN QUADRANTS

INTRODUCTION

The quadrant is made in the form of a quarter circle. Its arc is graduated in degrees and marked from 1 to 90. One of the radial edges is equipped with two sights. An index or plumb line is suspended from the apex of the right angle and functions as the vertical reference for the measurements. When the sun or a star is viewed through the sights, the index shows on the arc the angle of elevation or the altitude of the heavenly body. The quadrant is known since the time of Ptolemy in the second century AD.[1311]

From this plain quadrant, also known as the geometrical quadrant, two important varieties were developed in the Islamic world in the ninth century; these are the sine quadrant (Arabic *rubᶜ al-mujayyab*) for solving trigonometric problems and the horary quadrant (Arabic *rubᶜ al-sāᶜāt*) for determining the time from the sun's altitude . The earliest Arabic text dealing with these two varieties was published recently by François Charette and Petra G. Schmidl who attribute it to the famous Muḥammad ibn Mūsā al-Khwārizmī (ca. 825). [1312]

In the sine quadrant, radial sides are divided sexagesimally, and from the points of these divisions, half chords are drawn up to the arc, thus producing a grid or graph of sines and cosines of the angles marked on the arc. With such a grid, the angles measured on the arc can be directly converted into the corresponding sines and cosines. Aside from measuring the altitude of heavenly bodies, many trigonometric problems can be graphically solved with this sine quadrant.

There are two varieties of horary quadrants; those which measure time in seasonal hours and those which measure in equal hours. While the former can be used at any latitude and is often incorporated on the back of astrolabes, the latter can be used only at the latitude for which it is designed. The former is the universal horary quadrant (*rubᶜ*

[1311] Ptolemy, Book I, ch. 12, p. 61, Fig. D. Ptolemy's quadrant was drawn on a wall erected in the north-south direction and could be used to observe the heavenly bodies only when they are transiting the meridian. From this mural quadrant developed the portable quadrants engraved on wood or metal. Jai Singh erected mural quadrants in his observatories. See also King 1994.

[1312] Charette & Schmidl 2004, pp. 154-155; 179-181.

āfāqī); it consists of hour curves radiating from the centre and touching the arc at intervals of 15° and a semi-circle representing midday.

There are two other varieties of the quadrant, viz., the universal *Shakkāzīya* quadrant used for solving problems in spherical astronomy and the astrolabe quadrant or almucantar quadrant derived from the astrolabe.[1313] But these varieties are not relevant for India as they were not produced in India.

The sine quadrant was transmitted to India along with the astrolabe from the Middle East some time in the early medieval period. In India, the sine quadrant is often incorporated on the backs of Indo-Persian as well as Sanskrit astrolabes. The universal horary quadrant, on the other hand, is occasionally included on the back of the Indo-Persian astrolabes[1314], but rarely on the Sanskrit astrolabes.[1315]

Because the quadrants are invariably included on the back of astrolabes, independent quadrants are rather rare. Just four independent specimens of Indo-Persian quadrants are known to be extant; two of these (J002 and J003) are particularly valuable as they carry the names of the various elements on the sine quadrant.

[1313] Cf. King 1987b, pp. 8-10.

[1314] The astrolabes of the Lahore family carry occasionally the universal horary quadrants on the back, e.g. A042, A056, A101 and A125. Muḥammad Ṣāliḥ of Thatta, on the other hand, included the universal horary quadrant on nearly all his astrolabes (B009 - B014).

[1315] Just two Sanskrit astrolabes carry universal horary quadrants on the back, C001 of 1605 and C009 of ca. 1670, both produced in Gujarat.

J001 ⊙ SINE QUADRANT, ATTRIBUTABLE TO ḌIYĀ' AL-DĪN MUḤAMMAD

Not dated, second half of the 17th century

Radii 205 and 206 mm

London, Nasser D. Khalili Collection of Islamic Art (# SCI 31)

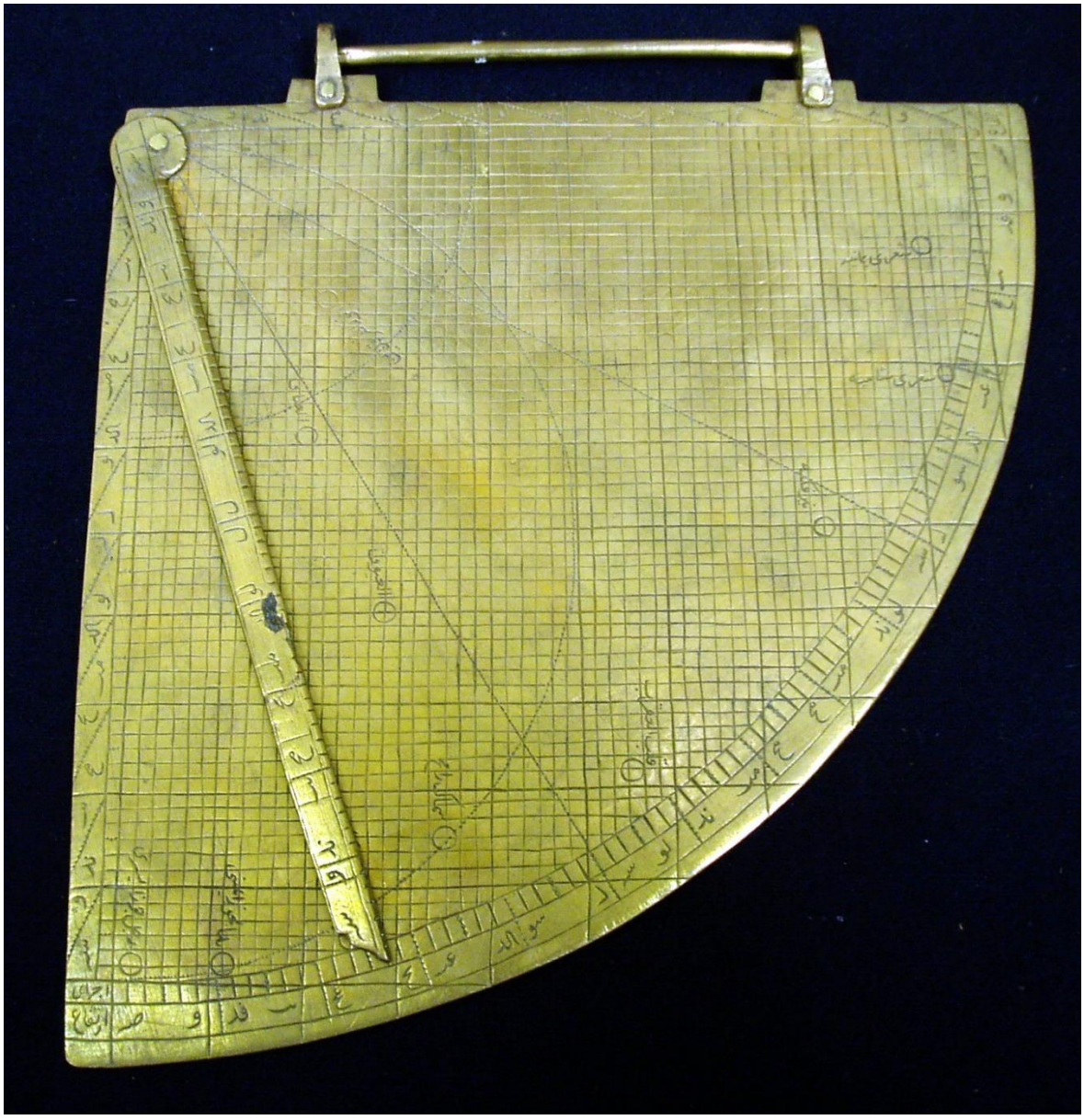


Figure J001.1 – Obverse side of the quadrant (photo by S. R. Sarma)

This well-crafted quadrant is engraved on the obverse side with a sine-cosine quadrant and the reverse side is designed like the lower right quadrant on the back of a common astrolabe, with a degree scale on the rim, followed by two cotangent scales which enclose a shadow square; the only difference is that there is no astrological or astronomical table within the shadow squares, but a geographical table with the longitudes and latitudes of 9 localities. Four of these are Indian cities, viz. Lāhūr,

Shāhjahānābād, Akbarābād and Burhānpūr. Shāhjahānābād and Akbarābād for Delhi and Agra respectively follow the Mughal usage after 1648 when Delhi was renamed Shāhjahānābād.

In the shadow squares, the scales are divided in feet (*aqdām*), in digits (*aṣābiʿ*) and also into sixty parts (*sittaynī*). The last mentioned division occurs in a astrolabe made by Muḥammad Muqīm (A030) and in three astrolabes by his nephew Ḍiyā' al-Dīn Muḥammad (A067, A072 and A092). Moreover, on several of his astrolabes (A062, A066, A071 etc.) Ḍiyā' al-Dīn designates cotangent scales of umbra recta or direct shadows on the rim as *ẓill mabsūṭ* while those on the shadow square are called *ẓill mustawī,* exactly as is done on the present quadrant. Therefore, it is highly probable that this rare quadrant was designed by Ḍiyā' al-Dīn Muḥammad in the second half of the seventeenth century.

Obverse Side

The arc is divided in 1° and 6°. Groups of 6° are numbered from 6 to 90 clockwise and anti-clockwise. Longer lines marking groups of 6° are dotted; so also the shorter lines marking each 3°.

Inside the degree scale on the arc are drawn 60 horizontal and 60 vertical parallels, with every sixth with thicker lines. These lines are numbered in 6s on the two straight sides from 6 to 60, in both directions. The numbers in one direction are separated from those in the reverse direction by dotted oblique lines. Two dotted radial lines are drawn from the apex to the arc at intervals of 30°.

Upon this grid are drawn a quarter circle of the obliquity at 23;30 and sine arcs or semicircles along both the straight sides. The positions of 11 prominent stars are marked with small circles and their names engraved next to them. These are listed in the table below.

An index with an ornate end is pivoted at the apex. Like the straight sides, it is also divided sexagesimally and numbered in 6s from 6 to 60 in both directions.

Table J001-1 Stars marked on the obverse side

	Star Name	Identification
1	*al-ᶜAyyūq*	α Aurigaeζ
2	*Rijl al-Jawzā’ Yusrā*	β Orionis
3	*Yad al-Jawza’ Yusrā*	γ Orionis
4	*Yad al-Jawzā’ al-Yumnā*	α Orionis
5	*Shiᶜrā Yamānīyah*	α Canis Majoris
6	*Shiᶜrā Shāmīyah*	α Canis Minoris
7	*Nayyir Fakkah*	α Coronae Borealis
8	*Qalb al-ᶜAqrab*	α Scorpii
9	*Anwār al-Farqadayn*	β Ursae Minoris
10	*al-ᶜAnāq*	ζ Ursae Majoris
11	*Simāk Rāmiḥ*	α Bootis

REVERSE SIDE

The reverse side of this quadrant is designed like the lower right quadrant on the back of a common astrolabe. The degree scale on the rim is divided in 1° and 6° and numbered in 6s in both directions as on the obverse. Inside the degree scale, there are two cotangent scales, one for the digits and the other for feet. The unequal divisions in the former are numbered 1, 2, 3, … 48, 54, 60, followed by the label *ẓill aṣābiᶜ mabsūṭ* (direct shadows in digits); the unequal divisions in the second cotangent scale are numbered 1, 2, 3, …60, followed by the label *ẓill aqdām mabsūṭ* (direct shadows in feet).

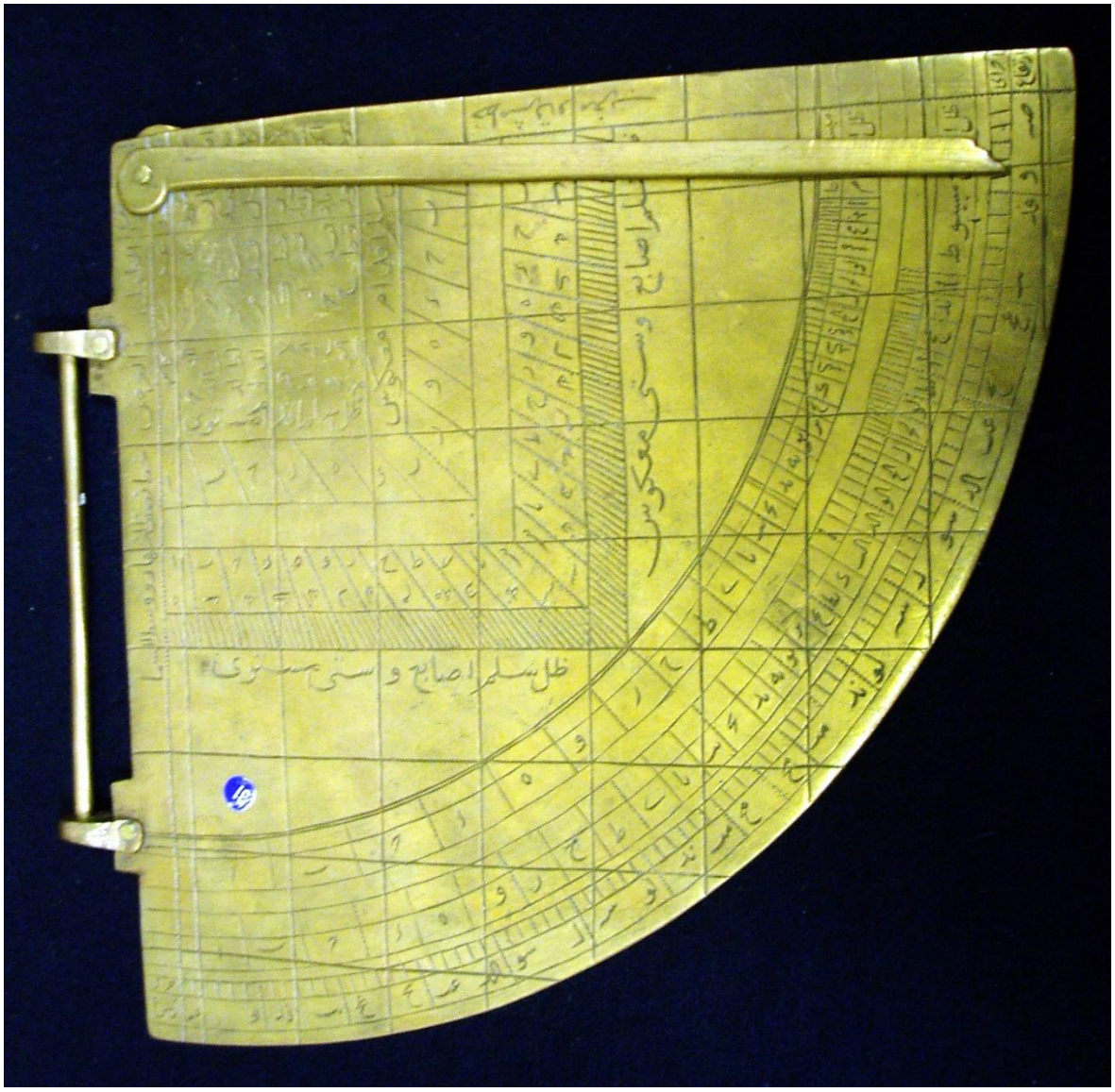


Figure J001.2 – Reverse side of the quadrant (photo by S. R. Sarma)

Inside these circular scales is a shadow square, with separate scales for the shadows cast by a gnomon of 12 digits and for the shadows cast by a gnomon of 7 feet, one inside the other. The outer scale for 12 digits is divided in 12 parts by dotted lines; each part is further subdivided in 5 units in an additional scale drawn outside. The scale of digits is numbered serially from 1 to 12 and the latter in 5s from 5 to 60. The horizontal side is labelled as *ẓill sullam aṣabi^{c} wa sittaynī mustawī* (scale of direct shadows in digits and in sixty divisions) and the vertical side *ẓill sullam aṣābi^{c} wa sittaynī ma^{c}kūs* (scale of reverse shadows in digits and in sixty divisions).



Figure J001.3 – Shadow squares on the reverse (photo by S. R. Sarma)

The inner scale of 7 feet is divided in 7 parts also by dotted lines and numbered serially from 1 to 7. Here the horizontal side is labelled as *zill sullam aqdām mustawī* (scale of direct shadows in feet) and the vertical side *ẓill sullam aqdām maʿkūs* (scale of reverse shadows in feet).

Within this scale of feet is engraved a geographical gazetteer in 3 columns and ten rows providing the names, longitudes and latitudes of 9 localities. It is reproduced in the table below.

Finally, the horizontal side of the quadrant is labelled as *khaṭṭ mashriq wa maghrib* (east west line) and the vertical side *khaṭṭ niṣf al-nahār wa wasat al-samā'* (line of midday and the line of the middle of heaven).

A plain ungraduated index is pivoted at the apex.

Table J001-2 Geographical Gazetteer engraved inside the Shadow Squares

	Place Name	L	φ
1	[Makkah]	77;10	21;40
2	Madīnah Munawwar	75;20	25;3
3	Iṣfahān	106;40	32;26
4	Samarqand	99;56	39;36
5	Kābul	84;40	34;30
6	Lāhūr	109;20	31;50
7	Shāhjahānābād	113;35	28;39
8	Akbarābād	115;3	26;3
9	Burhānpūr	109;8	20;31

PROVENANCE

The quadrant was formerly with the Time Museum, Rockford, Ill.; it was sold in an auction at Christie's, South Kensington, London, on 14 April 1988.

BIBLIOGRAPHY

Christie's, London, *Time Measuring Instruments from the Time Museum,* auction catalogue of 14 April 1988, lot 145, p. 80.

Maddison & Savage-Smith 1997, I, no.139, pp. 240-241.

J002 ⊙ SINE QUADRANT BY JAMĀL AL-DĪN MUḤAMMAD ᶜALĪ AL-ḤUSSAYNĪ, 1273 AH (AD 1856-57)

186 x 173 mm

Rampur, Rampur Raza Library

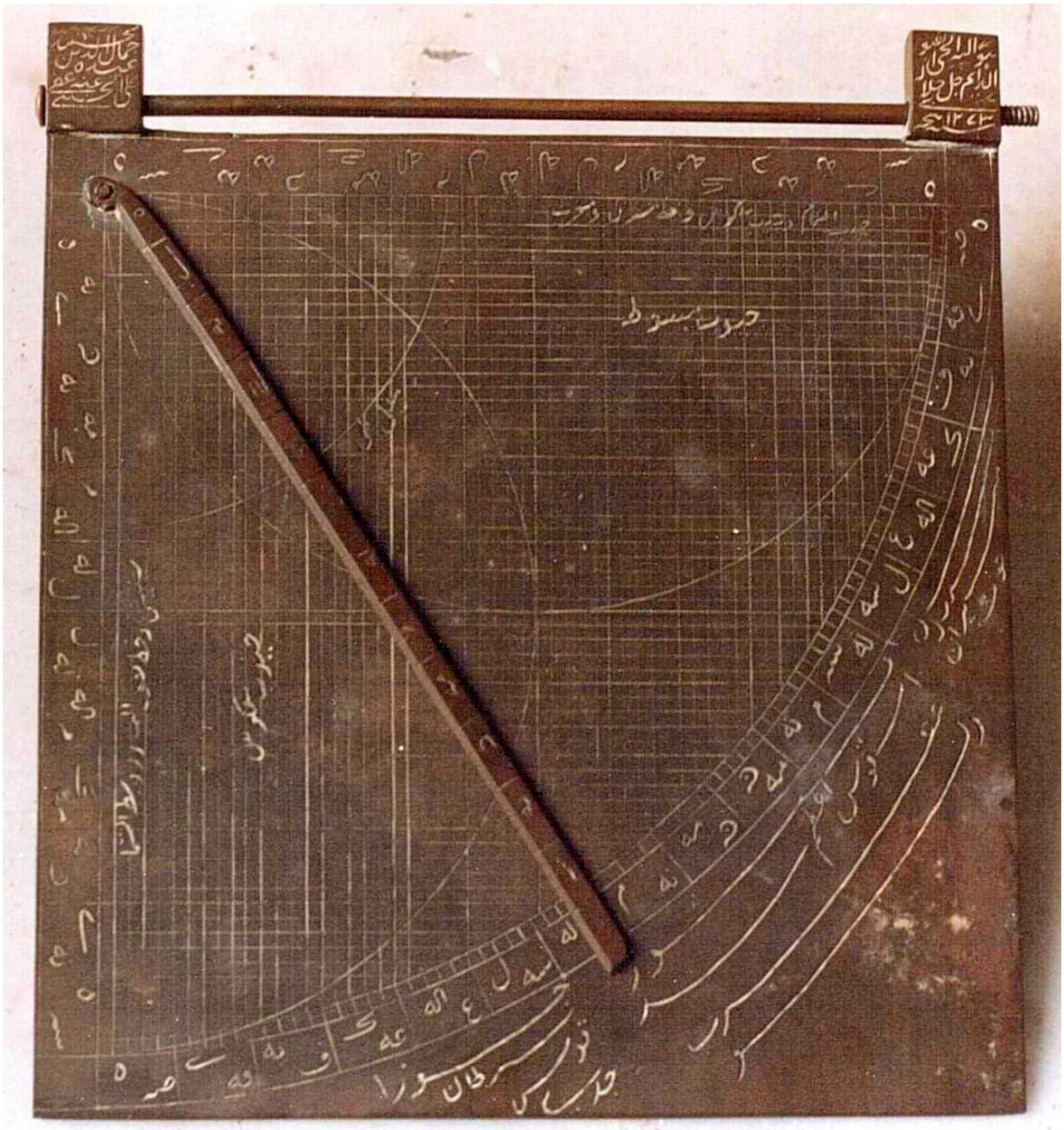


Figure J002.1 – Sine quadrant (courtesy Rampur Raza Library)

SINE QUADRANT

This is a well-crafted sine quadrant with all the lines, arcs and legends neatly engraved. Nothing is known about this instrument maker save this quadrant. This and the next specimen (J003) show all the main features of the sine quadrants.

It consists of an oblong copper plate measuring 186 x 173 mm. Two small oblong bits measuring 20.5 x 16.5 mm are soldered to one of the shorter sides at each end. These are thicker than the main plate and function as the sighting vanes. A sighting tube is inserted in the holes in these two bits, parallel to the shorter side. The plate is engraved on only one side, the other side is blank.

Taking a corner just below the sight on the left hand side as the centre and with a radius nearly equal to the length of the shorter side, a quarter circle is described on the surface of the plate. Two shorter quarter circles constitute a scale with two bands. The inner band is divided in single degrees. The outer band is graduated in 5° and numbered from 5° to 90° clockwise and anti-clockwise.

The vertical and the horizontal radii of the quadrant are divided into sixty divisions each, and groups of 5 divisions are numbered from 5 to 60 in both directions. From each of these divisions, parallels are drawn to the vertical side and the horizontal side, and each fifth line is highlighted. Two semicircles are drawn with the vertical and horizontal radii as their diameters. Furthermore, with the apex of the quadrant as centre, a quarter circle is described at the 24th division to represent the obliquity and is labelled as *mayl kullī* (maximum declination). An index is pivoted to the apex of the quadrant; it is also graduated in the same manner as the two radii.

Below the upper horizontal edge is written *jayb al-tamām wa jayb maᶜkūs wa khaṭṭ mashriq wa maghrib* (cosine and reverse sine and the east-west line). Just below this is another legend *jayūb mabsūṭ* ([lines of] cosines). Along the vertical edge on the right is written *sittaynī wa khaṭṭ niṣf al-nahār wa wasat al-samā'* (sixty-fold [divisions] and the line of midday and the line of the mid-heaven). A little away from this is the legend *jayūb mankūs* ([lines of] sines).

In the empty space outside the arc of the quadrant are engraved the names of the twelve signs of the zodiac with elongated letters and in a zig-zag fashion. The first line reads from right to left, the second from left to right, the third from right to left and the fourth from left to right, as shown below:

Jawjā' (Gemini)	*Thawr* (Taurus)	*Ḥamal* (Aries)
Saraṭān (Cancer)	*Asad* (Leo)	*Sunbulah* (Virgo)
Qaws (Sagittarius)	*ᶜAqrab* (Scorpio)	*Mīzān* (Libra)
Jadī (Capricorn)	*Dalw* (Aquarius)	*Ḥūt* (Pisces)

Here the signs are arranged in such a way that each vertical column here contains the names of signs which have the same rising times at the equator. Thus Aries, Virgo, Libra and Pisces rise in 1; 51, 36 hours; Taurus, Leo, Scorpio and Aquarius rise in 1;59,40s; and Gemini, Cancer, Sagittarius and Capricorn rise in 2;08,44 hours.[1316] In the middle column, next to *Asad* is written *qaws aᶜzum* (greatest arc).



Figure J002.2 – Sighting vanes (details from Figure J002.1)

INSCRIPTIONS[1317]

On the sighting vane on the left is engraved the maker's signature:

muḥammad jamāl al-dīn ᶜalī al-ḥussaynī ᶜabdahu ᶜaffa ᶜanha

'Muḥammad Jamāl al-Dīn ᶜAlī al-Husaynī, a slave, forgiven [by Allah].'

The sighting vane on the right carries an invocation and the year of manufacture:

hu Allah al-ḥyi al-qāyum, al-dāim, jal jalalahu 1273 hijrī

'He is Allah , the Ever-living, the Self-subsisting, Sustainer of all, He is forever the Almighty. 1273 Hijrī.'

The engraved lines and letters are filled with some white material.

BIBLIOGRAPHY

Sarma 2003, pp. 76-77.

1316 The 12 signs are arranged in this manner also on the backs of the astrolabes B024, C001 and C028. In the fifth chapter of his *Turyayantra-prakāśa* (light on the quadrant) of ca. 1572, Bhūdhara teaches how to employ this style of arrangement of zodiac signs for determining the declination of the sun at the desired moment; cf. SaKHYa 2014, pp. 21-23, 41-44.

1317 Mubashir Ul-Haq Abbasi has kindly transliterated and translated these inscriptions.

J003 SINE QUADRANT, NOT SIGNED, NOT DATED[1318]

19th century

223 x 223 mm

Karachi, National Museum of Pakistan



Figure J003.1 – Sine quadrant (photo by Mubashir Ul-Haq Abbasi)

[1318] Entry based on a photo and a detailed drawing kindly provided by Mubashir Ul-Haq Abbasi.

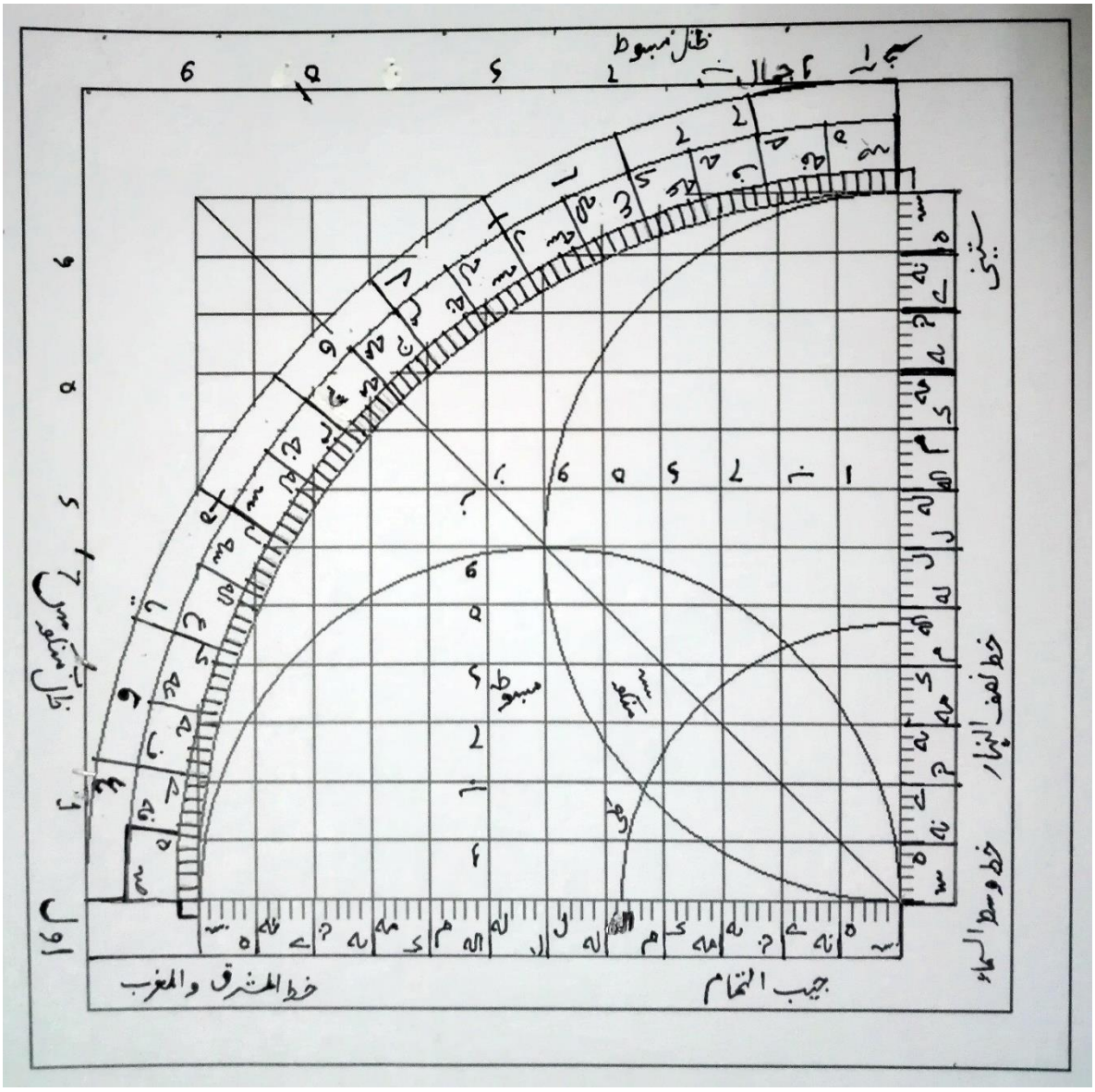


Figure J003.2 – Sine quadrant (drawing by Mubashir Ul-Haq Abbasi)

The engravings on the original instrument are badly effaced and it is difficult to decipher them on a photo. Therefore Mubashir Ul-Haq Abbasi has prepared a detailed drawing.

The sine quadrant is engraved on one side of a square sheet of brass measuring 223 x 223 mm. The other side is empty. Two pins are visible at the two ends of the vertical radius of the quadrant; these appear to be the remnants of the supports to hold the sighting tube which is missing now. Missing also is the index which may have been pivoted to the apex of the quadrant.

The arc of the quadrant consists of three bands; the inner band is divided in single degrees. In the middle band, groups of 5° are marked and numbered from 5° to 90°

both in clockwise and anti-clockwise directions. In the outer band are written some numbers; it is not clear what these numbers indicate.

The two radii are divided in 60 units each and groups of 5° are marked and numbered from 5 to 60 in both directions from the apex to the arc and from the arc to the apex. Eleven vertical and eleven horizontal parallels are drawn from the two radii at intervals of 5 units. Semicircles to measure the sines and cosines are drawn with each radius as the diameter. With the apex as the centre, the circle of declination is drawn with a radius of about 23 units and labelled *mayl kullī* (maximum declination). The horizontal parallels are labelled as [*jayūb*] *mabsūṭ* (cosines) and the vertical parallels [*jayūb*] *mankūs* (sines). The cells in the 8th column and in the 8th row are numbered from 1 to 7 starting from the corresponding radius.

Below the horizontal radius are engraved *jayb al-tamām* (cosine) and *khaṭṭ mashriq wa maghrib* (east west line). To the right of the parallels are written *sittaynī* (sixty-fold [divisions]), *khaṭṭ niṣf al-nahār* (line of midday, meridian) and *khaṭṭ wasat al-samā'* (line of mid-heaven).

The side opposite the horizontal radius is divided in 6 parts and numbered from 1 to 6. Below the line of division is the label *ẓill mabsūṭ* (direct shadow, tangent). The side opposite the vertical radius is also divided in 6 parts and numbered from 1 to 6; it is labelled *ẓill mankūs* (indirect shadow, co-tangent). At the beginning of the arc is written *awwal* ([the] first [division]) and at the end *ākhir* (end).

J004 ⊙ SINE QUADRANT, NOT SIGNED, NOT DATED

19th century

Radius 179 mm; length of the index 170 mm

Mumbai, Chhatrapati Shivaji Maharaj Vastu Sangrahalay



Figure J004.1 – Quadrant (photo by S. R. Sarma)

The instrument is made in the form of a quarter circle. Semi-circles are engraved along the two sides. The arc of the quadrant is divided in 6° and numbered in *Abjad* from 6 to 90 in both directions. The two sides are also divided in 6° and numbered from 6 to 60 in both directions. The index is divided in 1° and 6° and numbered from 6 to 60. The reverse side of the plate is blank.

There is a small circular projection at the apex with a hole to receive the index, but the index is not pivoted in that hole; instead it is attached a little lower down, with the result that the divisions on it do not match with the divisions on the sides.

On the horizontal side, there is a large rectangular projection; sights are attached on its two vertical sides.

J005 SINE QUADRANT, NOT SIGNED, NOT DATED

Dimensions ?

Hyderabad, Saidiya Library

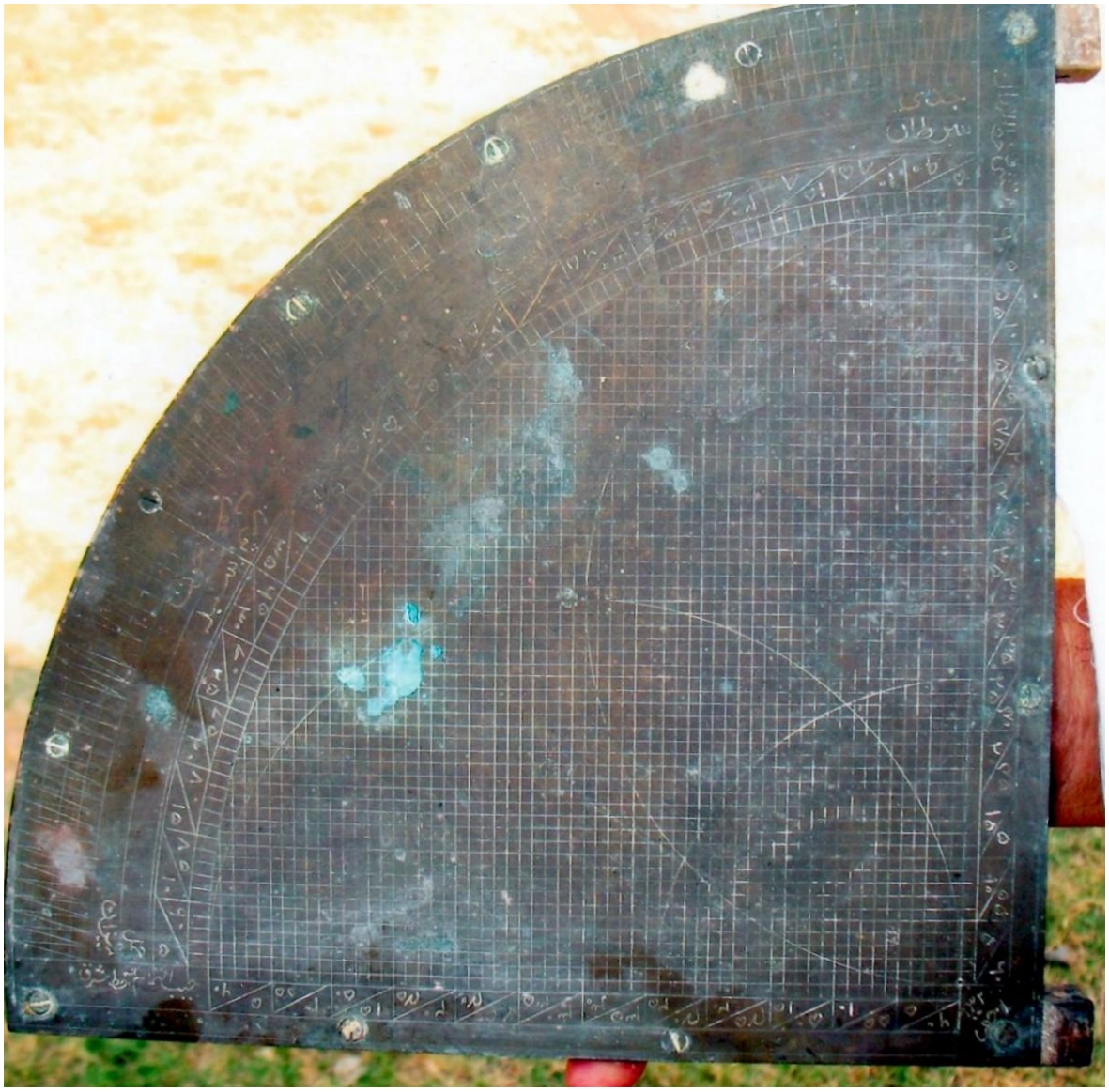


Figure J005.1 – Sine quadrant (photo by Ahmed Athaullah)

This sine quadrant, made of brass or of copper, appears to have been nailed to a wooden support. The vertical and the horizontal radii of the quadrant are divided into sixty divisions each, and groups of 5 divisions are numbered from 5 to 60 in both directions. From each of these divisions, parallels are drawn to the vertical side and the horizontal side. Two semicircles are drawn with the vertical and horizontal radii as their diameters. With the apex of the quadrant as centre, a quarter circle is described at the 24th division to represent the obliquity.

The arc of the quadrant is divided in 1° and groups of 5° are numbered from 5 to 90 in both directions. Beyond this arc, there are three concentric bands. The first and the second bands are engraved with the names of zodiac signs. Not all the names are visible in the photo, but it appears that the signs are arranged somewhat in the same manner as in J002 so that the names of the four signs which have the same rising times at the equator occupy 30° of arc space. In the outer band, which is very broad, the divisions of single degrees, made in the arc of the quadrant, are extended.

There is no signature or date on this quadrant. At the end of the horizontal radius is a label which reads *jayb al-tamām khaṭṭ* (?) *sharq* (cosine [and] east line). At the end of the vertical radius is another label which reads *sittaynī wa khaṭṭ al-shamāl* (?) (sixty-fold [divisions] and line of north).

K. SANSKRIT QUADRANTS (TURĪYA-YANTRA)

INTRODUCTION

In Sanskrit the quadrant is called *Turīya-yantra, Turya-yantra* or *Turya-gola(ka)-yantra*. It is mentioned for the first time by Brahmagupta in his *Brāhmasphuṭa-siddhānta* of 628 under the name *Turya-golaka-yantra.* Brahmagupta discusses the three instruments *Cakra* (circle), *Cāpa* or *Dhanus* (lit. 'bow', semi-circle) and *Turyagolaka* or (quadrant) which are closely related in shape and function. *Cakra* is a circular wooden plate with its circumference graduated into 360 degrees, *Dhanus* is its half, and *Turyagolaka* the quarter. In all the three, a perforation is made at the centre into which a thin rod is inserted as the axis and a plumb-line is suspended from the centre. These instruments are so held towards the sun that the axis throws a shadow on the circumference. Then the arc intercepted between the nadir (indicated by the plumb-line) and the shadow is the zenith-distance. Brahmagupta prefers the semi-circular variety and explains the various functions in connection with it and adds that the same can be done with the *Turya-golaka* and *Cakra*.[1319]

Following him, Bhāskarācārya also describes first the *Cakra-yantra* and then adds laconically that the *Cāpa* and *Turya-gola* are a half and a quarter respectively of the *Cakra* and that all the tasks of the *Cakra* can be performed with *Cāpa* and *Turya-gola* as well.[1320] However, the *Turya-gola* or the quadrant is a handier device and played an important role in India in the medieval period.

[1319] Brahmagupta, 22.17:
aṅkitam aṃśanavatyā dhanuṣo 'rdhaṃ turyagolakaṃ yantram |
ghaṭikā-natonnatāṃśa-grahāntarādyaṃ dhanurvad iha ||
'The *Turya-golaka-yantra* is [constituted by] a half of the *Dhanur [-yantra]*. It is marked with ninety degrees; as in the *Dhanur [-yantra]*, here also [can be determined the time in] *ghaṭikās*, the degrees of the zenith-distance (*natāṃśa*), the distance between two planets (*grahāntara*) and other [parameters].'

[1320] Brahmagupta, *Golādhyāya, Yantrādhyāya*, 15cd: *dalīkṛtaṃ cakram uśanti cāpaṃ kodaṇḍa-khaṇḍaṃ khalu turyagolam*, 'The *Cakra [-yantra]*, when halved, is called *Cāpa [-yantra]*; its [half] part is indeed the quadrant *(turya-gola)*.'
Sūryasiddhānta 13.20 enumerates the names of several instruments without actually describing them; these include *Cakra* and *Dhanus* but not *Turya*. Lalla mentions *Cakra-yantra* and the *Dhanur-yantra*, but not the quadrant in his the *Śiṣyadhīvṛddhida*. Likewise, Śrīpati, in his *Siddhātaśekhara*, describes the *Cakra-yantra* and the *Cāpa-yantra*, but not the quadrant.

SINE QUADRANT

Padmanābha

It has been mentioned above that the sine quadrant was developed at Baghdad in the ninth century and was transmitted to India along with the astrolabe. Because of its usefulness in solving trigonometric problems graphically, it was easily absorbed into the repertoire of Indian astronomical instruments. In India Padmanābha is the first one to describe the sine quadrant in his *Dhruvabhramaṇādhikāra* of 1423.[1321] In this work, he describes a new instrument for use in the night called *Dhruvabhrama-yantra* consisting of a rectangular plate and adds that the reverse side of this plate should be fashioned as a sine quadrant for use in the daytime.

To the existing design of the plain quadrant, equipped with two sights and the arc graduated in 90 degrees, Padmanābha added 30 parallels (*jyā-rekhās*) with uniform intervals perpendicular to the horizontal radius so that an angle measured on the arc can be directly converted to the corresponding Rsine (*jyā*). A plumb line is suspended from the apex of the quadrant. Also an index arm is pivoted to the centre. This index arm is graduated in the same divisions as the intervals between the vertical parallels or lines of sines.

Padmanābha envisages three kinds of uses for this sine quadrant. First, in the daytime, one measures the sun's altitude and from it determines the true solar time. Second, at night one measures the altitude of a lunar mansion (*nakṣatra*) and from it determines the sidereal time. For this purpose, he provides the meridian altitudes of the 28 lunar mansions at 24˚ latitude north, and teaches the method of converting these for one's own latitude. Third, he teaches the procedure how to obtain the time at one's own latitude from the time measured with an instrument calibrated for another latitude.

Cakradhara

After Padmanābha, the sine quadrant was discussed by several writers. Notable among these are Cakradhara and Bhūdhara who composed exclusive manuals on the sine quadrant. Cakradhara authored a manual entitled *Yantra-cintāmaṇi* together with a

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[1321] On Padmanābha and the *Dhruvabhrama-yantra* invented by him, see the next section L. For the text and translation of the *Dhruvabhramaṇādhikāra,* see Apx.D2.

commentary called *Vivaraṇa* sometime before 1621. This work enjoyed great popularity. Besides the author's own *vivaraṇa,* two other commentaries are extant: *Yantra-dīpikā* by Rāma Daivajña (ca. 1625) and *Turyayantropapatti* or *Yantracintāmaṇi-sūtrāṇam Upapatti* by Dādābhāī (ca. 1719). Moreover, some 90 manuscript copies of this work are known to exist.

The *Yantra-cintāmaṇi* is a slender work of just 26 verses. Cakradhara asserts that his work, though small, carries much substance (*alpam analpakārtham*). He goes on to say that the instrument described by him can solve several astronomical problems directly (*pratyakṣataḥ*) without the necessity of mathematical computation (*gaṇitānapekṣya*) and that it makes use of principles and rationales that have never been employed before (*apūrvayukti*).[1322] He coined a special name for the sine quadrant, *Yantra-cintāmaṇi* (wishing gem of an instrument). Two extant specimens (K013 and K014) carry this name, otherwise it did not become popular like Mahendra Sūri's name *Yantrarāja* for the astrolabe. Like the ordinary quadrant, the sine quadrant also continued to be referred to as *Turīya* or *Turya-yantra.*

Cakradhara's design for the sine quadrant is more refined than that of Padmanābha. He defines the various elements with greater clarity and precision, providing them with specific designations. The centre or the apex (A) is named *kendra* (centre)*,* the point diagonally across (H) is named *kuja* (horizon), and the point straight below (Z) is *gagana* (zenith). The line joining the apex and horizon (AH) is called *kṣiti* (earth, base line). Above this line are situated two sighting vanes (*kīlaka*) with holes for observing the heavenly bodies. This line (AH) is divided into 30 equal parts and from each point of division lines perpendicular to the horizontal line are drawn. Along the arc are drawn two circular scales. One is divided into 90 degrees of arc, and the degrees are numbered, from the horizon up to the zenith, to measure the altitude (*unnatāṃsa*) or zenith-distance (*natāṃśa*). The second scale is divided into 15 *ghaṭīs* for measuring time.[1323] In his commentary *Vivaraṇa* he explains how to find out directly the *Kramajīvā* (Rsine) and the *Utkramajīvā* (Rversed sine or Rversine):

[1322] Cakradhara, 1-2.

[1323] Cakradhara, 3.

If you want the Rsine of, say 30°, measure 30° from the zenith (i.e. 60° on the scale) and the corresponding sine-line, namely 15 *aṅgulas*, is the Rsine of 30°. If you want the Rversine of 30°, count 30° from the horizon, the distance on the *bhūmi* (AH) between the base of the corresponding sine-line and the horizon, namely 4 *aṅgulas*, is the Rversine of 30°.

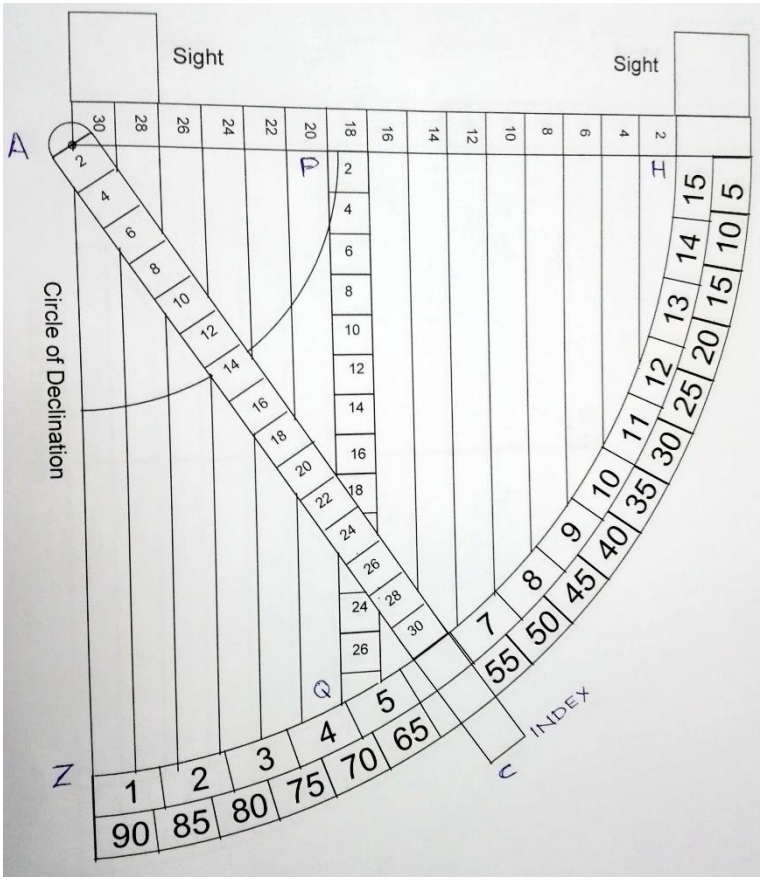


Figure K1 – Sine quadrant designed by Cakradhara
(drawing by Mubashir Ul-Haq Abbasi)

The vertical parallels are numbered from the arc to the apex. The 18th line, or more correctly the 18th column, is divided into parts equal to the intervals between the vertical lines. These intervals are designated as *aṅgulas* (digits). The reason for choosing the 18th column is as follows. When counted from the apex, it is the 12th column, and the distance from the apex to this line represents the gnomon of 12 *aṅgulas.*[1324] On this scale can be determined the shadow lengths of the gnomon at any given time.[1325]

[1324] In all the sine quadrants made by Bulhomal, the twelfth vertical and horizontal columns are numbered in this manner.

[1325] Cf. Rai 1985, pp. 327-328.

Then with the apex as the centre and with a radius of 12 and 1/5 *aṅgulas* a quarter circle is described. In Indian astronomy, the traditional value of the obliquity of the ecliptic (*parama-krānti*) is 24. Therefore, the Rsine of the obliquity (*parama-krānti-jyā*) is roughly 12 and 1/5. Thus this quarter circle represents the circle of declination (*krānti-vṛtta*) (see Figure K015.1 and Figure K016.1).

From the apex, a plumb line with a weight is suspended. An index (*paṭṭikā*), somewhat longer than the radius of the quadrant is pivoted to the apex. It is also divided into *aṅgulas* of the same dimension as before and the *aṅgulas* are numbered from the apex onwards. It can be held firmly at any degree on the arc or at any division on the 18th line for solving different trigonometric problems, such as the conversion of the equinoctial midday shadow (*palabhā*) into the latitude or vice versa.

Cakradhara envisages that the *Yantra-cintāmaṇi* is employed for determining the time at night also from the altitude of some bright stars, such as the junction-stars (*yogatārās*) of *Puṣya* (δ Cancri), *Maghā* (α Leonis), *Śatabhiṣā* (λ Aquarii) and *Revatī* (ζ Piscium). Since the celestial latitude (*śara*) of these stars is low (that is to say, they are not far from the ecliptic), sighting them is tantamount to sighting the ecliptic. Treating the altitude of any of these stars as the altitude of the sun, one should follow the same procedure as with the sun in the daytime.

Bhūdhara

The second exclusive text on the sine quadrant is the *Turyayantra-prakāśa* composed by Bhūdhara sometime after 1572 at Kāṃpilya (modern Kampil, UP, 27;37° N, 79;17° E); it is a larger work, consisting of 265 verses distributed into 21 chapters.[1326] While Cakradhara prescribes a series of 30 vertical lines, Bhūdhara in his *Turyayantra-prakāśa* prescribes 60 horizontal and 60 vertical parallels, so that both sines and cosines can be directly determined of the angles measured on the arc. An interesting feature of Bhūdhara's work is the employment of the sine quadrant in geodesy, which is discussed in the final chapter entitled *Parvatādi-unnati-jñāna* (knowledge of the height of mountains and others). This topic of the determination of the heights of mountains or

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[1326] A critical edition of the first ten chapters with translation and commentary was published by SaKHYa 2014.

the depths of wells was discussed much earlier in mathematical texts, and Bhāskara's *Līlāvatī* offers some charming examples, but Bhūdhara appears to be the only one to suggest the use of the sine quadrant for the solution of such problems.[1327]

Jñānarāja in his *Siddhāntasudara* of 1503[1328] and **Kamalākara** in his *Siddhāntatattvaviveka* composed in 1568[1329] discuss the sine quadrant and its application, basically in the same manner as taught by Cakradhara. Chronologically the last Sanskrit text to discuss the sine quadrant is the *Yantrasāra* [1330] composed in 1771 by **Nandarāma**. It deals with several instruments, but the lion's share, comprising 190 verses, goes to the sine quadrant, for which Nanadarāma also prescribes 60 vertical and 60 horizontal parallels.

Extant Specimens

The extant specimens of Sanskrit quadrants belong to the three catagories of plain or geometrical quadrants, sine quadrants and horary quadrants, but among these the sine quadrants predominate.

Sine Quadrants

The sine quadrants are incorporated on the back of Sanskrit astrolabes, on the back of *Dhurvabhrama-yantras* and also on the reverse side of several other kinds of instruments. But there are some specimens exclusively of sine quadrants.

Here two specimens deserve attention. In 1834, a person referring to himself as Vaijanātha's son designed a sine quadrant at the instance of the ruling prince of Kota in Rajasthan. The insription on the instrument states that this instrument is [described] in the *Yantra-cintāmaṇi.* This *Yantra-cintāmaṇi* must be the manual composed by

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1327 Mahendra Sūri, 5.55-57, teaches how to solve problems of this type by means of the astrolabe. The *Koneri-yantra,* consisting of a square board with 16 x 16 cells, functions in a similar manner; cf. Sinha & Hayashi 1983.

1328 On Jñānarāja and his *Siddhāntasundara*, cf. CESS, 3.75-76; 4.100; 5.122-123; Toke Lindegaard Knudsen, 'The *Siddhāntasundara* of Jñānarāja: A Critical Edition of Select Chapters with English Translation and Commentary,' PhD Thesis, Brown University, Providence 2008.

1329 Kamalākara, *Siddhāntatattvaviveka,* edited by Sudhakara Dvivedi, second edition revised by Muralidhara Jha, Benares 1924-1935, *Tripraśnādhikāra* 391-466, pp. 304-314. Here he refers to the sine quadrant by a strange name *aṅghri-yantra.* Of course, *aṅghri,* lit. 'foot', can also denote the foot of a verse and thus 'one-quarter [of a circle].'

1330 CESS, 3.128-130; 5.156-158.

Cakradhara. But Cakradhara's manual teaches only how to construct the sine quadrant; it does not say what to do with the back oof the plate. The specimen designed by Vaijanātha's son carries a sine quadrant on the obverse side, but on reverse it has a circular instrument along with a four-armed index, for determining the oblique ascensions for any given moment at the latitude of Kota. The consuction of this instrument was not mentioned in Cakradhara's book; then where did it come from?

Another specimen prepared by Hṛṣīkekeśa, most probably at Patiala, around 1850, carries a sine quadrant on the obverse and on the reverse an instrument somewhat different from that on the back of the instrument by Vaijanātha's son, but with the same function of determining the oblique ascensions of a place situated on a particular latitude. Where did this design come from? In his account of the astronomical instruments and Sanskrit manuscripts he saw at Kota, Lancelot Wilkinson reports as follows:

> 'The Maháráo's collection contains also a Turíya Yantrá, or quadrant, with a radius on one side of 30 digits, and linear rectangular intersections, rising from each digit, representing their whole canon of sines, cosines, and versed sines adapted to this radius. From the Maháráo's astronomer I procured a copy of the Sanscrit treatise on the quadrant, called Yantracitamani, by CHAKRADHARA, son of SRI WAMANA, containing directions for construction and use of the instrument, with the mathematical proofs and demonstrations of all the many problems which may be worked by it. The reverse side of this quadrant contains the signs and degrees of the ecliptic, and a hour circle, with an index hand by which you are entitled to tell at once the lagna (or horoscope), that is, the exact point or star of the ecliptic, rising in the horizon at any given time.'[1331]

The last sentence referring to 'the reverse side of this quadrant' is intriguing. Does it mean the reverse side of the quadrant as described in the book by Cakradhara, or the reverse side of the quadrant which was in the collection of the Maharao? In the former case, somebody must have made the addition to the text of the *Yantra-cintāmaṇi* in the

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[1331] Wilkinson 1834, p. 515.

manuscript procured by Wilkinson at Kota. In the latter case, Wilkinson saw at Kota sometime before 1834 an actual specimen on which the sine quadrant was engraved on one side and the oblique ascensions on the other side. Then this would be the forerunner of the silver specimen designed by Vaijanātha's son in 1834. However, on the silver instrument of 1834, Vaijanātha's son states that he made the instrument which is in the *Yantra-cintāmaṇi,* meaning that he designed the instrument as it was described in the *Yantra-cintāmaṇi.* This would support the first hypothesis, namely some unknown author made additions to the text of the *Yantra-cintāmaṇi,* describing how to engrave the reverse side of the sine quadrant so that the oblique ascensions can be determined with its help for any given moment of time.

Horary Quadrant

Sometime about the middle of the nineteenth century, Bulhomal of Lahore made an exclusive horary quadrant which is described under K005. He incorporates similar horary quadrants in some of his instruments, but this is the only piece which exclusively carries a horary quadrant on one side. This is obviously derived from a large instrument designed by Sawai Madho Singh with the title *Yantrādhipati.* It will be described in section T on the instruments designed by Madho Singh. It has not been possible to trace the antecedents of such a horary quadrant in the Islamic world. Therefore, it must have been an independent invention by Madho Singh.

Horary quadrants occur also on the back of some *Dhruvabhrama-yantras* which will be described in the next section L.

K001⊙ SANSKRIT GEOMETRICAL QUADRANT, NOT SIGNED, NOT DATED

19th Century

118 x 118 mm, thickness 4 mm

Jaipur, Museum of Indology

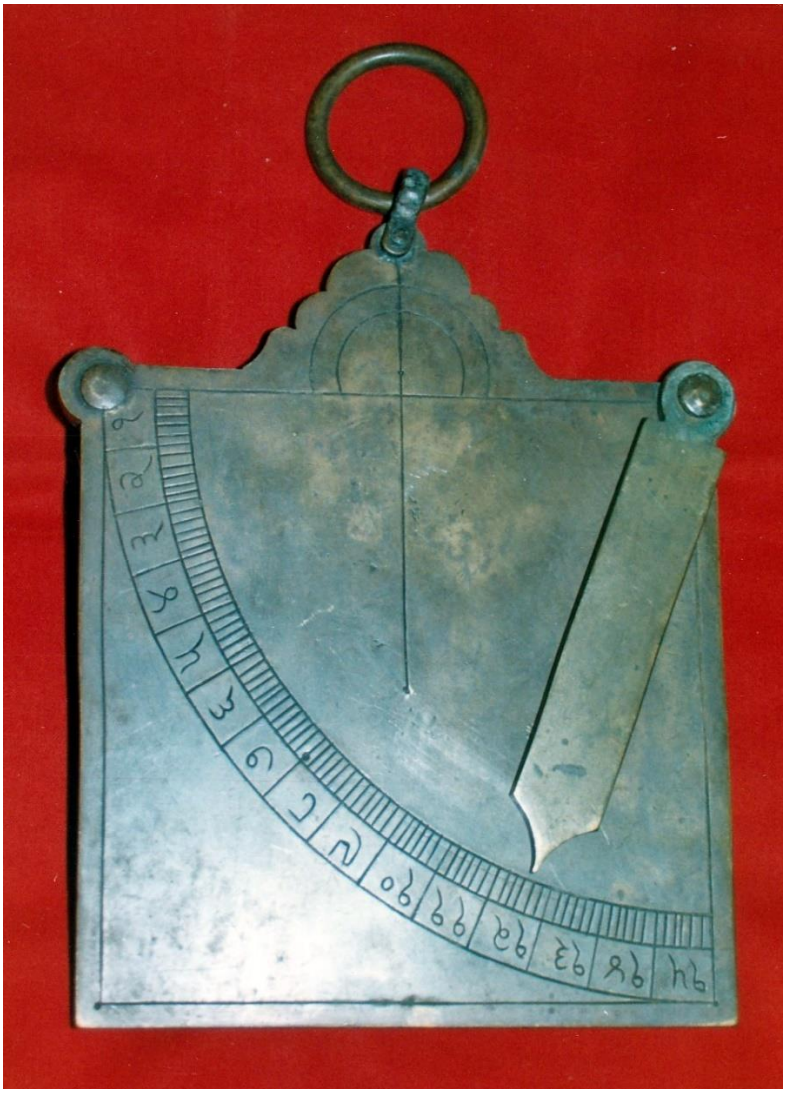


Figure K001.1 – Obverse side of the quadrant with the index (photo by S. R. Sarma)

This is a well-crafted solid brass piece; it is nearly square in shape, each side measuring 118 mm, with a thickness of 4 mm. The two upper corners have circular projections, jutting out of the outline and forming small circles. In the middle of the upper horizontal side, there is crown like projection, as in an astrolabe, with three lobes on each side. To the upper lobe is attached a small shackle through which passes a large ring. Two concentric circles are engraved on the crown for decorative purposes. A vertical line is drawn from the tip of the crown on to the surface of the square plate, but not completely.

On the surface of the square plate is engraved a degree scale in two bands. The inner band is graduated in degrees and in the outer band groups of six degrees are labelled as 1, 2, 3, … 15.

At the apex of the quadrant is pivoted an index with a pointed tip to read the angle of altitude.



Figure K001.2 – Reverse side of the quadrant with the sighting tube (photo by S. R. Sarma)

On the reverse side is engraved a degree scale exactly like the one on the obverse side. At the apex of the quadrant is pivoted a flat index with a pointed tip on which a heavy sighting tube is so mounted that it can be used either on the horizontal side or on the vertical side.

When a heavenly body is viewed through the sighting tube, the index on the obverse side will mark the angle of altitude on the quadrant scale.



Figure K001.3 – Quadrant with the two indices (photo by S. R. Sarma)

Although the construction looks quite ingenious, it is rather flawed. First, the graduated arc on the reverse side is redundant, because the index cannot be used here to read the angle of altitude. Moreover, the sighting tube pivoted at the apex of the quadrant looks as if it could be used either on the vertical side or on the horizontal side. But actually, it could be used only on the horizontal side. If it used on the vertical side, the index on the obverse side would hang down outside the plate and cannot point to the angle of altitude on the graduated arc.

It is strange that the instrument maker did not realise the flaw in the construction. Either he or somebody from the same milieu produced two other specimens (K002 and K003) in the same manner.

K002 SANSKRIT GEOMETRICAL QUADRANT, NOT SIGNED, NOT DATED[1332]

19th Century

Length of the side 105 mm; height 131 mm

PLU; ex-Drouot

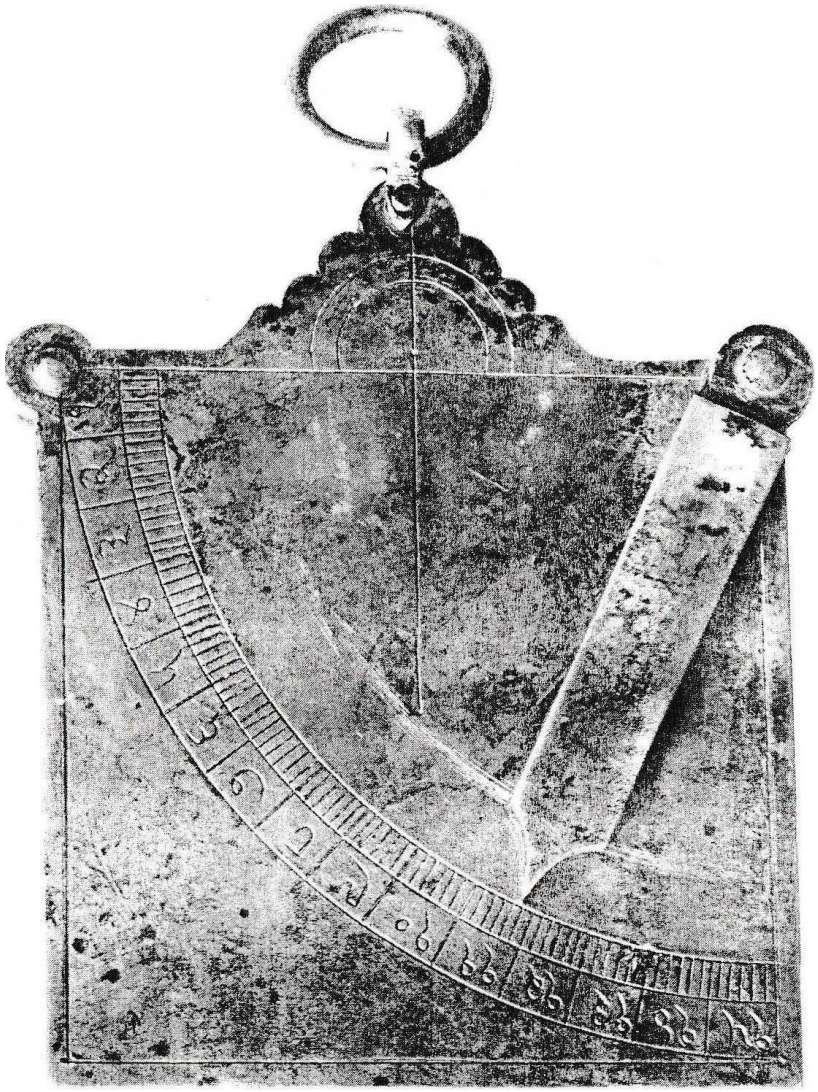


Figure K002.1 – Obverse side of the quadrant with the index (from the Drouot catalogue)

This is an exact duplicate of K001, but slightly smaller. The sighting tube fixed to the slot at the apex of the quadrant on the reverse appears to be lost.

[1332] Entry based on the Drouot, Paris, auction catalogue of 22 June 1979, lot 146.

K003 SANSKRIT GEOMETRICAL QUADRANT, NOT SIGNED, NOT DATED[1333]

19th Century

73 x 73 mm

PLU; ex-Sotheby's, London

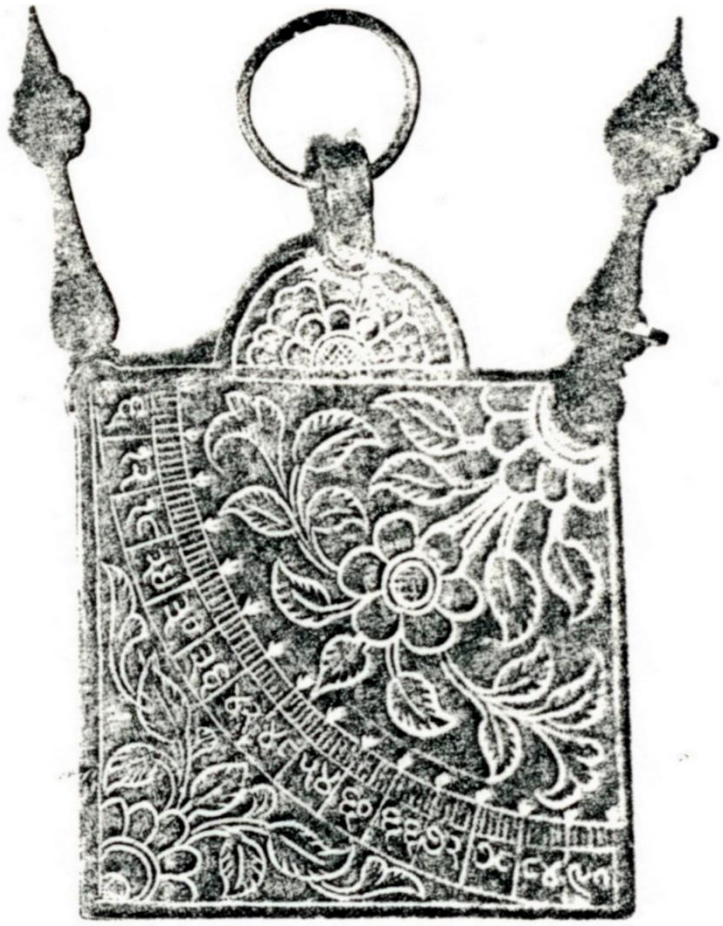


Figure K003.1 – Quadrant with the two indices (courtesy Anthony J. Turner)

This quadrant is almost similar to the previous two specimens, but much smaller and decorated with flower and leaf design within and without the graduated arc. The index on the right is equipped with two sighting vanes.

BIBLIOGRAPHY

Sotheby's, London, auction catalogue of 3-4 March 1994, lot. 497, p. 112.

[1333] Entry based on Sotheby's, London, auction catalogue of 3-4 March 1994, lot. 497, p. 112.

K004 SANSKRIT GEOMETRICAL QUADRANT, NOT SIGNED, NOT DATED[1334]

19th Century

Radius 114 mm

PLU; photo in MHS archives

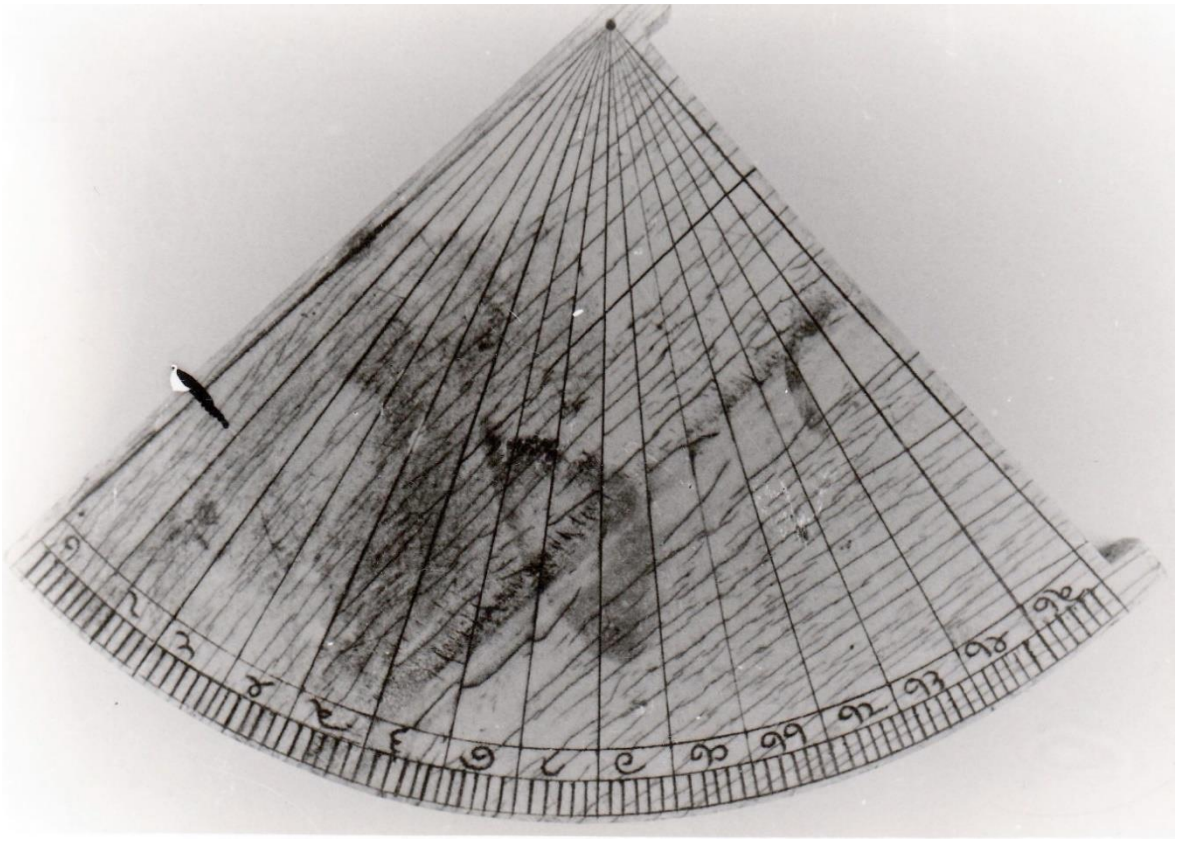


Figure K004.1 – Ivory quadrant (courtesy Museum of the History of Science, Oxord)

This is an ivory quadrant; the arc is divided in 1° and 6°; groups of 6° are numbered serially from 1 to 15. Radial lines are drawn from the apex to the arc at intervals of 6°. There are sighting vanes on the right at the apex and at the at the end of the arc, cut out of the same sheet of ivory.

[1334] Entry based on a photo in the archives of the Museum of the History of Science, Oxford, along with a note which reads 'Indian Altitude Quadrant / Not signed / Not dated /Sotheby item no. 385900 / Sent to Mr Maddison for examination on / 16 November 1982 / Ivory Nāgarī script length straight edge 115 mm (max), thickness 14 mm / Neg. ref. no. 82-29-25.S.

K005⊙ SANSKRIT HORARY QUADRANT BY LĀLAH BULHOMAL OF LAHORE

Not dated, mid-19th Century

Radius 119 mm

Oxford, Museum of the History of Science (# 39884)



Figure K005.1 – Horary Quadrant (© Museum of the History of Science, Oxford)

This is one of the several instruments produced by the versatile instrument maker Bulhomal of Lahore. In the metrical inscription engraved on the instrument, he refers to himself as Vulho-varmma.[1335] He incorporates horary quadrant in some of his instruments; this is the only piece which exclusively carries a horary quadrant on one side; the other side is blank.

At the two ends of the radius on the left are attached rectangular sights with holes in them. There is no index, but a brass plumb with black thread is suspended from the apex.

[1335] On his corpus and on the different ways he writes his name, see Sarma 2015b.

The arc of the quadrant carries a degree scale in two bands. The outer band is divided in single degrees. Groups of 6° are marked and numbered anti-clockwise in the inner band from 6 to 90.

The degree scale is followed by seven *ghaṭī* scales of different lengths, showing the number of *ghaṭīs* in half a day at different seasons, according to the varying declination of the sun throughout the year. Each cell is marked by the number of complete *ghaṭīs* and the final cell contains the fractional *ghaṭī*. On the left of each row are written the names of the zodiac signs to which the *ghaṭī* scale belongs. In the uppermost row, however, instead of the sign *Mithuna* (Gemini), the name of the month *Āṣāḍha* is written.

Table K005-1 *Ghaṭī* Scales

Name	duration
Āṣāḍa (sic! *Āṣāḍha*)	17;40 [*ghaṭīs*]
Vṛṣa-karkaṭau (Taurus & Cancer)	17;15
Meṣa-siṃhau (Aries & Leo)	16;15
Mīna-kanye (Pisces & Virgo)	15
Kuṃbha-tule (Aquarius & Libra)	13;45
Makara-vṛścikau (Capricorn & Scorpio)	12;45
Dhanuḥ (Sagittarius)	12;20

Accordingly, the longest day has a duration of 17;40 x 2 = 35;20 *ghaṭīs* (14;08 hours) and the shortest day 12;20 x 2 = 24; 40 *ghaṭīs* (9;52 hours). These are the values for the latitude of Lahore.[1336]

INSCRIPTION

śrīgirijāpati-pādam natvā turyyaṃ vināyāsaṃ |
vulhovarmma-kṛtaṃ śrīviduṣāṃ samayāvabodhāya ||1||

[1336] In Lahore astrolabes, the duration of the longest day at Lahore is given as 14;09 hours.

> ‘Having bowed to the feet of [Śiva,] the consort of the mountain’s daughter [Pārvatī], this quadrant (*turya*) was made by Bulho-varman (*vulhovarmma*) so that the illustrious scholars may know time without effort.’

BIBLIOGRAPHY

Maddison 1957, no. 191, p. 46, pl. xxxi.

Anderson 1982, no. 131, pp. 35-36.

Turner 1990, no. 94.

Verdet 1994.

Sarma 2010

Sarma 2015b

K006 SANSKRIT SINE AND HORARY QUADRANT, NOT SIGNED, NOT DATED

19th century

Radius 113 mm

Hastings-on-Hudson, NY, Tesseract



Figure K006.1 – Horary quadrant on the obverse (photo courtesy Dr David Coffeen)

This is a unique instrument combining two varieties of quadrants on the two sides. A horary quadrant is engraved on the observe side and a sine quadrant on the reverse side. A sighting tube is attached to the side on the right; at the apex is a pin from which a plumb line can be suspended, but it is now missing.

HORARY QUADRANT

The outer rim of the arc is divided in 1° and groups of 3° are serially numbered clockwise from 1 to 30. Within this degree scale is engraved a zodiac scale in three bands. The innermost band is divided in 6 cells; in the cells are written the names of the 12 zodiac signs, the first six clockwise and the next six anti-clockwise. Thus each cell carries the names of a pair of zodiac signs. Reading from right to left, these are: *Meṣa Mīna* (Aries Pisces); *Vṛṣa Kumbha* (Taurus Aquarius); *Mithuna Makara* (Gemini Capricorn); *Karka Dhana* (sic! *Dhanuḥ*) (Cancer Sagittarius); *Siṃha Vṛścika* (Leo and Scorpio); *Kanyā Tula* (sic! *Tulā*) (Virgo Libra). In the next band, each of these cells are

divided into five parts and numbered in 6s from to 6 to 30. The third band is divided in 2°.

Inside these two scales, there are nine concentric rows carrying nine *ghaṭī* scales, which are numbered from 1 to *x,* where *x* is the number of *ghaṭīs* in a half day; in the last column are mentioned the number of *ghaṭīs* in a full day. The numbers range from 34 (= 13;36 hours) at the bottom to 26 (= 10;24 hours) at the top.

When the sun is sighted through the sighting tube, the index or the plumb line indicates the angle of altitude in degrees. The time in *ghaṭīs* should be measured on one of the 9 *ghaṭī* scales. Probably one is to find out first the maximum duration of the sunlight in *ghaṭīs* in the given month from an almanac and then chose the appropriate *ghaṭī* scale. But then what is the function of the zodiac scale engraved below the *ghaṭī* scale?

The design of this horary quadrant is unlike any other horary quadrant in Sanskrit and rather intriguing.

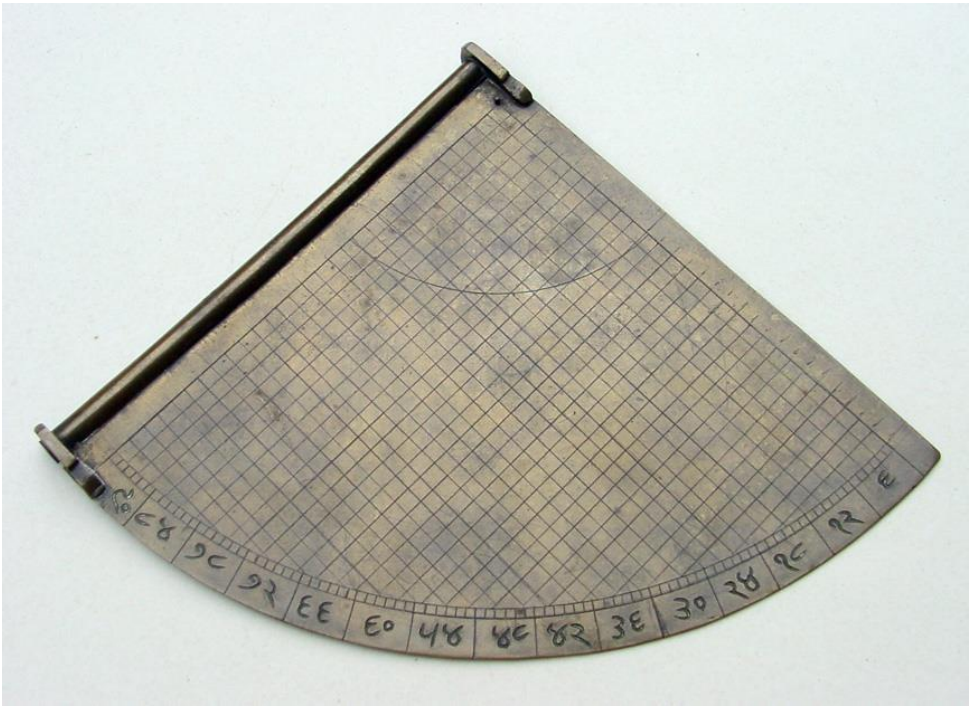


Figure K006.2 – Sine quadrant on the reverse (photo courtesy Dr David Coffeen)

SINE QUADRANT

On the reverse side is engraved a sine quadrant with 30 horizontal and 30 vertical lines which are not numbered. The arc of quadrant carries a degree scale, marked with 1° and labelled clockwise in 6s from 6 to 90. There is a circle of obliquity.

K007⊙ SANSKRIT SINE QUADRANT, NOT SIGNED, NOT DATED

Early 20th century

Radius 115 mm

Vadodara, Maharaja Sayajirao University of Baroda, Sanskrit Mahavidyalaya

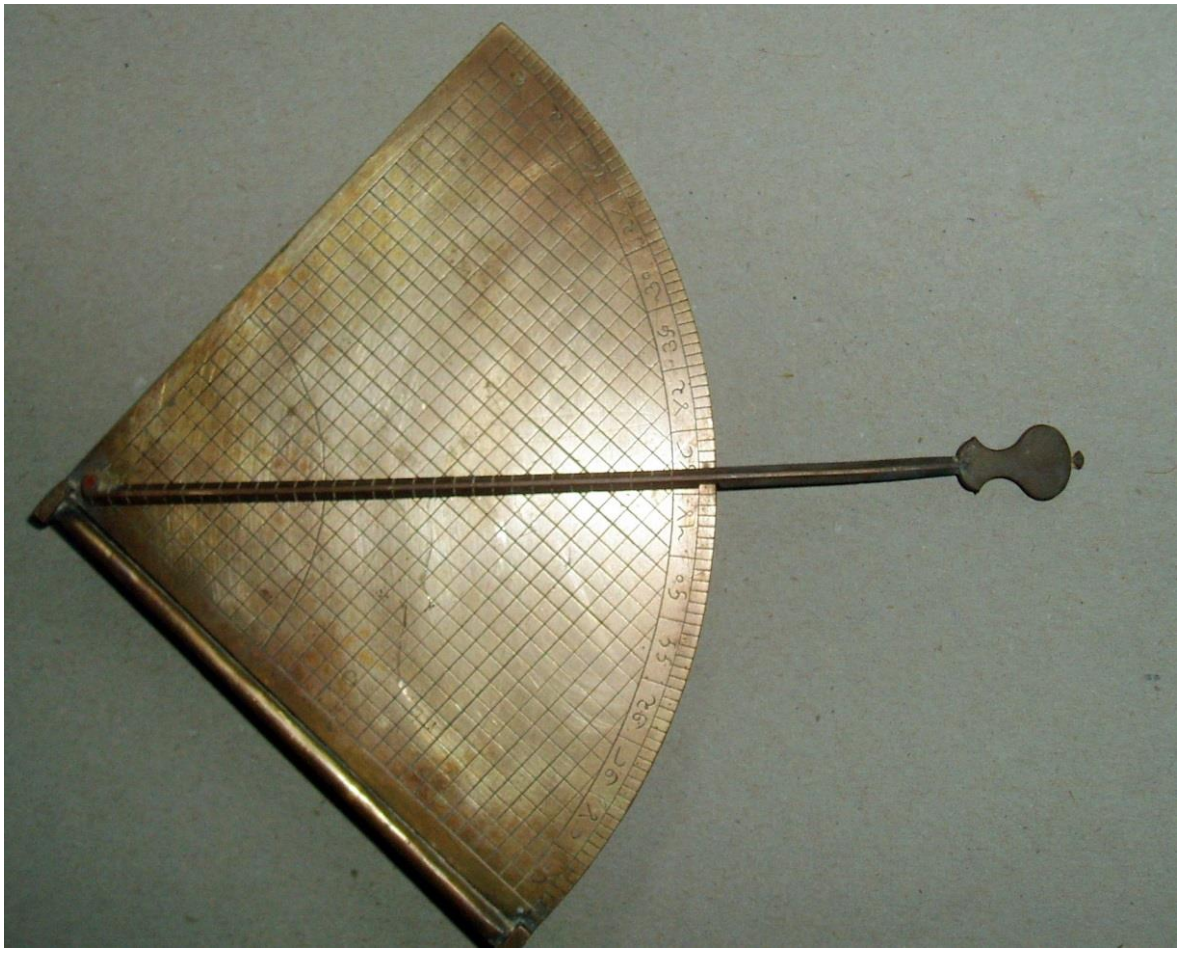


Figure K007.1 – Sine Quadrant (photo by S. R. Sarma)

Soon after the establishment of the Sanskrit Mahavidyalaya in 1915 where Sanskrit was to be taught in traditional method, some astronomical instruments were commissioned as teaching aids for Sanskrit astronomy (*Jyotiṣa*). This elegantly crafted quadrant is one of the six complete instruments which are still extant.

The present quadrant is engraved on a 2 mm thick brass plate cut in the shape of a quarter circle with a radius of 115 mm. To one of the sides is attached a sighting tube between two square supports. The tube is almost flush with the side of the quadrant. Along the arc of the quadrant, a circular scale in two bands is engraved. The outer band is divided in single degrees, while on the inner band groups of 6º are labelled in modern

Devanagari numerals from 6 to 90, starting from the corner close to the sighting tube and reaching up to the opposite corner.

The surface of the quadrant is filled with 30 horizontal parallels and 30 vertical parallels, but these are not numbered. A quarter circle is drawn tangent to the 12th line on the horizontal and vertical sides; this is the circle of obliquity. The lines are filled with a white substance so that they can be seen clearly.

A relatively long index of 175 mm is pivoted to a copper nail at the apex of the quadrant. The index has a triangular cross section and terminates in a violin-shaped weight. On the index are marked 30 divisions to match the 30 divisions on the sides of the quadrant. These divisions are engraved on the two upper sides of the triangular index so that the divisions can be read more conveniently. Such an index is not seen elsewhere and must be an innovation by the instrument maker of the Mahavidyalaya.

The back of the quadrant is blank. There is a projecting bit added at right angles to the surface of the plate. This appears to be a kind of handle to hold the quadrant while making observations.

K008⦿ SANSKRIT SINE QUADRANT, NOT SIGNED, NOT DATED

Early 20th century

151 x 154 x 3 mm

Vadodara, Maharaja Sayajirao University of Baroda, Sanskrit Mahavidyalaya

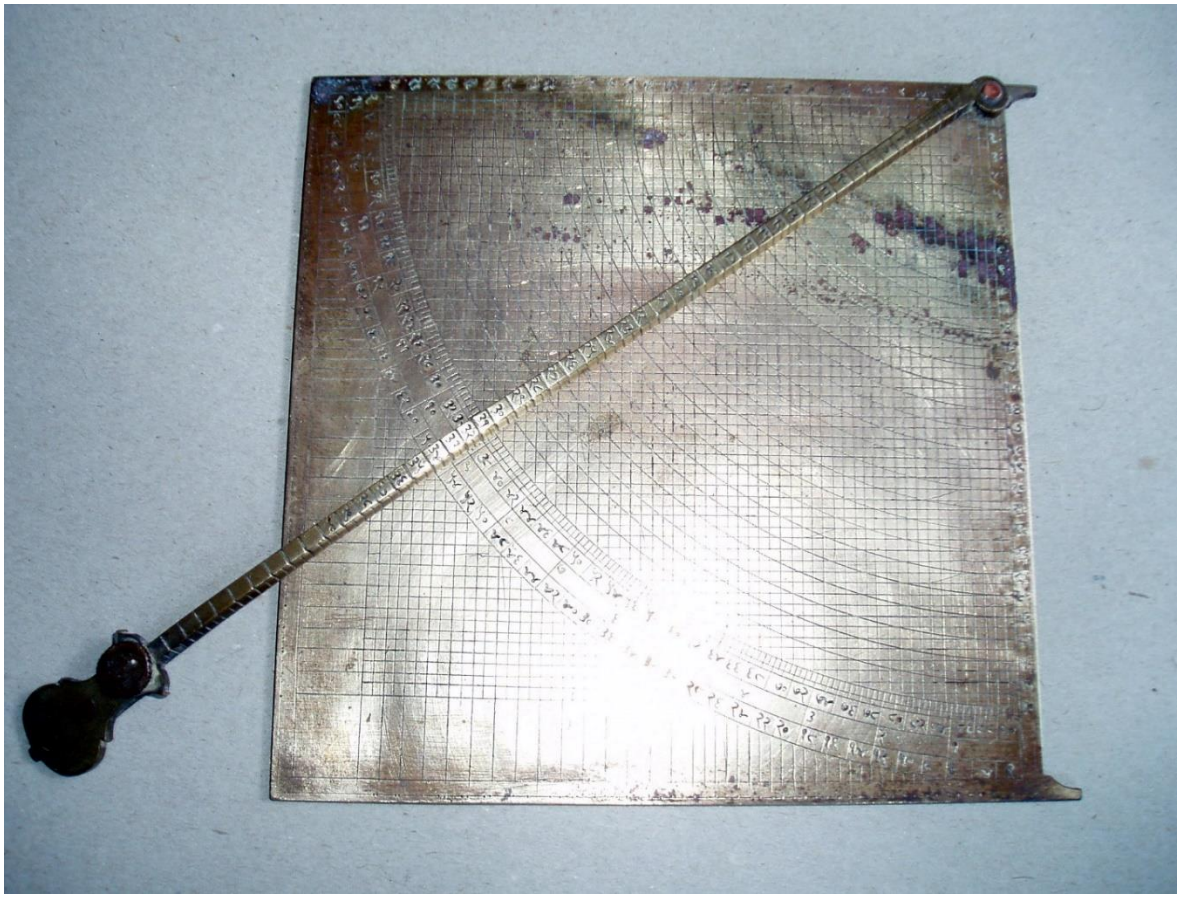


Figure K008.1 – Sine quadrant (photo by S. R. Sarma)

Like the previous quadrant (K007), this too is one of the instruments prepared as teaching aids in astronomy in the early twentieth century. It is engraved on a 3 mm thick brass plate. The plate is almost square, one side measuring 154 mm and the other 151 mm. On one of the longer sides, two supports of 8 mm height are attached at both the ends for holding a sighting tube, but the tube is now missing. At the upper corner of the same side is pivoted an index of 245 mm. This index also has a triangular cross section and terminates at a violin-shaped weight, as in the previous quadrant. At the back of this weight, there is a clip-like mechanism which was originally meant to fix the index at any desired position so that the reading can be recorded at leisure. But now the clip is broken and the index can not be fixed at any position. Such mechanism is not seen in any other quadrant and appears to be an innovation introduced by the artisan.

On the surface of the quadrant, an arc with a radius of 154 mm is drawn from the upper right hand side corner at the centre. Inside the arc is a circular scale of 19 mm width. This scale is divided into 5 bands. The innermost band is divided into units of 1/2° each, while the next very narrow band is divided into single degrees. In the following band groups of 2° are labelled as 2, 4, 6, … 86, 88, 90, starting at the lower left and reaching up to the upper right. These are the degrees of altitude (*unnatāṃśa*). The fourth band, which is very broad, is divided in 15 units, and labelled as 1, 2, 3 … 13, 14, 15, in the opposite direction, starting at the upper right and reaching up to lower left. These units represent the *nataghaṭīs,* i.e. the number of *ghaṭīs* to pass until the noon if observation is made in the forenoon or the *ghaṭīs* that have elapsed after the noon if the observation is made in the afternoon. The last or the outermost column is divided into 45 divisions and labelled 2, 4, 6, …86, 88, 90 in the same direction as the previous scale. These are degrees of the zenith distance (*natāṃśa*).

The horizontal and vertical radii of the quadrant within the inner column are each divided into 30 units, and labelled as 1, 2, 3, … 30, starting from the apex and reaching up to the arc. From these points, a series of 30 horizontal and 30 vertical parallels are drawn from each of the points of division. These are further subdivided into halves, so that there are 60 horizontal and 60 vertical parallels. The lines cover not only the surface of the quadrant, but extend to some distance beyond its outer arc. Also from each of these 30 points, quarter circles are drawn parallel to the arc of the quadrant and tangent to the 30 lines on the horizontal side and on the vertical side. Thus the surface of the quadrant is quite cluttered with 30 arcs, 60 vertical and 60 horizontal lines.

The index is graduated in the same divisions as the two radii and labelled from 1 to 40, but the divisions run beyond 40 up to the end of the index. On the adjacent surface of the triangular index, there are markings for ½ divisions.

The back of the quadrant is blank.

K009 SANSKRIT SINE QUADRANT, NOT SIGNED, NOT DATED

18th century ?

Radius 350 mm

Jaipur, Jai Singh's Observatory



Figure K009.1 – Sine quadrant (photo by Dr Jean-Michel Delire)

This sine quadrant is displayed at present in the gallery newly constructed in Jai Singh's observatory at Jaipur. It was not in the original collection at the observatory, when I had made the first inventory in 1991, nor have I seen it my subsequent visits. It appears to have been brought from some other collection. The museum label states that it is made of aluminium and was commissioned by Jai Singh in the eighteenth century. But the material and the construction are quite modern.

It is fairly large piece with a radius of 350 mm. The arc is divided in 1° and 6°; both divisions are numbered serially in clockwise direction. The degree scale is extended beyond 90° by about 24° for measuring larger angles. The surface is engraved by 30 vertical and 30 horizontal parallel lines. An index bar is pivoted to the apex. To the side on the right is attached a very sleek sighting tube with a funnel-shaped eye-piece.

K010⊙ SANSKRIT SINE QUADRANT, NOT SIGNED, NOT DATED

19th century

Radius 54 mm

Brussels, PC

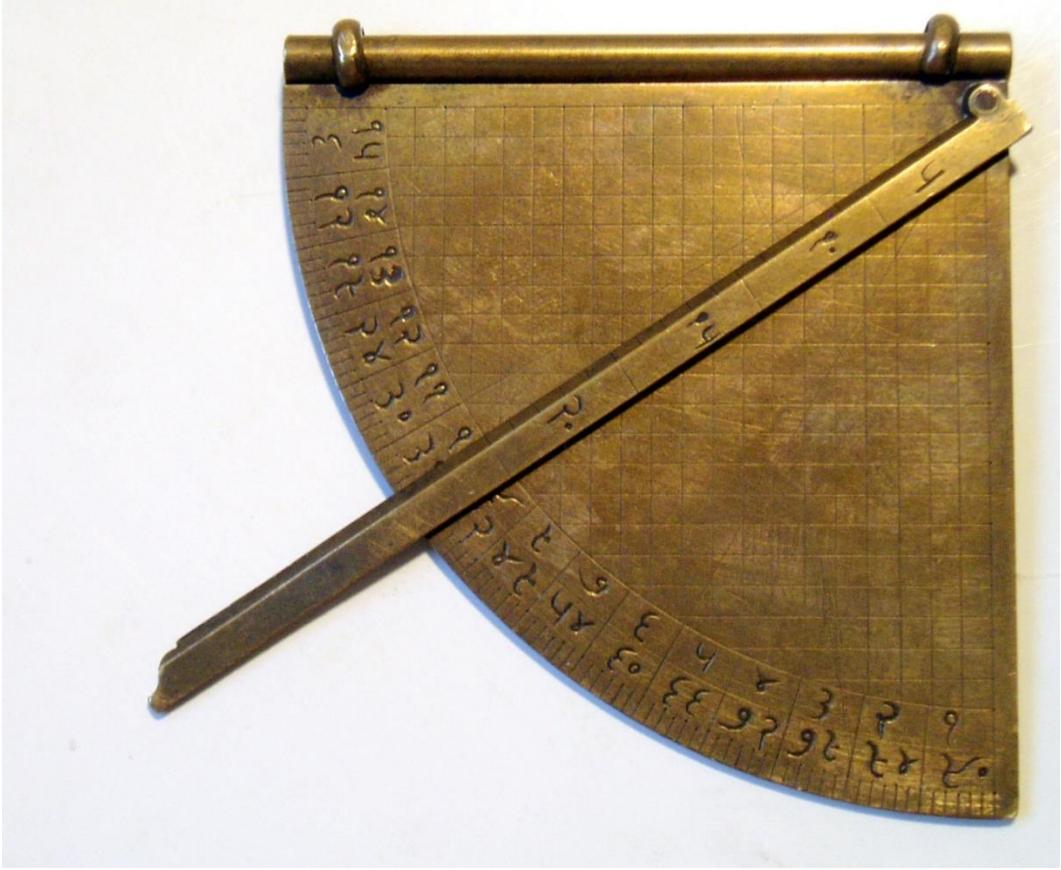


Figure K010.1 – Sine quadrant on the obverse (photo by S. R. Sarma)

This well-crafted sine quadrant is engraved with 20 horizontal parallels and 20 vertical parallels, which are not numbered. The degree scale on the arc is divided in 1° and groups of 6° are numbered from 6 to 90 anti-clockwise. In the next row these groups of 6° are numbered serially from 1 to 15 in the reverse direction. These indicate the time units of *ghaṭīs.* Two radial lines are engraved at 30 degrees intervals from the apex to the arc. A quarter circle is drawn tangent to the 8th line on the horizontal and vertical sides, to represent the obliquity of the ecliptic.

A thick sighting tube is attached to one of the straight sides by means of two rings. A 76 mm long index with a sloping edge is pivoted to the apex of the quadrant. It is divided into groups of 5 and numbered as 5, 10, 15, 20. These divisions correspond to the cells on the sine graph.



Figure K010.2 – Reverse side (photo by S. R. Sarma)

The reverse side bears an elaborate table in 9 columns and 19 rows. The upper row is labelled *dīnamāna* (sic! *dinamāna,* 'measure of the day'). The first column on the right is labelled *ghaṭīs* and the cells are engraved with numbers from 1 to 17, which show the half-duration of sunlight hours (from sunrise to midday, or from midday to sunset). The upper carries the numbers 27 to 34, which can be either the duration of the sunlight hours or the latitudes in northern India. But it is not clear how this table should be used in conjunction with the sine table engraved on the obverse.

Dīnamāna	27	28	29	30	31	32	33	34		*ghaṭi*
	5	5	5	5	5	5	5	5	1	
	10	10	10	10	10	10	10	9	2	
	15	15	15	15	15	15	14	14	3	
	19	21	21	21	21	21	21	19	4	

	23	25	26	26	26	26	25	24	5
	27	30	31	31	31	31	31	29	6
	31	35	36	36	36	36	36	35	7
	35	39	41	41	41	41	41	40	8
	38	43	45	46	46	42	47	45	9
	41	47	49	50	50	52	52	51	10
	43	50	53	54	54	57	57	56	11
	47	53	56	57	57	62	63	62	12
		55	58	60	62	67	68	67	13
		56	60	68	66	70	73	72	14
				63	76	73	77	77	15
						77	81	82	16
								87	17
								30	

Figure K010.3 – Table engraved on the reverse

K011⊙ GURMUKHI DOUBLE QUADRANT (CĀPA-YANTRA), NOT SIGNED

Not dated, mid-19th century

Diameter 130 mm

Germany, PC



Figure K011.1 – Double quadrant (photo by Oskar Kober)

Double quadrant is called *Cāpa-yantra* (bow instrument) in Sanskrit. In his *Brāhmasphuṭa-siddhānta*, Brahmagupta describes the construction and use of the double quadrant in detail and adds that the single quadrant is just a variety of the double quadrant.[1337] *Cāpa-yantras* must have been produced and used by astronomers of India from Brahmagupta's time onwards, but this and the next one are the only specimens extant.

It is made of copper with a diameter of 310 mm. Along the diameter is attached a sighting tube, made of brass, which has now become slightly bent. From the centre of

---

[1337] Brahmagupta, *Brāhmasphuṭasiddhānta,* 22.8-17; cf. Sarma 1986-87a; Sarma 2008d, pp. 33-34.

the semicircle is suspended a plumb line, which passes through a hole in the centre and hangs on both sides of the quadrant, with a cone-shaped copper bead attached to each end. A copper wire is tied to the two ends of the sighting tube, probably for suspending the instrument when not in use. A 265 mm long handle with a fan-shaped top is attached to the double quadrant, at the central point of the arc.

The labels on it are in Panjabi language and in Gurmukhi script,[1338] as in the Gurmukhi astrolabe made for the Maharaja of Patiala in 1850 (C031); it may also have been produced about the same time at the court of Patiala.

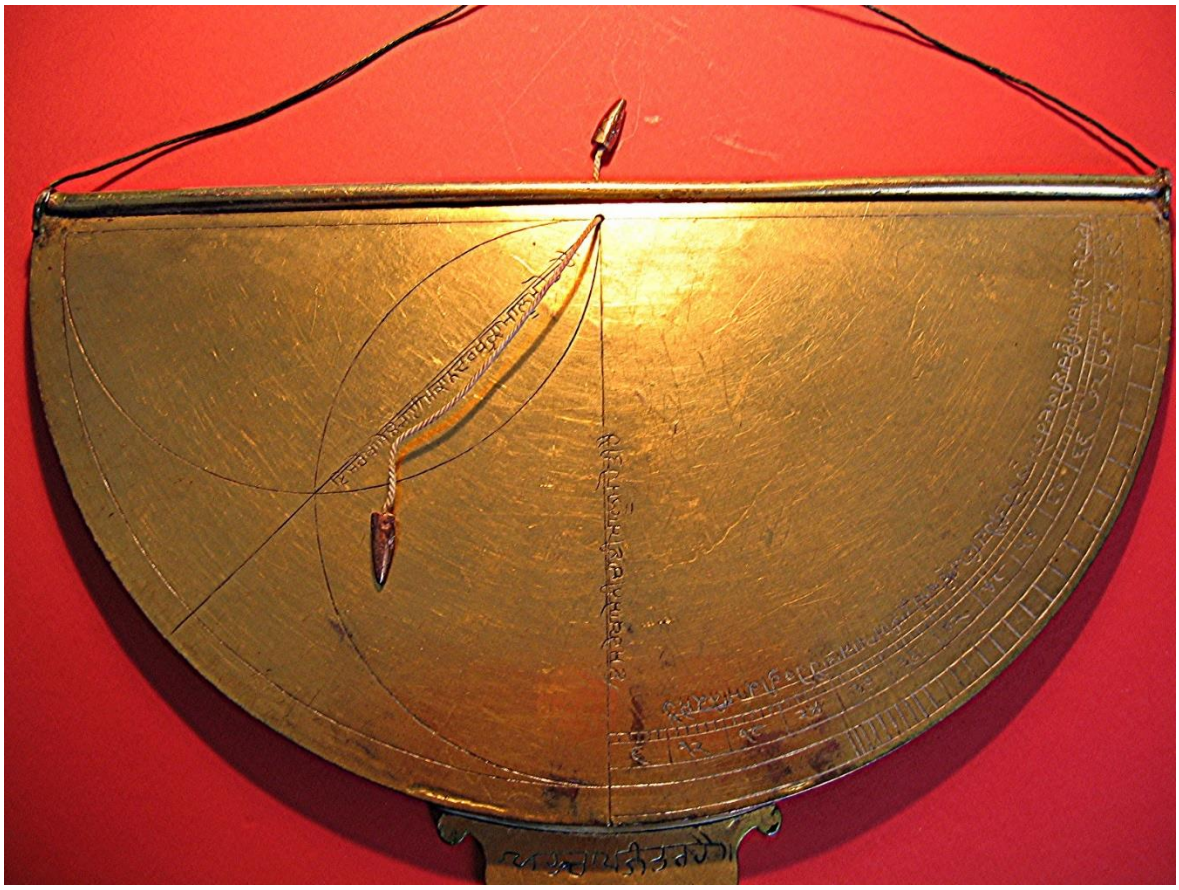


Figure K011.2 – Obverse side of the double quadrant (photo by Oskar Kober)

On the obverse side, on the fan-shaped top of the handle is engraved in Panjabi language and Gurmukhi script *hayahu cāp jīt rahai,* ‘may this bow [instrument] be victorious’.

1338 I am grateful to Dr Jaspal Singh, Cambridge, Mass, for his help in deciphering and translating the Panjabi passages.

The semi-circle is divided into two halves by a radius in the middle. On the quadrant on the left hand side, two semicircles are drawn along the vertical and horizontal radii. Through their intersection is drawn a radial line, along which is engraved the inscription: *is rekhā se u[ṃ?]cāī makān darakht kā mālūm hotā hai,* 'with this line, the height of houses and trees becomes known'.

Along the vertical radius which divides the semi-circle into two quadrants is engraved the inscription: *is rekhā se nīcāī mālūm hotā hai,* 'with this line, the depth becomes known'.



Figure K011.3 – Detail of the obverse side (photo by Oskar Kober)

In the quadrant on the right hand side, there are three scales along the arc. The innermost scale is divided into single degrees. The middle scale is divided into groups of 6° and is labelled as 6, 12, … 90, starting from the vertical radius and reaching up to the horizontal diameter. The outermost scale is a co-tangent scale as is found on the back of the astrolabes. Along these scales is engraved the inscription. The first eight syllables could not be deciphered; the rest is as follows: ... *ūcāī ke darje mālūm hotā hai* [|] *dariyāu kā coḍāī māpā jātā hai hor bhī kām nikase he* (?), '[With this scale along the arc] the degrees of height (i.e. of altitude) become known [.] The breadth of rivers can be measured [.] Other tasks also can be performed.'

Thus these inscriptions emphasize that the *cāpa-yantra* or double quadrant can be used for astronomical observations as well as for land survey.

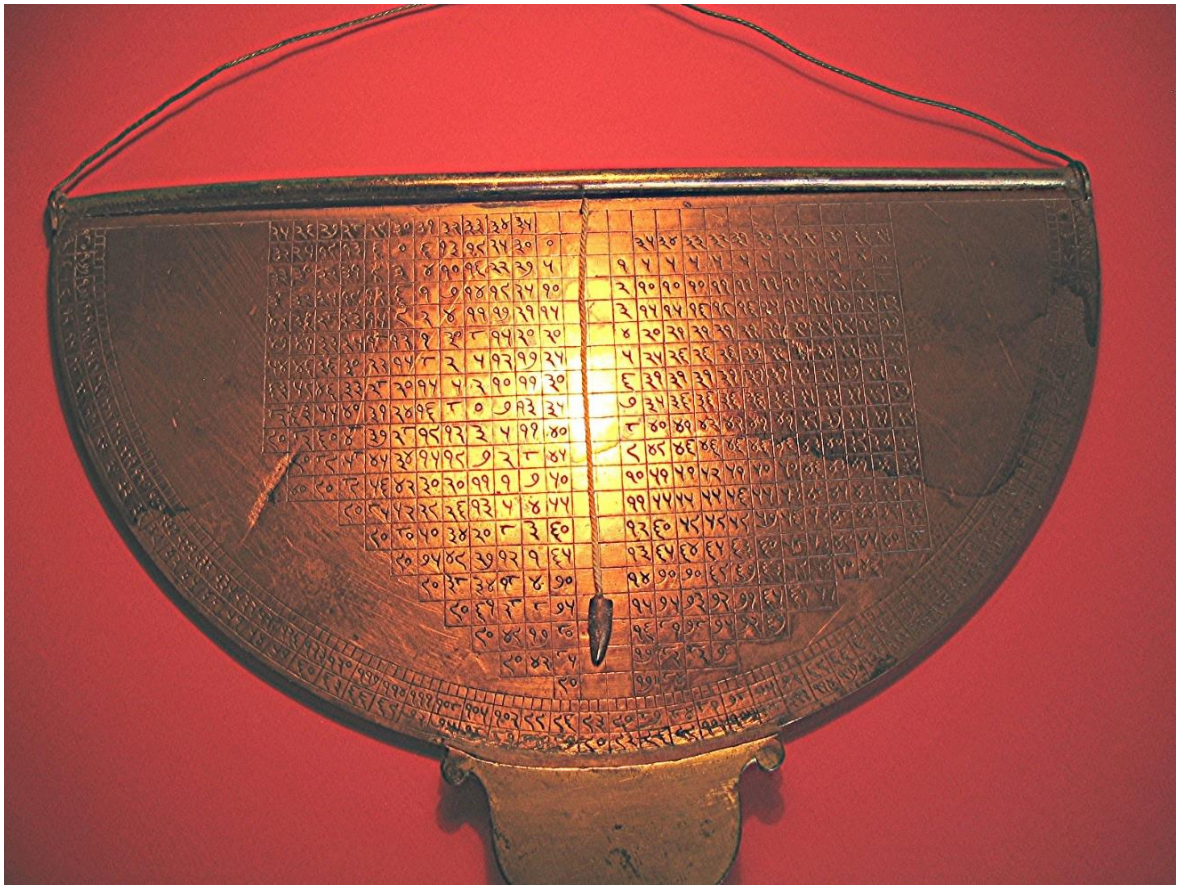


Figure K011.4 – Reverse side of the double quadrant (photo by Oskar Kober)

On the reverse side, there are three scales along the semi-circular arc. The outermost scale is divided into units of 3° each and is labelled as 3, 6, 9 … 174, 177, 180 from left to right. The middle scale is also calibrated for 3° and labelled as 3, 6, 9 … 174, 177, 180 in the reverse direction, i.e. from the right to the left. The innermost scale is calibrated into single degrees. Within these scales is a large table in two halves.

The first column in the right half is engraved with numbers 1 to 17 and 17 ½. As in the previous specimen (K010), these show the half-duration of daylight in *ghaṭīs*. The upper row in the left half is engraved with numbers 25 to 35; the same numbers in reverse order are engraved in the right half. These could be the latitudes or duration of the daylight in *ghaṭīs*. How this table should be used in conjunction with the geometrical quadrants on the obverse is not known.

Left Half of the Table

25	26	27	28	29	30	31	32	33	34	35	
32	25	19	13	6	0	6	13	19	25	32	0
33	30	22	31	9	3	4	10	16	22	27	5

38	32	35	19	12	6	1	7	14	19	25	10
42	36	28	23	15	9	2	4	11	17	21	15
47	41	33	25	18	12	1	30	8	15	20	20
54	46	36	30	22	15	8	2	5	12	17	25
63	59	46	33	28	20	15	5	2	10	11	30
82	63	55	40	31	24	16	8	0	7	13	35
90	82	60	48	37	28	19	12	3	5	11	40
	90	89	58	45	34	15	19	7	2	8	45
	40	90	89	56	42	30	20	11	1	7	50
			90	85	52	29	26	13	5	4	55
				90	80	50	34	20	8	3	60
					90	75	49	27	12	1	65
						90	38	34	18	4	70
							90	61	28	8	75
								90	49	17	80
									90	42	85
											90

Right Half of the Table

	35	34	33	32	31	30	29	28	27	26	25
1	5	5	5	5	5	5	5	5	5	4	4
2	10	10	10	11	11	11	10	10	9	9	8
3	15	15	16	16	16	15	15	15	10	13	13
4	20	21	21	21	21	21	20	20	19	18	11?
5	25	26	26	26	27	26	25?	24	23	21	21
6	31	31	31	31	31	31	30	29	27	21	20

7	35	36	36	36	36	36	35	33	31	29	27
8	40	41	42	42	41	41	39	37	35	31	29
9	49	46	46	46	46	46	43	40	39	34	32
10	51	51	52	51	50	50	46	43	41	3??	34
11	55	55	55	56	55	53	48	45	43	39	35
12	60	59	59	59	57	56	52?	48	44	39	36
13	65	64	65	63	60	58	53	49	45	42	38
14	70	70	69	67	63	59	54	50	46		
15	75	73	72	71	65	61	55				
16	81	78	75	72	67						
17	82	82	78?								
17 ½	84										

Figure K011.5 – Table on the reverse side

K012 CĀPA-YANTRA PRESENTED BY THE MAHARAJA OF BENARES TO THE PRINCE OF WALES, 1876

Dimensions ?

PLU

During his tour of India in 1875-76, the Prince of Wales (the future Edward VII) was presented a set of astronomical instruments by the Maharaja of Benares, Sir Ishwari Prasad Narayan Singh, GCSI, on 5 January 1876. An account of this tour was published by William Howard Russel in his *The Prince of Wales' Tour.* A detailed list of the presented instruments is added at the end of the book (pp. 616-617).

The list was apparently prepared by Bapu Deva Sastri, the well-known scholar of Indian astronomy who did pioneering work in interpreting Sanskrit astronomy for modern readers. He was at that time Professor of Astronomy at the Queen's College, also known as Sanskrit College of Benares.[1339] It is quite likely that the instruments were prepared under his direction. These instruments include

> 8. CHÁPA-YANTRA (semi-circle) [for] for finding the zenith distance and altitude of the sun.

These instruments are not with any public museum in UK; they may be in some uncatalogued collection of the British royal family.

BIBLIOGRAPHY

William Howard Russel, *The Prince of Wales' Tour: A Diary in India; with some account of the visits of His Royal Highness to the courts of Greece, Egypt, Spain, and Portugal*, with illustrations by Sydney F. Hall, M.A., Artist in the Suite of H.R.H. The Prince of Wales, second edition, Sampson Low, Marston, Searle & Rivington, London 1877, pp. 389-91; 616-17.
https://archive.org/details/princeofwalestou00russuoft
[also https://goo.gl/V8sHM3, last accessed in June 2017].

Sarma 1996c.

Sarma 2014b.

[1339] Cf. Sarma 1996c.

K013 TURĪYA-YANTRA, NOT SIGNED, NOT DATED

Probably 19th century

Dimensions ?

PLU; ex-Kota, palace of the Mahārāo.

In his celebrated essay of 1834, Lancelot Wilkinson reports: 'The Maháráo's collection contains also a Turíya Yantrá, or quadrant, with a radius on one side of 30 digits, and linear rectangular intersections, rising from each digit, representing their whole canon of sines, cosines, and versed sines adapted to this radius.'[1340]

In 2000 V. N. Sharma published an account of the astronomical instruments displayed in the palace museum at Kota, but this sine quadrant is not amongst them.[1341] Its present location is unknown.

BIBLIOGRAPHY

Wilkinson 1834, p. 515.

1340 Wilkinson 1834, p. 515.

1341 Sharma 2000.

K014 TURĪYA-YANTRA PRESENTED BY THE MAHARAJA OF BENARES TO THE PRINCE OF WALES, 1876

Dimensions ?

PLU

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> 9. TURÍYA-YANTRA (a quadrant) [for] for finding the zenith distance and altitude of the sun.

These instruments are not with any public museum in UK; they may be in some uncatalogued collection of the British royal family.

BIBLIOGRAPHY

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https://archive.org/details/princeofwalestou00russuoft
[also https://goo.gl/V8sHM3, last accessed in June 2017].

Sarma 1996c.

Sarma 2014b.

[1342] Cf. Sarma 1996c.

K015 YANTRA-CINTĀMAṆI BY VAIJANĀTHA'S SON, 1891 VS (AD 1834)[1343]

Dimensions?

PLU; Kolkata, The Asiatic Society?

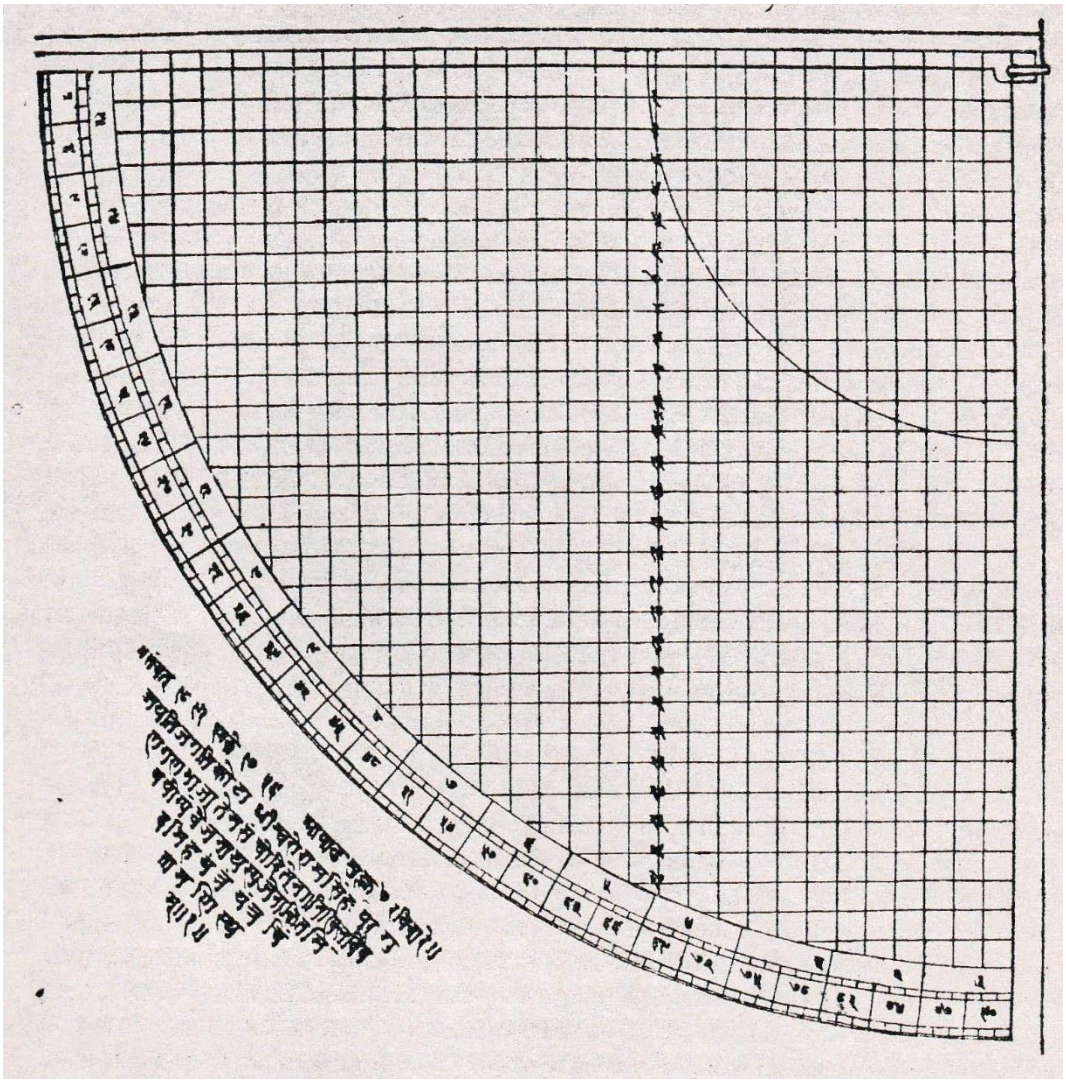


Figure K015.1 – Sine quadrant (from Middleton 1839)

This silver instrument, completed on a date corresponding to 11 July 1834, was designed by a man who does not mention his actual name but calls himself merely the son of Vaijanātha. About the father Vaijanātha, Lancelot Wilkinson states that he was the family priest (*purohit*) of the Maharao of Kota and was well-versed in

[1343] Entry based on Middleton 1839.

Jyotiḥśāstra.[1344] The instrument was commissioned by Maharao Ram Singh II (r. 1818-1866), the ruler of the princely state of Kota in Rajasthan, who presented it to the British colonial Government of India, with its capital at Calcutta (now renamed Kolkata).

Artefacts presented to the British Colonial Government or those collected by the various officials were preserved in those days in the Asiatic Society at Calcutta which was established in 1784. Later many of these were transferred to the Indian Museum which was founded at Calcutta in 1814. Neither institution responded to my queries about the presence of this instrument in their holdings. Its present location, therefore, remains unknown.

J. J. Middleton, Esq., of the Hindoo College, Calcutta, published its description, together with three drawings, under the title 'Description of an Astronomical Instrument presented by Raja Ram Sing [sic! Singh] of Khota [sic! Kota], to the Government of India' in the *Journal of the Asiatic Society* in 1839.[1345]

Middleton states that 'the instrument consists of a square plate of pure and massive silver,' but neglects to mention its dimensions. The obverse side is engraved as a sine quadrant and the reverse side carries circular scales displaying the oblique ascensions of the zodiac signs. At the centre is pivoted a highly ornate index with four arms which are at right angles to one another. When the sun is sighted by appropriately tilting the plate in a vertical plane, the plumb line on the sine quadrant shows the altitude of the sun at the moment of observation which can be converted into the time since sunrise in *ghaṭīs,* and the four arms of the index on the reverse side will point the four pivots,

---

1344 Wilkinson 1834, p. 399. 'I have met and cross-questioned many hundreds of Joshís of late years; but in this large number, have found only two men who had a rational and full acquaintance with their own system. One is VAIJNA′TH, purohit of the Mahárάo of Kotah ; the other, JINCHAND, a jattí (sic! *Yati*) of great celebrity at Ajmere, and late of Jhulai′ in Jypur. It is singular that neither of these are professed jyotishís ; the former an expounder of Puráns, and the latter a great Gurú of Jains.'

1345 Middleton 1839. British colonials generally do not acknowledge the help of the 'natives', but Middleton is a laudable exception. He concludes the article thus: 'I must not quit this subject without expressing my grateful acknowledgements to Bishnonath Turkabhooshuna (sic! Viśvanātha Tarkabhūṣaṇa) and Jogodhan Missi (sic! Yogadhyāna Miśra), two learned Pundits of this city, for their valuable assistance in translation of the inscription.' This Yogadhyāna Miśra published in 1828 the *Kṣetra-tattva-prakāśa,* based on Charles Hutton's *Geometry,* at the instance of A. F. Troyer, the secretary of the Calcutta Sanskrit College; cf. Sarma 1996c, p. 194.

namely the ascendant, descendant, upper mid-heaven and lower mid-heaven at the place of observation.

Sine Quadrant

The sine quadrant on the obverse contains 30 horizontal and 30 vertical parallels. These are not numbered along the two radii. A degree scale in three bands is engraved on the arc. The outer band is divided in 1° and in the middle band groups of 3° are numbered anti-clockwise from 3 to 90. In the inner band groups of 6° are numbered clockwise from 1 to 15, these representing the time units of *ghaṭīs.* At 12 ¾ from the apex a quarter circle is drawn as the circle of obliquity. The 12th vertical line is numbered at each intersection from 1 to 27 from the radius to the arc. There is said to be an index pivoted to the apex of the quadrant, but it is not shown in the illustration. There is said to be a sighting tube of about 4 mm diameter attached to one of the sides of the plate; this not shown in the illustration either.

Reverse Side

The reverse side is engraved with several concentric circular scales. Inside the outer circumference, there are four circular scales displaying the oblique ascensions of the six pairs of the zodiac signs in one half of an equinoctial day of 30 *ghaṭīs*. Counting from the inside, the first or the innermost one is divided in 30 equal divisions, which are numbered from 1 to 30 anti-clockwise. These are the *ghaṭīs* in a half day.

Scale 2 is divided in cells which are numbered from 1 to 30 six times (= 2° each). The beginning of these two numbered scales do not coincide.

In scale 3, each cell of scale 2 is divided into 4 parts (= ½° each).

Scale 4 carries six cells of varying lengths, filled with the names of zodiac signs Aries to Virgo anti-clockwise and Libra to Pisces clockwise, so that Aries and Pisces occupy the first cell, Taurus and Aquarius the second cell and so on. The names of Cancer and Sagittarius, of Virgo and Libra are not shown in the illustration.

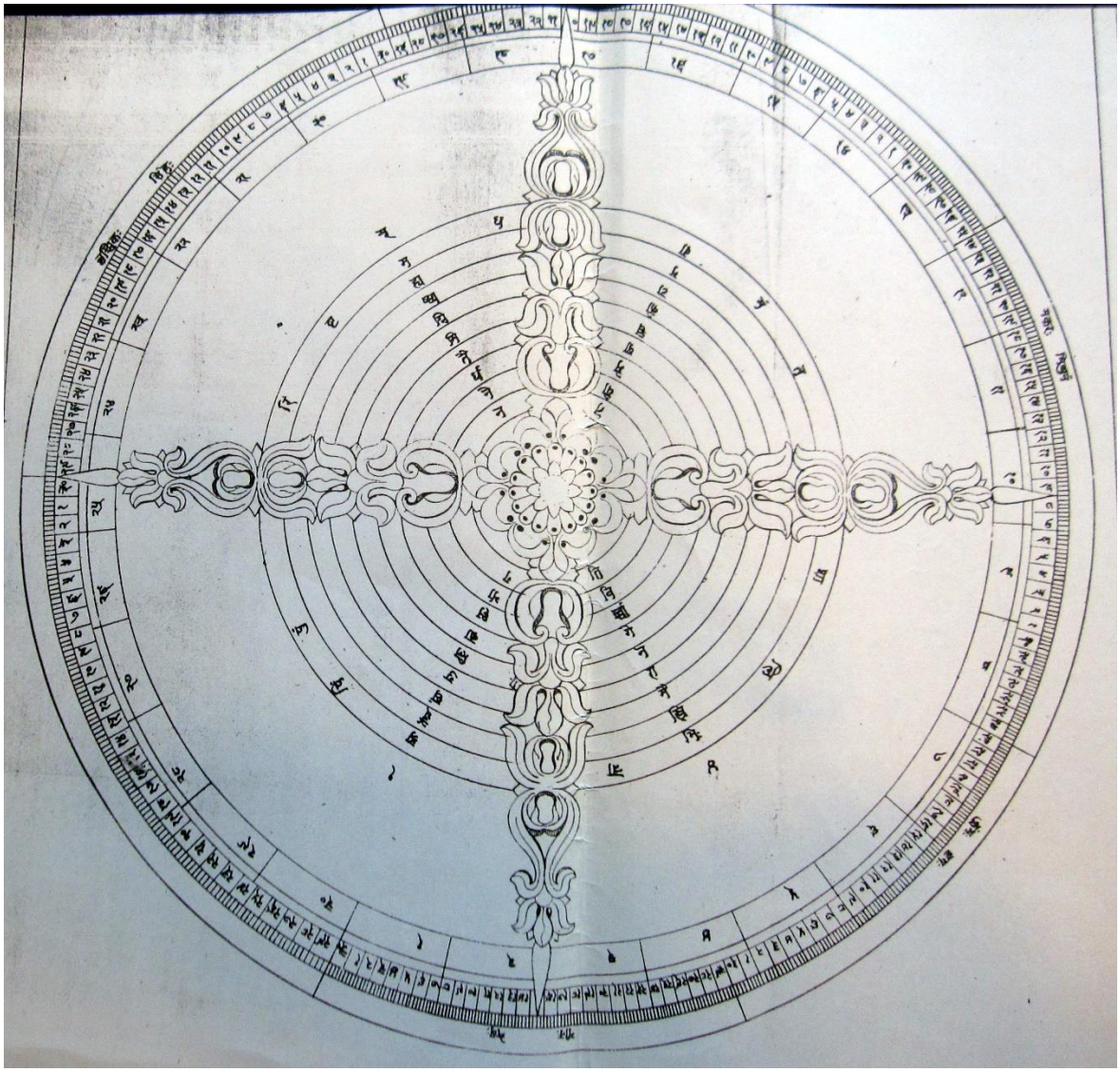


Figure K015.2 – Oblique ascensions on the reverse (from Middleton 1839)

Some distance away from these four scales, ten concentric circles are drawn where the syllables of a Sanskrit verse are arranged in the so-called *Padma-bandha* (lotus arrangement) mode, with the syllable *mi* engraved in a large size at the centre of the circles. The syllables of the first three feet of a verse are written along the three diameters, marked 1, 2 and 3, in such a manner that the syllable *mi* is incorporated in the middle of each foot. The fourth foot of the verse is written in the outer circle.

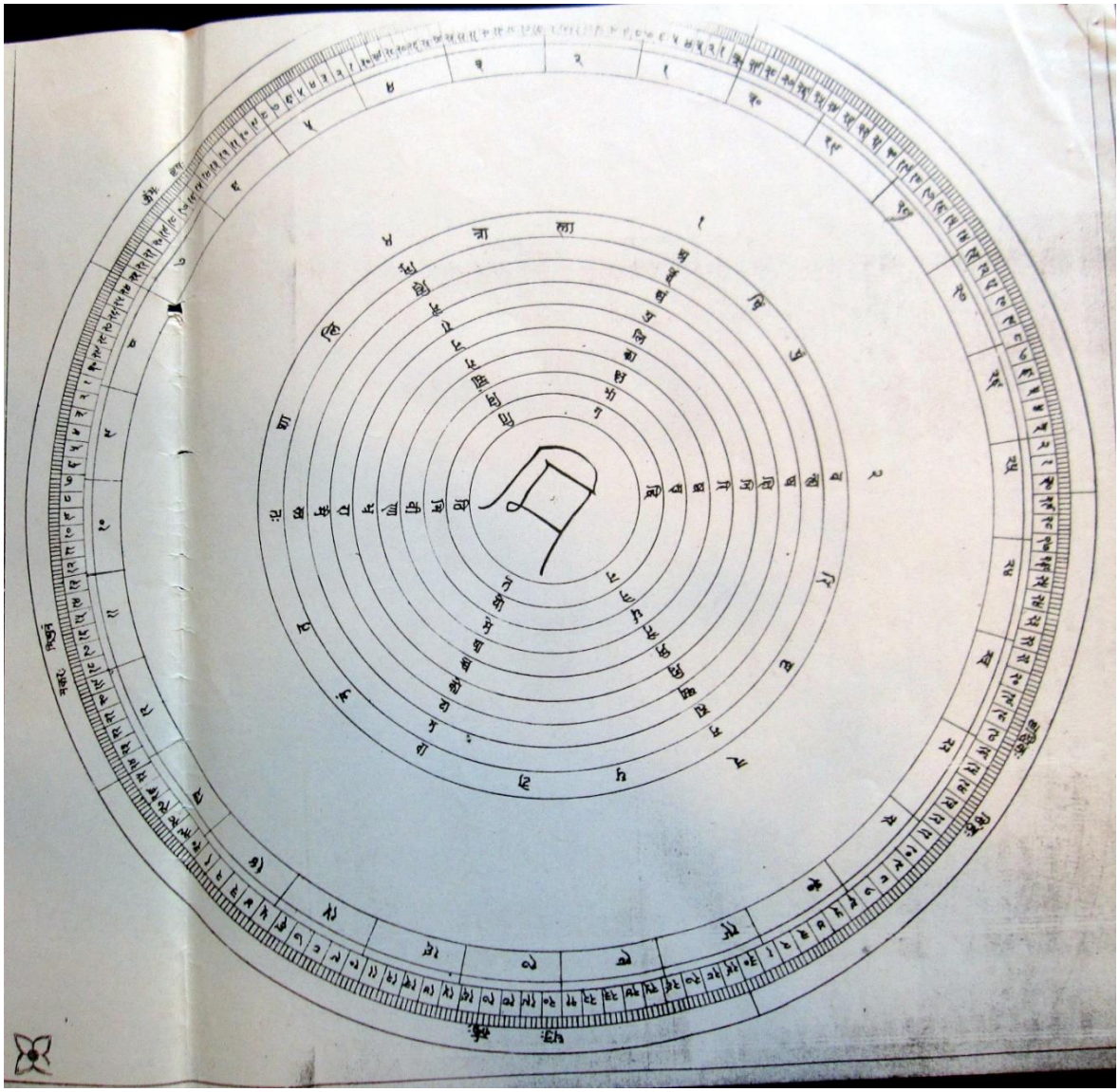


Figure K015.3 – Reverse side without the index (from Middleton 1839)

The verse in the *Śārdūlavikrīḍita* metre mentions the noon equinoctial shadow (*akṣabhā*) at Kota and then enumerates the oblique ascensions of the zodiac signs at Kota. The numerical quantities are expressed in the so-called *Bhūtasaṃkhyā* system. The verse is difficult to decipher in many parts because the conjunct consonants are not clearly reproduced in the illustration. Therefore, we follow Middleton's translation:

> 'The length of the shadow of the gnomon at Khota is five *aṅgulas* and 30 *vyaṅgulas,* in consequence of which the elevation of the signs above the horizon takes place in times the particulars of which are as follows:
>
> | | | | | |
> |---|---|---|---|---|
> | Aries | 3 | Dundas | 43 | Pulas |
> | Taurus | 4 | " | 15 | " |
> | Gemini | 5 | " | 41 | " |

Cancer	5	“	41	“
Leo	5	“	43	“
Virgo	5	“	33	“

‘But the other six signs, namely Libra, Scorpio, Sagittarius, Capricorn, Aquarius and Pisces are in point of rising above horizon equal to the former six, when taken inverse order; that is to say, Libra rises at the same time as Virgo, and so on.’

In this translation, the term ‘Dunda’, more correctly *daṇḍa,* is used in the sense of *ghaṭī* and the term ‘Pula’ should be understood as *pala,* one-sixtieth part of a *ghaṭī.*

In fact, there is no need of this verse for enumerating the oblique ascensions. The four circular scales display not only the oblique ascensions, but also their sub-divisions more effectively. The verse was added merely to impress the patron Ram Singh and through him the British Colonial Government with the erudition and verbal jugglery of Vaijanātha’s son.

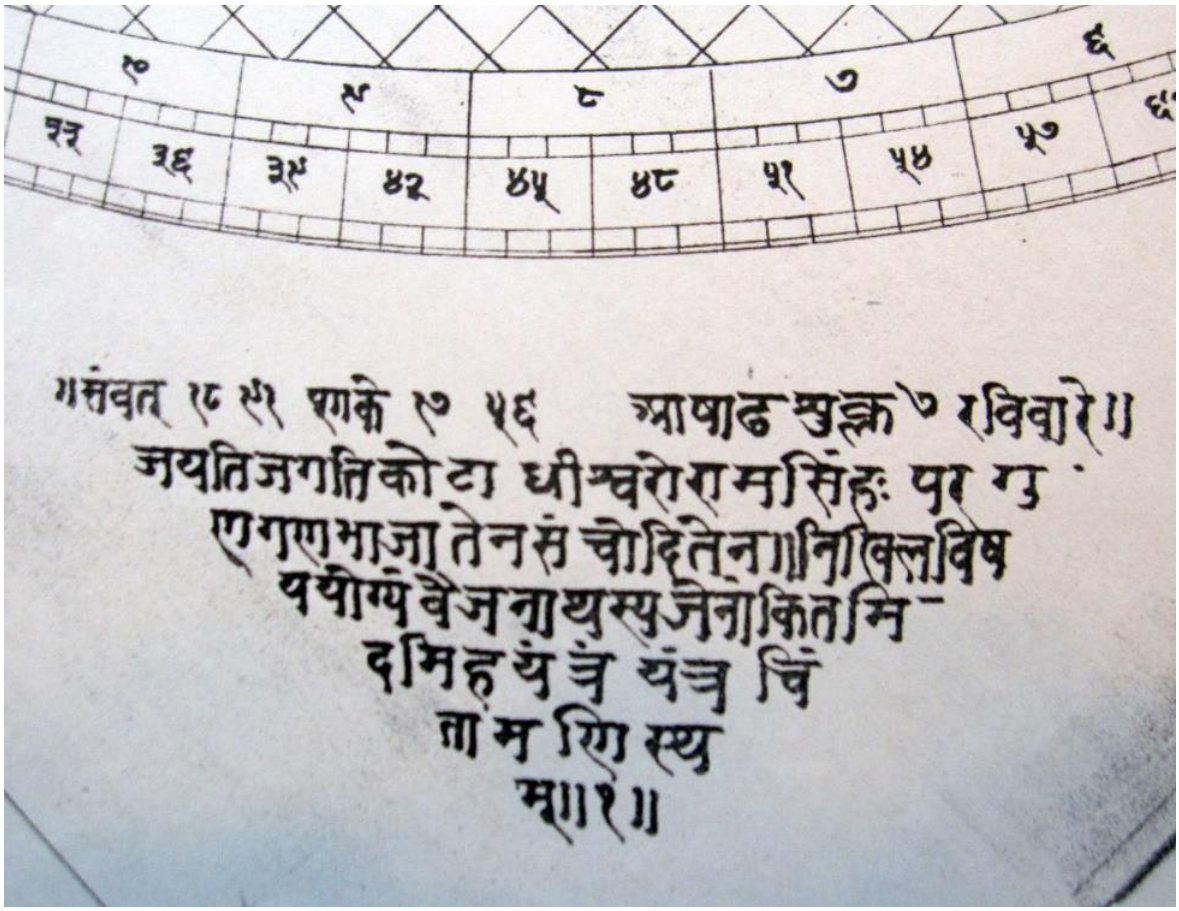


Figure K015.4 – Inscription (detail of Figure K015.1)

INSCRIPTION

On the obverse side, in the space between the arc and the corner of the plate, the following inscription, in the *Mālinī* metre, is engraved.

> ‖ *saṃvat 1891 śāke 1756 āṣāḍha śukha 7 ravivāre* ‖
> *jayati jagati koṭādhīśvaro rāma-siṃhaḥ*
> *paraguṇagaṇabhājā tena saṃcoditena [|]*
> *nikhila-viṣaya-yogyaṃ vaijanāthasyajenāṃ-*
> *kitam iha yaṃtraṃ yaṃtra-ciṃtāmaṇistham* ‖ *1*‖
> 'In the *Saṃvat* [year] 1891, *Śaka* [year] 1756, on Sunday, the seventh [lunar day] in the bright half [of the month of] *Āṣāḍha* ‖
> 'May Rāma Siṃha, the ruler of Koṭa, be victorious in this world. Under his orders, he who is appreciative of the merits in other persons, this instrument was prepared by Vaijantha's son, the instrument which is [described] in the *Yantra-cintāmāṇi* and which is suitable for all regions (*sakala-viṣaya-yogya*).'

In this verse, the compound *vaijanāthasyaja,* in the sense of 'Vaijanātha's son,' is grammatically inadmissible; it ought to be *vaijanāthātmaja,* and this would also fit in the metre. It cannot be decided whether this gross error was committed by Vaijanātha's son, or by the silversmith who fabricated the instrument and engraved the letters, or by the person who drew the illustrations for Middleton. It is also inexplicable why Vaijanātha's son did not mention his actual name by choosing an appropriate metre. In Muslim culture, there are instances where a person is known as *Ibn X* (son of X), but no such practice is prevalent among the Hindus.

The date translates to Sunday, 11 July 1834. The *Yantra-cintāmaṇi* is the manual on the construction and use of the sine quadrant composed by Cakradhara. Wilkinson writes that he obtained a copy of this text from the court astronomer of Kota sometime before 1834.[1346] Therefore, the text must have been available to Vaijanātha's son also in 1834. The instrument is said to be 'suitable for all regions'; it means that it can be used

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[1346] Wilkinson 1834, p. 515: 'From Maháráo's astronomer, I procured a copy of the Yantra Chintámani, by CHAKRADHARA, son of SRI WÁMANA, containing directions for the construction and use of the instrument, with the mathematical proofs and demonstrations of all the many problems which may be worked by it.'

at all terrestrial latitudes. However, this is true only as the sine quadrant on the obverse is concerned; the oblique ascensions on the reverse are valid only for the latitude of Kota.

BIBLIOGRAPHY

Wilkinson 1834.

Middleton 1839.

Rai 1985, pp. 326-327 (illustrates and describes the sine quadrant, but not the oblique ascensions on the reverse).

K016 YANTRA-CINTĀMAṆI BY HṚṢĪKEŚA FOR THE SON OF CAṆḌĪDATTA[1347]

Not dated, mid-19th century

Radius 137 mm

Chicago, Adler Planetarium (# W-103)

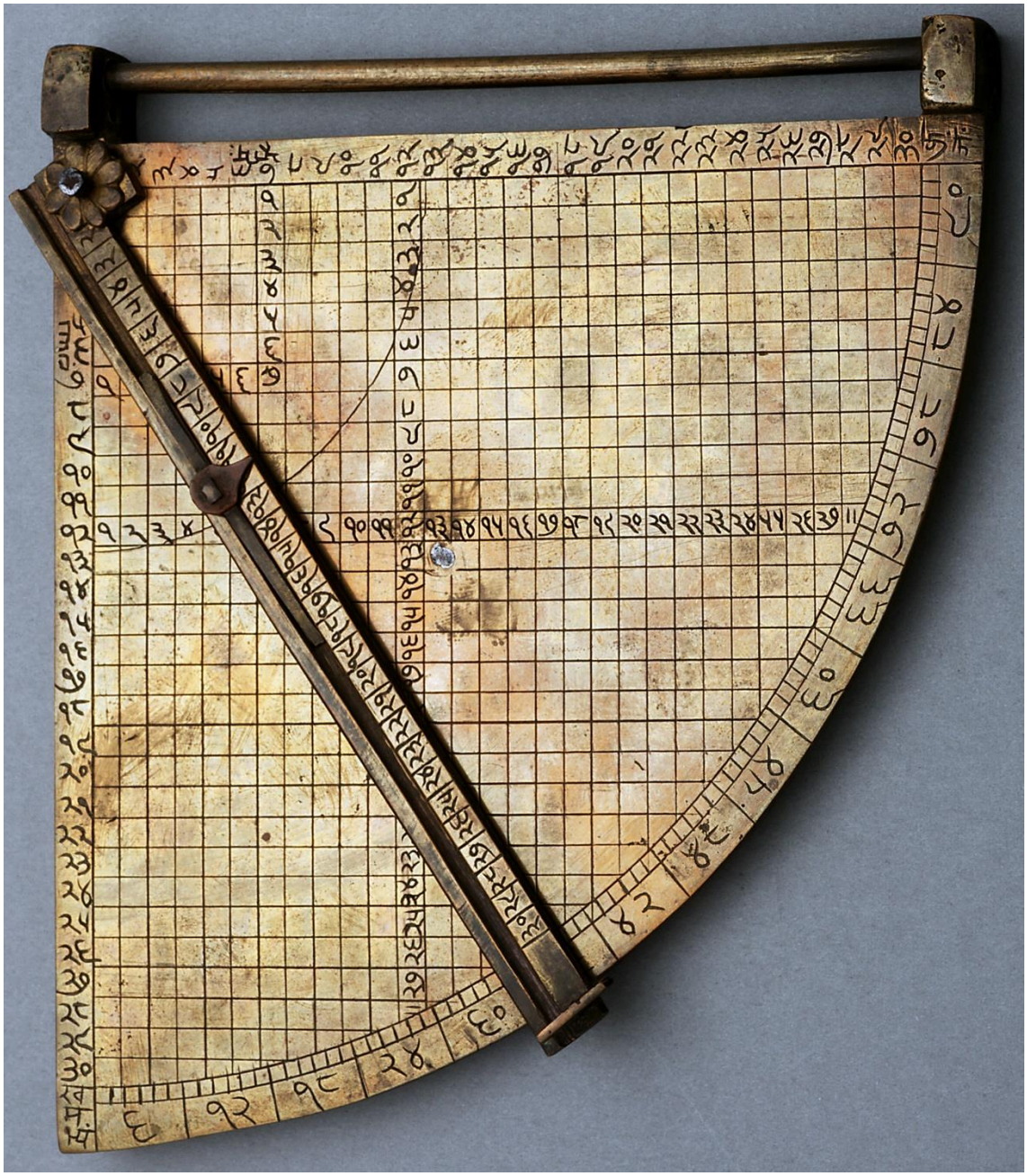


Figure K016.1 – Sine Quadrant (accession no. W-103)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

[1347] Entry based on Pingree 2009, pp. 206-207, and photos kindly provided by the Adler Planetarium.

On the back of this well-crafted instrument is written that it was made by Jyotirvid (astrologer/astronomer) Hṛṣīkeśa. It is probable that he is identical with the Rishīkes who designed the Gurmukhī astrolabe in 1850 (C031) and with the Jyotirvid Hṛṣīkeśa of Kumaon who owned the reworked astrolabe E005. Then this quadrant too must have been produced in the middle of the 19th century. According to Pingree, the noon equinoctial shadow of 7;1 mentioned on the back of the instrument indicates a latitude of ca. 30;20. This would exactly be the latitude of Patiala (30;20,24° E, 76;22,40 E). This factor also strengthens the probability that this instrument was designed at the court of Patiala by the same Jyotirvid Hṛṣīkeśa of Kumaon.

The instrument has the shape of a quarter circle. At the two ends of the horizontal radius are two rectangular sights, these are thicker than the plate and are pierced with two pinholes. A sighting tube is inserted in the larger pinholes of the two sights. An index is pivoted to the apex of the quadrant in the front; there are two flower-shaped washers on both sides of the plate. On the back is an index pivoted to the centre of the circles, with a flower-shaped washer.

Sine Quadrant

The obverse side is fashioned as a sine quadrant. The arc is divided in 1° and groups of 6° are numbered from 6 to 90 anti-clockwise. Inside the degree scale, the quadrant is engraved with 30 horizontal and 30 vertical parallels and numbered from 1 to 30 from the apex to the arc along each radius. At 12 ¼ divisions the quarter circle of obliquity is drawn. The horizontal and vertical columns for 12 are numbered from the radius up to the arc. The horizontal and vertical columns for 7 are numbered partially up to 7 cells in each direction. The 0° point on the arc is labeled *kha-madhya* (zenith), the 90° point *kuja* (horizon) and the horizontal radius *bhūmi* (earth), as prescribed by Cakradhara. At the 7° on the vertical side is engraved *nasab* in Arabic (proportion).

The broad index, pivoted to the apex of the quadrant, is graduated and numbered in the same manner as the two radii. There is a longitudinal groove on the surface of the index in which slides a circular curser with a pointed tip. On the lower edge of the index is affixed a bar which prevents the cursor from sliding out of the groove.



Figure K016.2 – Oblique ascensions on the reverse side (accession no. W-103)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

REVERSE SIDE

The reverse side carries the projections of oblique ascensions in eight concentric circular scales as shown below:

1. Degree scale divided in 2°.
2. Groups of 12° (= 1 *ghaṭī*) are marked and numbered anti-clockwise from 1 to 30; the numbering commences at a point which is closest to the apex of the quadrant on the obverse.
3. This scale carries the names of the first six zodiac signs from Aries to Virgo in cells whose extent corresponds to their oblique ascensions measured against the

degree scale. The names are engraved anti-clockwise thus: *Sāyana-meṣa-lagnam 1* (tropical ascendant of Aries), *Vṛṣa-lagnam 2, Mithuna-lagnam 3, Karka-lagnam 4, Siṃha-lagnam 5* and *Kanyā-lagnam 6.*

4. Each sign is divided in 30 equal parts.
5. Groups of 6 parts are numbered 6, 12, 18, 24, 30 anti-clockwise, separately for each sign.
6. This scale carries the names of the remaining six signs from Libra to Pisces in the same manner as above, but in clockwise order so that Pisces comes below Aries and shares the same oblique ascension, and so on. The names of the signs are engraved thus: *Tulā-lagnam 7, Vṛścika-lagnam 8, Dhanu[r]-lagnam 9, Makara-lagnam 10, Kuṃbha-lagnam 11* and *Mīna-lagnam 12.*
7. Each sign is divided in 30 equal parts.
8. Groups of 6 parts are numbered 6, 12, 18, 24, 30 anti-clockwise, separately for each sign.

The midpoint of a straight index, longer than the diameter of the outer circle, is pivoted to the centre of the circular scales along with a flower-shaped washer.

The oblique ascensions shown on the plate can be tabulated as follows:

Table K016-1 Oblique Ascensions (OA)

Signs	OA	Signs
Aries	21°	Pisces
Taurus	24°	Aquarius
Gemini	29°	Capricorn
Cancer	35°	Sagittarius
Leo	35°	Scorpio
Virgo	36°	Libra

INSCRIPTION

Inside the innermost circle on the back is inscribed the following data:

palabhā 7|1

cara-khaṇḍāni 70 | 56 | 23

śrī-jyotirvid-hṛṣīkeśa-nirmito yantraciṃtāmaṇiḥ

śrī-caṃḍīdattātmājasyārtham

'Equinoctial shadow 7;1.

Ascensional differences or half-equations of daylight (*cara-khaṇḍa*) 70, 56, 23.

Yantracintāmaṇi made by the illustrious astrologer/astronomer Hṛṣīkeśa for the son of Caṇḍīdatta.'

Palabhā is the length of the shadow cast by a gnomon of 12 digits at midday on an equinoctial day and is a function of the terrestrial latitude. The *Palabhā* of 7;1 digits mentioned here indicates Patiala at 30;20°. Regarding the *cara-khaṇḍas,* Pingree writes that these 'are increments to the half-equation of daylight when the Sun is at Taurus 0°, Gemini 0° and Cancer 0° respectively; therefore, the half-equation of daylight for the longest day is 149 = 2;29 ghaṭikās, and the longest daylight is 34;58 ghaṭikās and the shortest 25;2 ghaṭikās.'[1348] The *cara-khaṇḍa*-s are expressed in *palas,* which are one-sixtieth parts of a *ghaṭikā* or *ghaṭī* of 24 minutes. Therefore, the longest day at the place for which the instrument is designed has the duration of 34;58 *ghaṭikās* = 13;59,12 hours and the shortest day of 25;2 *ghaṭikās* = 10;00,48 hours.

When the quadrant is tilted so that the sun's ray passes through the sighting tube, the index on the obverse side shows the sun's altitude on the degree scale on the arc; the index on the reverse side indicates the corresponding oblique ascensions; the point in the zodiac which is rising on the eastern horizon and the point of the zodiac which is setting in the western horizon.

BIBLIOGRAPHY

Pingree 2009, pp. 206-207.

[1348] Pingree 2009, p. 206.

K017⊙ YANTRA-CINTĀMAṆI, NOT SIGNED, NOT DATED

19th century

Radius ca. 120 mm

Jaipur, PC

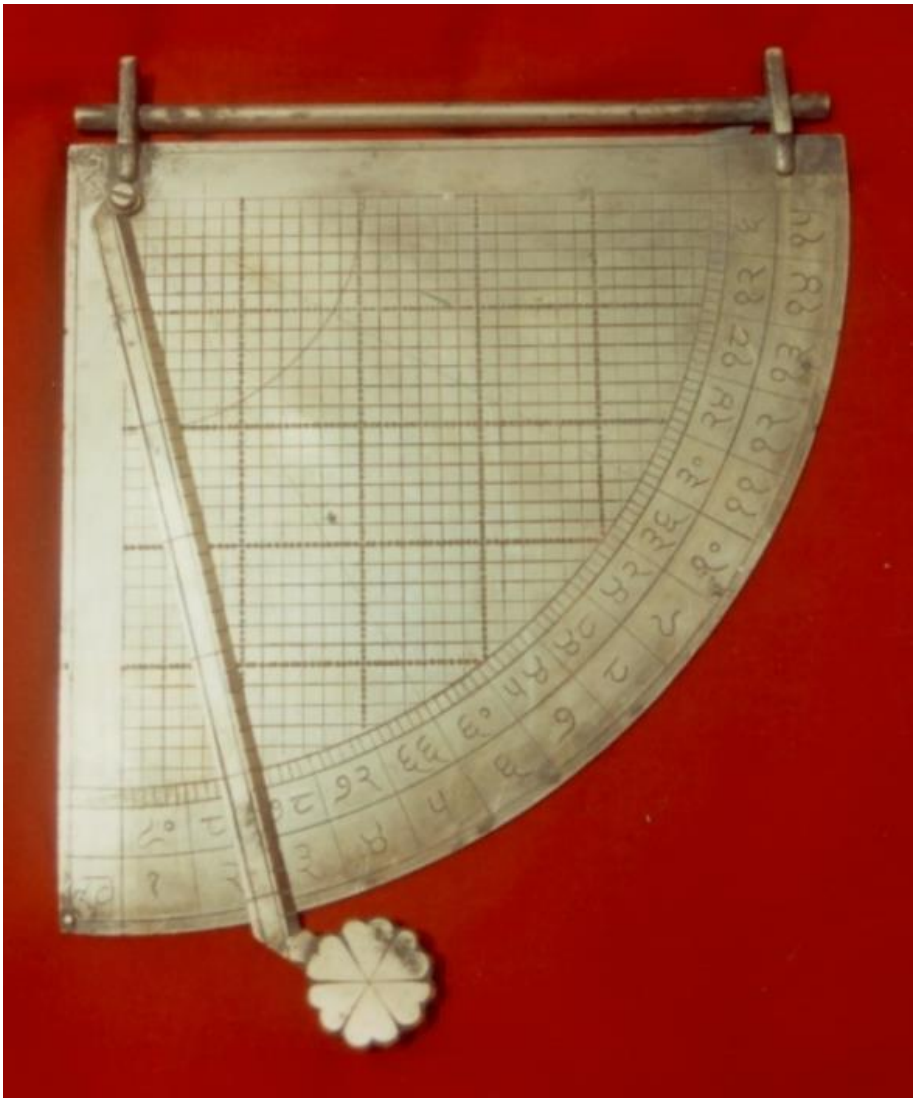


Figure K017.1 – Sine Quadrant (photo by S. R. Sarma)

SINE QUADRANT

This is a neatly made sine quadrant with an elegant index and weight. The obverse side is fashioned as a sine quadrant with a grid of 30 horizontal and 30 vertical parallels, each sixth highlighted. There is a circle of obliquity. The arc is engraved with three bands of scales; the innermost band is divided in 1°. In the middle one, groups of 6° are numbered anti-clockwise from 6 to 90, for measuring the zenith-distance. In the outer band, groups of 6° are numbered serially from 1 to 15 in the reverse direction, to indicate *ghaṭīs* which have elapsed since sunrise. At the apex of the quadrant is written

ke[ndra] (centre); at the end of the horizontal radius *ku[ja]* (horizon); and at the end of the vertical radius *kha[madhya]* (midheaven).

A sighting tube is attached parallel to the horizontal radius upon two supports. An ungraduated index is pivoted to the apex; its lower tip is curved inside so that it glides along the rim of the quadrant. An elegant weight, shaped like a stylized lotus with six petals, is hinged to the end of the index.

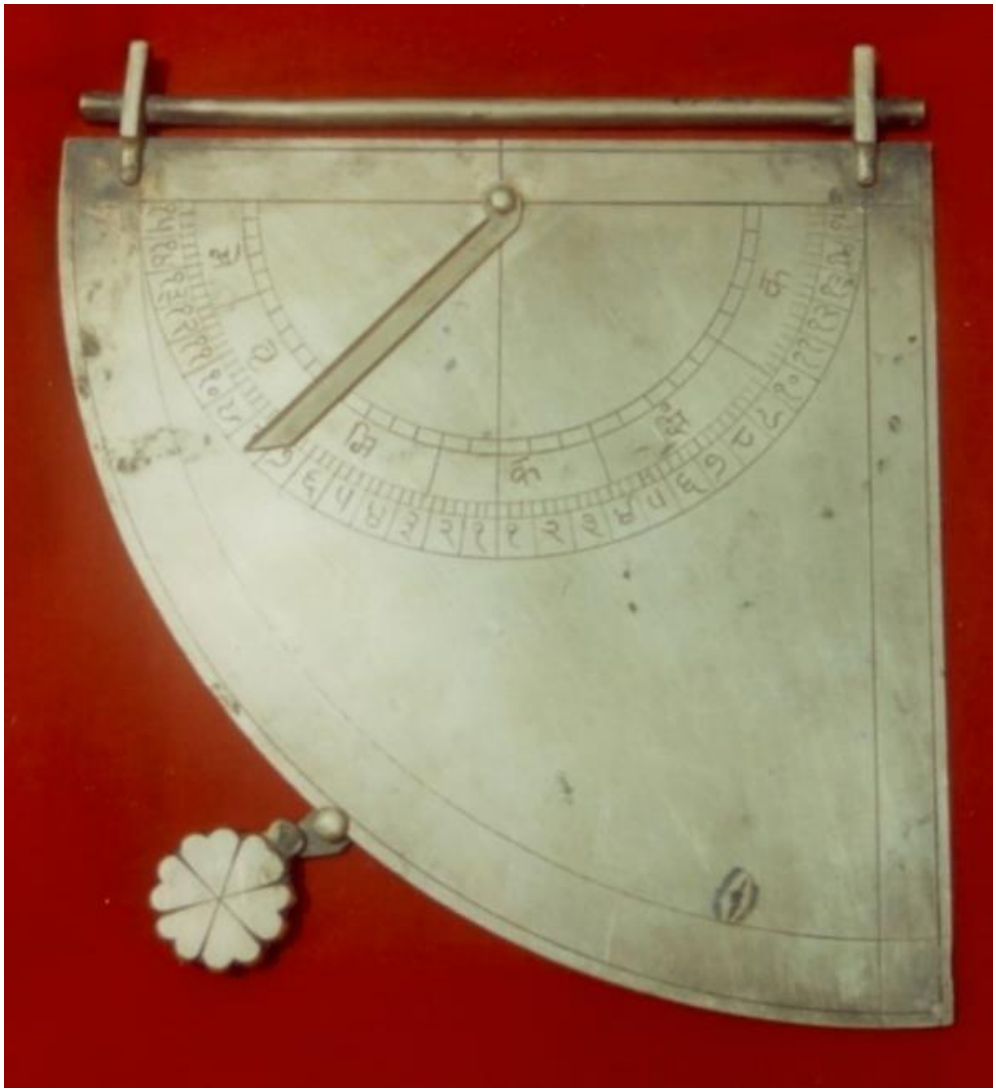


Figure K017.2 – Oblique ascensions on the reverse (photo by S. R. Sarma)

REVERSE SIDE

The reverse side shows oblique ascensions of the first six zodiac signs at the place of manufacture of this instrument. The other six zodiac signs are not shown here because their oblique ascensions are the same as those of the first six, but in a reverse order. There are four semi-circular scales. Starting from the outside, these contain the following:

1. *Ghaṭī* scale, 30 symmetric divisions numbered 15, 14, … 1; 1 … 14, 15.
2. Each division of the previous scale divided into 1/3 *ghaṭīs* = 20 *palas* = 2 degrees of arc
3. The names of the first six signs of the zodiac are engraved anti-clockwise from *Me[ṣa]* (Aries) to *Ka[nyā]* (Virgo). The lengths of the cells occupied by these signs are in accordance with the oblique ascensions of these signs at the place of manufacture.
4. 1/6 parts of the signs.

At the centre is pivoted a short index. Without a weight, it cannot rotate on its own when the quadrant is tilted towards the sun. Therefor the index cannot indicate the oblique ascensions as in K015 and K016.

L. DHRUVABHRAMA-YANTRA OF PADMANĀBHA

INTRODUCTION

1. PADMANĀBHA

In pre-modern times, instruments developed gradually in the course of several centuries, through occasional improvements or borrowings from other cultures; therefore, their invention cannot be attributed to any single individual. But there are two exceptions. In 1150, Bhāskarācārya declared that he invented a new instrument by name *Phalaka-yantra.* Around 1423, Padmanābha, son of Nārmada, claimed the invention of a novel instrument *Dhruvabhrama-yantra.* Of these two, the *Dhruvabhrama-yantra* was more popular, attested by the number of extant specimens. Therefore, it will be treated first.

Padmanābha is known from three small tracts on the construction and use of three different instruments, viz. the *Yantrarājādhikāra* on the southern astrolabe,[1349] the *Dhurvabhramādhikāra* (=DBA) on the *Dhruvabharma-yantra* and the *Diksādhana-yantra* on an instrument of the same name. The first two are said to be the first and second chapters of a work variously mentioned as *Yantra-kiraṇāvalī* or *Yantra-ratnāvalī,* but manuscript copies of the full text are not extant. Therefore it is not known whether *Diksādhana-yantra* is also a chapter of the same work or whether it is an independent work. Padmanābha also wrote commentaries on his *Yantrarājādhikāra* and DBA, and on the *Karaṇakutūhala* (AD 1183) of Bhāskara II.[1350] Both Padmanābha's father Nārmada[1351] and Padmanābha's son Dāmodara[1352] were also astronomers.

In his DBA (verses 24-26), Padmanābha gives the meridian altitudes (*madhyonnatāṃśas*) of the lunar mansions (*nakṣatras*) for the terrestrial latitude of 24°.

1349 Ôhashi 1997 provides a critical edition, English translation and mathematical commentary of this work.

1350 On Padmanābha, his works and their manuscript copies, see CESS, A-4, 170-172; A-5, 205; Ôhashi 1997, Sarma 2012a.

1351 Nārmada composed *Nabhogasiddhi* following the Brāhmapakṣa; cf. CESS, A-3, 171b; A-5, 183a.

1352 Dāmodara is known from three works: a *Karaṇa* work called *Bhaṭatulya* based on the *Āryabhaṭīya* of Āryabhaṭa, another *Karaṇa* by name *Sūryatulya* based on the *Sūryasiddhānta,* and a commentary on the *Karaṇaprakāśa* of Brahmadeva; cf. CESS, A-3, 100b-101a; A-4, 108a; A-5, 137a.

He must, therefore, belong to some place close to this latitude in Central India. In his *Yantrarājādhikāra,* he gives the precession (*ayanāṃśa*) for the Śaka year 1345 (= AD 1422-23), which may be the year of composition of this work.[1353] Padmanābha's son Dāmodara composed his *Sūryatulya* in Śaka 1339 (= AD 1416-17). Thus both Padmanābha and his son must have flourished in the first quarter of the fifteenth century somewhere in Central India.

The DBA is a small text of 31 verses in different metres, accompanied by an auto-commentary.[1354] Here Padmanābha gives the most detailed instructions for the construction and the use of the instrument. Such detailed instructions are not to be found in any other Sanskrit text on instruments.

2. Dhruvabhrama-yantra and the Diurnal Rotation of the Stellar Sphere

The *Dhurvabhrama-yantra* is an oblong (*āyata-caturasra*) metal plate one side of which is designed as the *Dhurvabhrama-yantra* and the reverse side as a sine quadrant (*Turya-yanta*). The *Dhurvabhrama-yantra* proper is a kind of nocturnal, i.e. an instrument to be employed at night. Its construction is based on the apparent diurnal rotation of the stellar sphere around the celestial poles. In his commentary, Padmanābha explains the diurnal rotation thus:

> 'At the beginning of the creation, the resplendent Brahmā arranged two stars as the celestial poles at the end of the southern and northern directions so that the stellar sphere (*bhacakra*) can properly revolve in the sky towards the west, without any support but impelled by the *Pravaha* wind. These two stars were designated as the celestial poles (*dhruva*). That which is the southern [Pole] Star is situated below the horizon at a distance of the degrees of the local latitude (*palāṃśa*). The northern Pole Star lies above the horizon at a distance of the degrees of the local latitude. Around the latter is seen a fish-shaped constellation (*maṇḍala*) consisting of twelve stars. This is designated as the Polar Fish (*dhruva-matsya*). Two bright stars are visible at its mouth

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1353 Ôhashi 1997, p. 217.

1354 The full text of the *Dhruvabhramaṇādhikāra* and extracts from the commentary together with a translation will be given in Apx.D2.

> and tail. Of these, the one at the mouth lies at an interval of three degrees (*bhāga*) from the [actual] Pole Star and the one at the tail lies at thirteen degrees. The two are separated from one another by sixteen degrees.'[1355]

The rotation of the *Dhruva-matsya* was known to earlier astronomers as well. Brahmagupta makes a brief reference to it in his *Brāhmasphuṭa-siddhānta.*[1356] Bhāskarācārya, in his *Vāsanā-bhāṣya* commentary on his *Siddhānta-śiromaṇi,* speaks of the daily rotation of the *Dhruva-matsya* in somewhat greater detail:

> 'When the sun is situated in the lunar mansion *Bharaṇī*, then at the time of his setting, the Polar Fish becomes horizontal. The star at its mouth will be in the west and the star at the tail in the east. It means that the sun would be in line with the star at the mouth. At the end of the night, the star at the mouth reverses its position and comes to the east and the star in the tail goes to the west. Then will be seen the rise of the sun who is again in line with the star at the mouth.'[1357]

The *Dhruva-matsya* is a constellation of twelve stars. Of these the stars at the mouth and tail of the fish figure are α and β in the constellation Ursa Minor. The remaining ten stars should include some of the stars in Ursa Minor. But no Sanskrit text seems to have described this constellation in detail.

Padmanābha lays strong emphasis, at the beginning and at the end of his work, on the fact that, while other instruments make use of the sun or of other fixed stars, his is

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[1355] Padmanābha, commentary on DBA 11: *pūrvaṃ sṛṣṭyādau śrībrahmaṇākāśa ādhārarahitasya pravahānilākṣiptasya bhacakrasya samīcīnapaścimābhimukhaparibhramaṇāya dakṣiṇottarayoḥ prāntasthite dve tārake dhruvatve niyukte | tayor ubhayor dhruva-saṃjñā kṛtā | yā dakṣiṇā tārā sā tu palāṃśaiḥ kṣitijād adhasthād vartate | yā tūttarā tārā sā palāṃśaiḥ kṣitijād uparito varīvarti | tatparito dvādaśatārakābhir matsyākāramaṇḍalam upalakṣyate | tasya dhruvamatsya-saṃjñā vihitā | tanmukhe pucche sthūle tārake dve dṛśyete | tayor madhye yā mukhasthā sā dhruvatārāyās tribhir aṃśair antaritā | yā pucchasthā sā tu trayodaśabhir aṃśair antaritā vartate | ubhe parasparaṃ ṣodaśabhāgāntarite staḥ |*

[1356] Brahmagupta, 11.3:
bhāni catuṣpañcāśad dvau dvāv arkaindavo jinoktaṃ yat |
dhruvamatsyasyāvarto bhavati yato 'hnā tatas tad asat ||

[1357] Bhāskarācārya, *Vāsanābhāṣya*, p. 345: *yadā bharaṇīstho ravir bhavati tadā tasyāstamayakāle dhruvamatsyas tiryakstho bhavati | tasya mukhatārā paścimataḥ | pucchatārā pūrvataḥ | tadā mukhatārāsūtre ravir ity arthaḥ | atha niśāvasāne mukhatārā parivartya pūrvato yāti | pucchatārā paścimato yāti | tato mukhatārāsūtra-gatasyaivārkasyodayo dṛśyate |*

the only instrument which makes use of the Pole Star and that it is a multi-purpose instrument. Thus he states at the beginning of the work:

> 'All the instruments measure time etc. according to the sun or according to the fixed stars. This one, however, shows time according to the celestial Pole. Therefore it is called the best of the instruments. … Apart from the time of the night, it also indicates the ascendant (*lagna*), other astrological houses (*bhāva*), and the results in time (*kālaphala*) (oblique ascensions) related to these. The time of the night etc. are found by observing the Polar Fish (*dhruva-matsya*). Therefore the name *Dhruvabhrama* is quite appropriate.'[1358]

Again at the end of the work, he repeats that such an instrument based on the Pole has never been mentioned previously by any astronomer:

> '[Others] taught previously how to measure time from the stars, but none [has taught how to find time] from the Pole Star. Therefore, out of intellectual curiosity (*kautuka*), this has been done [by me].'[1359]

3. Dhruvabhrama-yantra and the European Nocturnal

Padmanābha may not be aware that the Pole Star was employed for orientation by sailors also. On the west coast of India sailors measured time and fixed their bearings at night by observing the relative position of the two stars β and γ Ursae Minoris vis-à-vis the Pole Star. Tibbets writes:[1360]

> The Farqadān (sic! *Farqadayn*, β and γ Ursae Minoris) were most important in the Indian Ocean navigation because they were the brightest stars in the vicinity of the Pole, were circumpolar and never at any great distance from the meridian. They were thus the most prominent objects on the northern

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1358 Padmanābha, commentary on DBA 1: *sarvāṇi yantrāṇi sūryavaśān nakṣatravaśād eva kālādy-avayava-bodhakāni | idam pṛthag dhruvavaśāt kālāvabodhakam | tasmād yantravaram ity uktam | … triyāmāsamayādibodhakam …. ādiśabdāl lagnādibhāvās tatsambandhīni kālaphalāny api bodhayati | anena yantreṇa rātreḥ samayādijñānaṃ dhruvamatsyālokanād evotpadyata ity ato dhruvabhramaṃ nāma suyuktam |*

1359 Padmanābha, DBA 31:
nakṣatrāt samayajñānaṃ tamisrāyāḥ puroditam |
dhruvāt kenāpi na proktaṃ tad etat kautukāt kṛtam ||

1360 Cf. Tibbets 1981, p. 337.

horizon immediately after the Pole Star has disappeared and measurements taken from them in any position were relatively accurate. Like the Mediterranean navigators the Arab navigators recognized eight positions of the Guards, two horizontal, two vertical together with the two culminations and two extreme positions of the Greater Farqad (β Ursae Minoris). There were four other positions being the culmination and extreme positions of the smaller Farqad, but they were not so important.'

The same phenomenon gave rise to another related instrument, viz. the European nocturnal, which is based on the diurnal rotation of the line joining the α and β Ursae Majoris with the Pole Star. It is not known who invented it, but it was first mentioned by Martin Cortes in *Arte de Navegar* in 1551 and the earliest extant specimens belong to the late sixteenth century.[1361] The *Dhruvabhrama-yantra* and the European nocturnal have much in common in the basic principle as well as in the design. But the former is older by about one and half centuries. In the present state of knowledge, it is difficult to decide whether Padmanābha's *Dhruvabhrama-yantra* has inspired the European nocturnal or whether the two are independent inventions.

4. DHRUVABHRAMA-YANTRA ON THE OBVERSE

4.1. Main Plate

The *Dhruvabhrama-yantra* consists of an oblong plate with a narrow horizontal slit close to and parallel to one of the shorter sides, say at the top. Below the slit are drawn eight concentric circles, producing seven annuli (*koṣṭhakas*). These annuli contain different scales and the legends pertaining to them. Padmanābha numbers these scales, counting them from the outside.

The outermost or the first annulus (*prathama-koṣṭhaka*) contains a scale of *ghaṭīs*. The scale is divided into 60 equal parts to represent the 60 *ghaṭīs* in a nychthemeron (*ahorātra*). These *ghaṭīs* are numbered in the following manner. At the uppermost point of the circle, i.e. where it is closest to the horizontal slit, is marked the commencement of the 22nd *ghaṭī*. To put it differently, if the circle is divided into 360 degrees from the

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[1361] Wynter & Turner 1975, p. 69; Bud 1998, pp. 414-418.

uppermost point where the 22nd *ghaṭī* commences and number the degrees serially clockwise, then the *ghaṭī* scale and all other scales would commence from 234°. Thus Padmanābha places the vernal equinox at 234°. He does not explain the reason for choosing 234° as the vernal equinox, but he must have empirically arrived at this arrangement of the *ghaṭī* scale by observing the position of the stars α and β Ursae Minoris at his place situated on the latitude of 24°.[1362] The remaining six annuli are calibrated accordingly. The innermost scale is divided into 12 unequal units in accordance with the oblique ascensions, i.e. the times of the risings of the twelve signs of the zodiac at the observer's latitude (*svodaya*). The middle scale is divided into 12 unequal units to represent the right ascensions, i.e. the times of the risings of the twelve zodiac signs at the equator (*nirakṣodaya*). There are also additional scales containing the names of these two sets of the zodiac signs (*rāśis*), their sub-divisions, and the lunar mansions (*nakṣatras*) pertaining to these two sets of the zodiac signs. Thus the specifications of these seven scales, counted from the outside, are as follows:

1. *Ghaṭī* scale.
2. Names of the 28 lunar mansions as related to the zodiac signs in scale 4 and their meridian altitudes, after correcting these for precession (*āyana-dṛkkarman*).
3. Twelve unequal divisions as in scale 4, with further subdivisions. (In the extant specimens, each division is subdivided in five parts and numbered as 6, 12, 18, 24, 30, as is generally done on the retes of astrolabes).
4. Twelve unequal divisions containing the names of the zodiac signs. The lengths of these divisions should be in proportion to their right ascensions.

[1362] Garrett & Guleri 1902, pp. 63-64, explain the reason thus: 'Now when Beta Ursae Minoris is due east of the Pole Star, the sidereal time is approximately 8 hours 48 minutes or 22 ghatis. But the Hindus reckon their time from the instant of the rising of the equinox on the eastern horizon, whereas we reckon from the equinox on the meridian. The difference is evidently six hours. Hence subtracting 6 hours or 15 ghatis, we get 2 hours 48 minutes or 7 ghatis as the Hindu sidereal time. If now the Dhruvabhrama Yantra be held in a vertical plane, so that the Pole Star and Beta Ursae Minoris are both seen through the slit, which in this case will be horizontal, then the west indicator must point to 7 ghatis, as in the plate [X], and having fixed the west point in this manner, the whole ring is divided into the usual graduation of 60 ghatis of 6 degrees each. Then the other rings can be graduated as described above.'

5. Names of the 28 lunar mansions as related to the signs in scale 7 and their true polar longitudes (*sphuṭa*), after correcting them for the observer's latitude (*akṣa-dṛkkarman*).
6. Twelve unequal divisions as in scale 7, with further subdivisions. (In the extant specimens, each division is subdivided in five parts and numbered as 6, 12, 18, 24, 30).
7. Twelve unequal divisions containing the names the zodiac signs. The lengths of these divisions should be in proportion to their oblique ascensions.

4.2. Index

Loosely pivoted at the centre of these concentric circular scales is an index with four pointers which project into the four cardinal directions at right angles to one another. These pointers should be of unequal length so that they reach up to different scales. The eastern pointer, which is the shortest, reaches up to the sixth scale to point the degree of the zodiac sign rising at the observer's latitude. The northern pointer is of middle length and reaches the third scale to point the signs rising at the equator. The western pointer is the longest to reach the outermost scale containing the *ghaṭī* divisions. The southern-most projection is actually not a pointer but the plumb. Either a plumb bob is suspended from this projection, or it is made considerably heavier than the others, so that it always points downwards and gives a vertical line of reference. Therefore, irrespective of the tilt of the plate, the eastern and western pointers will always be horizontal and the northern pointer will always be vertical.

4.3. Observation with the Dhruvabhrama-yantra

At night the instrument is held in a vertical plane and tilted in such a manner that the two stars α and β UMi are visible in a line through the slit in the instrument (DBA 9-10). Then the eastern pointer will indicate that point of a zodiac sign which is rising in the east at that moment; this is the ascendant for that moment (*lagna*). The point at which the western pointer touches the *ghaṭī* circle is called 'point of observation' (*vedha-cihna*). Let us call it *A*. Now find out the solar longitude for that moment from an almanac (*pañcāṅga*). Place the tip of the eastern pointer at the solar longitude with precession plus six signs (*sa-calana-lava-ṣaḍ-bha*). Note where the western pointer is situated now. That point will indicate the time of the previous sunset. Let us call it *C*.

The distance *CA* equals the number of *ghaṭīs* elapsed (*gata-ghaṭikās*) in the night from the previous sunset up to the time of observation. On the other hand, if the tip of the eastern pointer is placed just at the solar longitude with precession (i.e. without adding 6 signs), then the corresponding western point will indicate the time of the next sunrise. Let it be *B*. Then the distance *AB* is tantamount to the number of *ghaṭīs* to come in the night from the time of observation up to the next sunrise (*eṣya-ghaṭikās*) (DBA 11-13). Thus the time of observation is *CA ghaṭīs* after the previous sunset and *AB ghaṭīs* before the next sunrise, the total duration of the night being *CB ghaṭīs*.

While the ascendant and the sidereal time of observation are determined thus with the help of the eastern and western pointers, the point at which the middle pointer touches the scale of the risings at the equator is the upper culmination (*madhyama-lagna*) with precession (*sāyana*). Then from the upper culmination (*viyad-lagna*) and the ascendant (*udaya-lagna*), other astrological houses (*bhāvas*) can be determined easily.

In horoscopy (*horāśāstra*), the zodiac circle is divided into twelve houses (*bhāvas*) which are different from the twelve signs (*rāśis*). The twelve houses are divided on the basis of four key points, or pivots, where the ecliptic intersects the local horizon and the local meridian. These are as follows: 1. 'ascendant' (*lagna, udaya-lagna*), i.e. the point or the degree of the ecliptic which is on the eastern horizon; 2. 'lower culmination' or 'lower midheaven' (*pātāla, caturtha-bhāva*), i.e. the degree of the ecliptic which is on the lower meridian; 3. 'descendant' (*asta-lagna, saptama-bhāva*), i.e. the degree of the ecliptic which is on the western horizon; and 4. 'upper culmination' or 'upper midheaven' (*khamadhya, madhyama-lagna, viyad-lagna, daśama-bhāva*), i.e. the degree of the ecliptic which is on the upper meridian. Of these the ascendant (*lagna*) and the descendant (*saptama-bhāva*) are diametrically opposite, i.e. at 180 degrees from one another; so also the upper culmination (*daśama-bhāva*) and the lower culmination (*caturtha-bhāva*).

Thus the *Dhruvabhrama-yantra* is a multipurpose instrument with which the sidereal time and the four key points on the ecliptic which are important in horoscopy can be read off from the dial without resorting to complicated computations. On the astrolabe also these four points can be directly read off from the dial, when once the rete is correctly set for the moment. What distinguishes the *Dhruvabhrama-yantra* from the

astrolabe is the relatively simple design, avoiding the difficult stereographic projections needed for the astrolabe. Padmanābha's design consisting of the horizontal slit for orientation, the series of circular scales and the index with multiple arms to reach up to different scales, though simple, is brilliantly conceived. In this design, the angle of the rotation of the line connecting α and β Ursae Minoris is translated automatically into (i) the time units of *ghaṭīs,* (ii) the zodiac signs and parts thereof which rise on the eastern horizon and (iii) the zodiac signs or parts thereof which are crossing the meridian at the time of observation.

5. Sine Quadrant on the Back

The *Dhruvabhrama-yantra* which is described here can be used only at night. Padmanābha desires that it is used also in the daytime and prescribes that the reverse side of the oblong plate is fashioned as a sine quadrant (*Turīya-yantra*). As stated in the introduction to section I, the sine quadrant was developed in the Islamic world in the ninth century. In India, Padmanābha was the first to describe it in Sanskrit. He prescribes that from one of the radial edges thirty lines be drawn parallel to the other radial edge. The arc of the quadrant is graduated into 90 degrees. At the apex of the quadrant, an index is pivoted, which is marked with 30 divisions, and also a plumb line. Furthermore, two sighting vanes with holes are attached to one of the sides of the quadrant.

Holding the sine quadrant in a vertical plane, one observes the sun or the stars through the two sights by tilting the quadrant appropriately. Where the plumb line touches the graduated arc is the altitude of the object sighted. With the help of the index and the parallel lines drawn on the quadrant, time can be measured.

5.1. Measuring Time at Night with the Sine Quadrant

With the sine quadrant time can be measured at night by sighting a star whose meridian altitude is known. For this purpose, Padmanābha gives the meridian altitudes of the 28 lunar mansions which are valid for the latitude of 24° (DBA 24-26). For those who live at other geographical latitudes, Padmanābha also teaches how convert the given meridian altitudes for other latitudes (DBA 27).

In the case of the *Dhruvabhrama-yantra,* it may be recalled that some of the circular scales are related to the oblique ascensions which pertain to a specific terrestrial latitude. It cannot, therefore, be used at other latitudes, while the sine quadrant can be

used at all latitudes. Padmanābha also teaches how to obtain time at one's own latitude with a *Dhruvabhrama-yantra* made for another latitude (DBA 28). However, he omits to teach how to adjust the *ghaṭī* scale for latitudes other than that of 24°. Nor does he explain how to determine the ascendant and culmination in the daytime with the *Dhruvabhrama-yantra*.

6. Reception of the Dhruvabhrama-yantra

The *Dhruvabhrama-yantra* is not mentioned in any subsequent Sanskrit work on instruments, either in Rāmacandra Vājapeyin's *Yantraprakāśa* (1428), Viśrāma's *Yantraśiromaṇi* (1615) or in Nandarāma Miśra's *Yantrasāra* (1772). However, in his voluminous commentary (1621) on Bhāskara II's *Siddhāntaśiromaṇi,* Nṛsiṃha gives a fairly long description of the *Dhruvabhrama-yantra*.[1363]

But, more important are the nearly seventy manuscript copies of the *Dhruvabhramādhikāra*[1364] and the twenty and odd actual specimens which are extant; these show that the *Dhruvabhrama-yantra* was next to the astrolabe in popularity. Most of these surviving specimens belong to the nineteenth century. There is much variation in these specimens, not only in the outer form of the plate—oblong, circle or quarter circle— and the design of the four-armed index, but also in the configuration of the circular scales. The wide variety in the style of execution and in the arrangement of scales indicate the popularity of the instrument in the nineteenth century; this may be true of the earlier centuries as well.

Muslim astronomers of India have also adapted *Dhruvabhrama-yantra* with Arabic/Persian legends.[1365] Two specimens have come to light so far, one at the Khuda Bakhsh Oriental Public Library of Patna (L024)[1366] and the other at the Raza Library of Rampur (L025).[1367] In these versions, the obverse side, calibrated as the nocturnal, is called *Shabnumā*, 'night indicator' and the reverse side with the quadrant is called

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1363 Nṛsiṃha, pp. 446-457.

1364 CESS A-4, 170-172; A-5, 205.

1365 Sarma & Bagheri 2011.

1366 Sarma 1999b.

1367 Sarma 2003, pp. 22-23, 85-88.

Rūznumā, 'day indicator'. These two specimens are manufactured in the nineteenth century but there must have been forerunners in earlier periods of which we do not yet know. Nor do we know at present whether these are discussed in any Persian or Arabic manual. Though it is clear that this version was inspired by the *Dhruvabhrama-yantra* and that this adaptation took place within India itself, the exact path of transmission still remains to be mapped.

Though clearly based on the *Dhruvabhrama-yantra,* the two extant specimens of the *Shabnumā-wa-Rūznumā* differ from the former in the following respects.

1. There is no horizontal slit in the *Shabnumā-wa-Rūznumā* as in the *Dhruvabhrama-yantra*; instead the upper edge is used as the reference.
2. There is no four-armed index in the *Shabnumā-wa-Rūznumā*; instead there are two indices in the specimen at Patna. If there were any indices in the Rampur specimen, they are missing now.
3. Initial points of the scales. In the *Dhruvabhrama-yantra*, the 21st *ghaṭī* division ends and the 22nd *ghaṭī* division begins just below the slit. Therefore the starting point of this scale is 234°. This is also the starting point in the scales of right ascensions and oblique ascensions. But the *Shabnumā-wa-Rūznumā,* especially the specimen at Rampur has several starting points, the significance of which is not clear.
4. The *Dhruvabhrama-yantra* determines, in addition to time, the ascendant and the culmination. On the other hand, the *Shabnumā-wa-Rūznumā* measures, besides the time in *ghaṭī*s, the ascendant and the *taḥwīl* (sun's passage from one sign to the other).

7. Extant Specimens of the Dhruvabhrama-yantra

As stated above, the twenty odd specimens exhibit much variation in the outer form, in the disposition of the circular scales, in the choice of the quadrant for the reverse side and so on. Such wide variations do not occur in other instruments. These variations will be discussed in the descriptions of the respective specimens, but an overview is given below.

7.1. Outer form of the main plate

Although Padmanābha clearly prescribes that the plate should be oblong in shape, some astronomers/instrument makers experimented with other shapes as well. For example, Sonī Morarajī of Bhuj, Gujarat, prepared two identical pieces in 1815 with the shape of a quarter circle (L003 and L004). There is one more such specimen in Jaipur (L017).

In the same city of Jaipur, the Shri Sanjay Sharma Museum & Research Institute owns two *Dhruvabhrama-yantras* which have the form of the full circle (L019 and L020). One of these (L020) resembles an astrolabe in outline. But it has no horizontal slit and it is difficult to sight the two stars α and β UMi in a straight line. The instrument maker engraved on the back a sine quadrant in the middle of the circular surface without providing any edges along the two radii. Consequently no observation can be done with this quadrant either.

The other circular specimen (L019) in the same collection tried to overcome these two difficulties to a certain extent. In the front, above the circle, two triangular holes were created through which the two stars can be observed, but the angle of rotation of the line joining them cannot be measured accurately. The quadrant at the back was more successful. Here the instrument maker filled the circular surface with four quadrants and fixed an alidade for sighting at the centre of the circle. In a compendium at the Victoria and Albert Museum, London (L018), there is one more circular *Dhruvabhrama-yantra*. Here the instrument maker cut a longish slit for observation.

But these variations do not mark any improvement on the oblong form prescribed by Padmanābha. In fact, for a portable instrument to be used also at night, the oblong form provides the optimum of convenience in handling.

7.2. Horizontal slit

Even in oblong plates, some instrument makers dispensed with the horizontal slit (nos. L002, L007, L015, L019 and L020). This does not cause any disadvantage, because the upper edge of the plate can safely be used as the line of reference for observing the stars α and β Ursae Minoris.

7.3. Quadrant on the Back

Padmanābha prescribes a sine quadrant with 30 vertical parallels on the back with which time can be measured in the daytime by observing the sun and at night by observing a star whose meridian altitude is known. Instead of the sine quadrant, several instrument makers engraved a horary quadrant. It is easier to measure time with this in the daytime, because the time can be read off from the point where the plumb line intersects the hour scale of the season, instead of making additional computations as in the case with the sine quadrant. However, unlike the sine quadrant, the horary quadrant cannot be used for measuring time at night. Moreover, the horary quadrant is latitude-specific and cannot be used at all latitudes like the sine quadrant.

7.4. Ghaṭī Scale

Padmanābha prescribes that for the latitude of 24°, the *ghaṭī* scale should be so arranged that the commencement of the 22nd *ghaṭī* should be at the topmost point of the circle, which point is situated under the horizontal slit and closest to it. That is to say, the scales begin at 234° and the 22nd *ghaṭī* commences at 0°.

In two three specimens, the *ghaṭī* scale seems to have been adjusted for the latitude. In L001 at the Jaipur Observatory, made presumably for the latitude of 27°, the scale begins at 228° and the 23rd *ghaṭī* commences at the top at 0°. In the two pieces made by Sonī Morarajī L003 and L004), which he designed for the latitude of 22;30°, the scale begins at 240° and the 21st *ghaṭī* commences at 0°.

In three specimens (L002, L015, L016), the scale begins at 0°, obviously by mistake. In L015, the scale comprises only 48 and not 60 *ghaṭīs* ! In L007, there is no distinct *ghaṭī* scale. The remaining specimens follow the arrangement prescribed by Padmanābha.

7.5. Index

Just as the astrolabe-maker shows his artistic skill in the design of the openwork rete of the astrolabe, the maker of the *Dhruvabhrama-yantra* exhibits his artistry in fashioning the multiple-armed index. Several pretty indexes can be seen in the extant specimens. In his two creations (L003 and L004) Sonī Morarjī even reversed the specifications for the pointers: he made the eastern pointer the longest to reach up to the *ghaṭī* scale and the western arm the shortest to reach up to the scale of oblique

ascensions. In one specimen (L013) all the arms are made of equal length, which was obviously done by mistake.

7.6. Numerical Tables

Padmanābha enjoins that the names of the 28 lunar mansions and their meridian altitudes should be engraved in scale no. 2 and the names of the lunar mansions and their true polar longitudes in scale no. 5 (DBA 5-6). It is not clear what advantage can be derived from engraving such numerical data (which can be consulted in any book) on the instrument; it would merely make the instrument too cluttered. Nevertheless, several instruments carry such numerical data. In particular Bulhomal of Lahore fills his instrument (L006) with so much data that it becomes, instead of a handy tool, a learned tome of reference which is difficult to consult.

7.6.1. Meridian Altitudes of the Lunar Mansions

Meridian altitudes are engraved on four specimen, viz. L006 (New York, Columbia), L010 (London, Sotheby's), L009 (Pune, Kelkar) and L011 (Varanasi, Banaras Hindu University). L009 carries also the meridian altitudes of the twelve signs.

7.6.2. Polar Longitudes of the Lunar Mansions

These are engraved only on two instruments (L008 and L009). In the latter specimen, there are two sets of polar longitudes, one in scale 2 and the other in scale 5. Strangely there are variations in the two sets. It is also strange that each value in scale 2 ends in 10 minutes. On specimen L001, some other parameters of the lunar mansions are engraved, which are not identifiable.

7.6.3. Tables of Zodiac Signs

Bulhomal's instrument (L006) at Columbia University contains the right and oblique ascensions of the twelve zodiac signs. Sonī Morarjī's two instruments (L003 and L004) carry the oblique ascensions on the back; these values are in *palas.*

7.6.4. Tables of Shadow Lengths

Sonī Morarajī (L003 and L004) incorporates in his two specimens tables of shadows cast by gnomons of 7 and 12 digits at 22;30° N for each 3° of solar altitude.

8. DHRUVABHRAMA-YANTRA FOR USE IN THE DAYTIME

Towards the middle of the nineteenth century, Bulhomal of Lahore made an attempt to modify the *Dhruvabhrama-yantra* for use in the daytime and named his new version *Jyotiḥsattā.* The three extant specimens are described in section U below. Somewhat more successful is the version designed by Joshi Dharm Chand under the name *Āyīnah Falqī* (Mirror of the Heavens) which is discussed in section X.

L001 ⦿ DHRUVABHRAMA-YANTRA & HORARY QUADRANT, NOT SIGNED

Not dated, 18th century

178 x 162 mm

Jaipur, Jai Singh's Observatory



Figure L001.1 – Dhruvabhrama-yantra (photo by S. R. Sarma)

This *Dhruvabhrama-yantra*, preserved in Sawai Jai Singh's Observatory at Jaipur, may have been commissioned by Jai Singh's son Madho Singh in the second half of the eighteenth century. Though not signed or dated, it is therefore the earliest extant specimen. It also displays certain features not envisaged by the original inventor Padmanābha.

It is made in the form of a rectangular brass plate. The obverse side of the plate is engraved with a *Dhruvabhrama-yantra.* There is a horizontal slit at the top of this instrument. At the centre is pivoted a four-armed index. Two sights in the form of rings are welded to the two corners at the top of the plate. On the back is a horary quadrant. At the apex of the quadrant is pivoted a plain index without any graduations. The circles and lines are not drawn well, but the Sanskrit orthography is flawless.

DHRUVABHRAMA-YANTRA

On the obverse side, just below the level of the slit is an inscription engraved in two parts to the left and right of the slit which reads '*dhruvabhrama*' '*yantram idam*,' informing that this is the *Dhuvabhrama-yantra.*

The instrument introduces an innovation to Padmanābha's basic design. Padmanābha prescribes two scales showing the lunar mansions rising in the east and those on the meridian. This instrument adds one more scale for the lunar mansions on the western horizon. Thus this instrument shows, for the moment of observation, in addition to the sidereal time in *ghaṭīs* and the signs rising on the eastern horizon and those crossing the meridian, also the lunar mansions rising on the eastern horizon, those transiting the meridian and those setting in the western sky.

Below the horizontal slit, there are nine circular scales, all proceeding clockwise. Counting from the outside, these are as follows:

1. Scale divided into one-forth parts of a *ghaṭī,* each cell representing 15 *palas* or 6 minutes.
2. *Ghaṭī* scale with 60 divisions. This and the other scales commence at 228° and not at 234° as prescribed by Padmanābha. Consequently, the 22nd *ghaṭī* ends and the 23rd *ghaṭī* commences at 0°.
3. Names of lunar mansions (initials) at irregular intervals and a label stating that these are the lunar mansions setting on the western horizon (*bhānām aste sati lagna*).
4. Names of lunar mansions (initials) at irregular intervals together with a label stating that these are the lunar mansions on the meridian (*bhānāṃ madhye sati lagna*).
5. Names of lunar mansions rising on the eastern horizon. The scale apparently begins with *revatī* where the *ghaṭī* scale begins. Here are written at irregular

intervals the initial syllables of the names followed by small circles to indicate that these are abbreviations; then is added, in many cases but not in all, the letter '*u*' meaning *udaya* 'the rising'. For example, for *Aśvinī,* it is written *a*° *u.* In addition, there is a label stating that these are lunar mansions rising on the eastern horizon (*bhānām udayalagnāni*).

6. One-fifth parts of the signs marked in the next scale, numbered separately for each sign as 6, 12, 18, 24, 30.
7. Names of the signs (their lengths varying according to their right ascensions), marked by the initial syllables.
8. One-fifth parts of the signs marked in the next scale, numbered separately for each sign as 6, 12, 18, 24, 30.
9. Names of the signs (their lengths varying according to their oblique ascensions), marked by the initial syllables.

Pivoted at the centre is a four-armed index, the four arms being in the shape of triangles of different sizes. The largest one should also always point downwards. According to Garrett and Guleri,[1368] a plumb bob was welded to this arm, but now it got detached and lost; all that remains is a welding mark at the tip of the arm. On the other three arms are written the names of the parameters which are indicated by them: *ghaṭī* (time in *ghaṭīs*) on the western arm*, 10 bhāva* (= *daśama-bhāva,* upper midheaven) on the northern arm and *lagna* (ascendant) on the eastern arm. All the four arms are decorated with arcs and lines; the tip of the northern arm is fashioned as a face with two eyes, a long nose and a mouth.

[1368] Garrett & Guleri 1902, p. 63.



Figure L001.2 – Horary quadrant (photo by S. R. Sarma)

HORARY QUADRANT

Padmanābha prescribes that the back should carry a sine quadrant. But this specimen has a horary quadrant instead. Below the arc of the quadrant is engraved *turīyayantram* (quadrant). With the corner to the left of the slit as the centre, 13 concentric quarter circles are drawn to produce 12 scales. The outermost one is the degree scale, unevenly divided into 90 degrees. The next scale is divided into groups of 6° and is labelled anti-clockwise from 6 to 90. The remaining 10 are *ghaṭī* scales, to be used in different seasons. In the first and last cell of each scale are written the duration of the half day in *ghaṭīs.* These values are 17 ½, 17, 16 ½, 16, 15 ½, 15, 14 ½, 14, 13 [½] and 13 *ghaṭīs.* There should have been one more scale for the half day of 12 ½ *ghaṭīs,* so that all the seasons are completely covered. At present there is provision between the longest day of 35 *ghaṭīs* (14 hours) and the shortest day of 26 *ghaṭīs* (10:24 hours). An ungraduated plain index is pivoted to the apex of the quadrant.

In the empty space between the last *ghaṭī* scale and the apex, there are two and odd columns of writing. In the first two columns are the initial syllables of the names of the 28 lunar mansions together with some unidentified values. Here the fractions are expressed by vertical strokes (one stroke | for ¼ and two strokes ‖ for ½). In the third column, five lunar mansions listed in the second column are merely repeated; the engraver probably thought that the letters there were not distinct enough.

Table L001-1 Lunar Mansions

	Lunar Mansions	Junction Stars	unidentified values
	I Column		
1	*A[śvinī]*	β Arietis	16 ½
2	*B[haraṇī]*	41 Arieties	17
3	*Kṛ[ttikā]*	η Tauri	16 ½
4	*Ro[hiṇī]*	α Tauri	16 ¼
5	*Mṛ[gaśirā]*	λ Orionis	16
6	*Ā[rdrā]*	α Orionis	16
7	*Pu[narvasu]*	β Geminorum	17
8	*Pu[ṣya]*	δ Cancri	16 ½
9	*A[śleṣā]*	ζ Cancri	15 ½
10	*Ma[ghā]*	α Leonis	16
11	*Pū[rva-phālgunī]*	δ Leonis	16
12	*U[ttara-phālgunī]*	β Leonis	16
13	*Ha[sta]*	δ Corvi	13 ¾
14	*Ci[trā]*	α Virginis	14
15	*Svā[ti]*	α Bootis	16 ¾
	II Column		
16	*Vi[śākhā]*	α Librae	13 ½

	Lunar Mansions	Junction Stars	unidentified values
17	*A[nurādhā]*	δ Scorpii	13 ¼
18	*Jye[ṣṭhā]*	α Scorpii	13
19	*Mū[la]*	λ Scorpii	12 ¾
20	*Pū[rvāṣāḍhā]*	δ Sagittarii	12 ¾
21	*U[ttarāṣāḍhā]*	σ Sagittarii	13
22	*A[bhijit]*	α Lyrae	18 ½
23	*Śra[vaṇa]*	α Aquilae	15 ¾
24	*Dha[niṣṭhā]*	β Delphini	16 ¼
25	*Śa[tabhiṣā]*	λ Aquarii	14 ½
26	*Pū[rva-bhādrapadā]*	β Pegasi	16 ¼
27	*U[ttara-bhādrapadā]*	γ Pegasi	16 ¾
28	*Re[vatī]*	ζ Piscium	15 ½
	III Column		
21	*U[ttarāṣāḍhā]*	σ Sagittarii	13
22	*A[bhijit]*	α Lyrae	18 ½
23	*Śra[vaṇa]*	α Aquilae	15 ¾
24	*Dha[niṣṭhā]*	β Delphini	16 ¼
25	*Śa[tabhiṣā]*	λ Aquarii	14 ½

BIBLIOGRAPHY

Garrett & Guleri 1902, pp. 62-64, plate X.

Ôhashi 1986-87, p. 167.

Sarma 1994b, pp. 517-518.

Sharma 2016, p. 191.

L002 ⦿ DHRUVABHRAMA-YANTRA & SINE QUADRANT BY MOTĪRĀMA FOR KING KĪRTICANDRA, 1707 ŚAKA (AD 1784-85)

Wood and ivory, 276 x 240 x 9 mm

Brussels, PC



Figure L002.1 – Dhruvabhrama-yantra (photo by S. R. Sarma)

Chronologically this is the earliest dated extant specimen of the *Dhruvabhrama-yantra*. It is also the only known instrument made of wood with ivory finishing, on which the lines, letters and numerals are produced by inlaid silver wire. Unfortunately,

this extraordinary piece was not completed. A grid was made on the front side for the *Dhruvabhrama-yantra,* but was left unfinished. The sine quadrant on the back is complete; there is also the maker's signature on the back. It is, therefore, reasonable to assume that Motīrāma, the instrument maker, prepared the sine quadrant on the back first and then, while preparing the front side made a serious mistake which could not be undone and therefore, abandoned the work midway.

The instrument is made out of a wooden board which is so cut that it includes the two projecting sights as well. Ivory strips, 4 mm broad, are used as decorative borders. These strips are nailed to the wooden board with iron nails which are now rusting. The lines and the legends are inlaid with silver wires. Some of the inlaid wires are missing, especially in the sine cosine grid in the quadrant on the reverse.

DHRUVABHRAMA-YANTRA

The *Dhruvabhrama-yantra* is created on the obverse side of the wooden board. There is no horizontal slit to view the two stars α and β Ursae Minoris; but they can be viewed in one line along the upper edge. The surface of the board is covered by a circle with a diameter of 231 mm, inside which 6 other concentric circles are drawn, creating thus 6 annuli or circular scales. A vertical diameter is drawn from the uppermost point in the circle (i.e. 0°) to the lowermost point (i.e. 180°). Another diameter is partly drawn from 126° to 306°. The instrument maker made a mistake in drawing this diameter; he should have drawn instead one from 234° to 54° (i.e. a mirror image of the former), for the scales commence from 234°. Of the six scales, only the first and the last are filled with labels; the rest are divided into cells, but these cells are not filled in.

The outermost circle is divided into 60 units to represent the sidereal *ghaṭīs* and numbered from 1 to 60, starting from the topmost point (0°) and proceeding clockwise. This is contrary to Padmanābha's prescription according to which the 22nd *ghaṭī* should commence at 0°. Scales 3 and 6 are divided into 12 equal divisions; Padmanābha instructs that these should be divided into 12 unequal divisions, the former according to the right ascensions of the zodiac signs and the latter according to their oblique ascensions. The cells are not filled in scale 3, in scale 6 they are filled with the names of the signs, starting from a cell which is adjacent to *ghaṭīs* 21-25; thus the scale starts from 126°. The names of the signs are written very meticulously, including terminal *visarga* which is rarely used in instrument labels, as *Meṣaḥ, Vṛṣaḥ, Mithunaḥ, Karkaḥ,*

Siṃhaḥ, Kanyā, Tulā, Vrścikaḥ, Dhanuḥ, Makaraḥ, Kumbhaḥ, Mīnaḥ. Scales 2, 3 and 4 are divided into 60 units but the cells are not filled in. The numbers and letters are done very neatly; however the numeral 3 is written in three different styles, 6 in two styles.

There are flaws in the division of the scales and in labelling them. All scales should start from 234° and not from 0° or 126°. Only the outermost scale needs 60 divisions for 60 *ghaṭīs*. Other scales, which pertain to the right or oblique ascensions, their names, their subdivisions and the related lunar mansions, need only 12 or 27 divisions.

It appears that after preparing the grid and filling in the scales 1 and 6, the instrument maker realized the flaws in the arrangement, which obviously could not be undone, and therefore left the instrument unfinished.

At the centre of the board, there is a pin with a broad flat head. Under this is a small circular piece, probably a washer. But the four-armed index, if it ever was made, is missing.



Figure L002.2 – Sine quadrant on the reverse (photo by S. R. Sarma)

SINE QUADRANT

The back of the wooden board is fashioned as a sine quadrant. The horizontal radius is graduated in 30 divisions which are labelled as 1, 2, 3, … 30 from the apex to the arc. The vertical radius is also divided into 30 divisions but not labelled. At each of these divisions horizontal and vertical parallels are drawn, thus producing a sine-cosine grid. An arc is drawn tangent to the 12th parallel, showing the obliquity of the ecliptic. In the 13th vertical column, the cells (and thus the lines of sines) are numbered from 1 to 27.

The arc of the quadrant carries two scales; the outer scale is graduated in single degrees of arc, and in the inner scale groups of 6° are marked and labelled as 1, 2, 3, … 15 anti-clockwise.

There is a small peg at the apex, where the index must have been attached, but it is missing now. The wooden board is so cut that it includes the sights as well. A sighting tube is inserted through the sights. It is longer than the width of the board by about 2 mm on either side.



Figure L002.3 – Inscription on the reverse (photo by S. R. Sarma)

INSCRIPTION

On the back of the instrument, parallel to the arc of the quadrant is an inscription, produced very skilfully and very correctly by inlaid silver wire. The inscription in the *Indravajrā* metre reads as follows:

munyabhravāraikamite śakābde
śrīkīrtticaṃdrasya nṛpādhipasya |
ājñānusārād akarot suyaṃtraṃ
śrīmotirāmābhidhaśilpisiṃhaḥ ||1||

‘In the Śaka year counted by sages-sky-weekdays-one (7-0-7-1; when read from the left, it becomes 1707), on the order of the lord of the kings, the illustrious Kīrticandra, Motirāma, a lion among the artisans, made this excellent instrument.’

The Śaka year 1707 corresponds to AD 1784-85. In the artisan's name, the second syllable was shortened for the sake of metre. His actual name would be Motīrāma. Kīrticandra must have been the ruler of some state in Rajasthan, but it has not been possible to identify him.

L003 ⦿ DHRUVABHRAMA-YANTRA & HORARY QUADRANT BY SONĪ MORARAJĪ FOR PREMAJĪ PAṆḌYĀ AT BHUJ, 1872 VS (AD 1815)

Radii: 117, 113 mm; thickness 4 mm

Paris, Observatoire de Paris (# I.A. n°. 1938)



Figure L003.1 – Dhruvabhrama-yantra (photo by S. R. Sarma)

This and the next specimen (L004) are identical, but for a slight difference in size. According to the inscription, these were made by the goldsmith (*sonī*) Morarajī for Premajī Paṇḍyā on the day corresponding to 2 June 1815. Most likely the Brahmin astronomer Premajī Paṇḍyā designed this instrument, prepared the technical drawings, including the Sanskrit labels and inscriptions, and got two copies fabricated by the goldsmith Morarajī.

The instrument is made out of a brass plate which is cut in the form of a quarter circle. At the end of the longer radius are two sights. Along the shorter radius is a long horizontal slit which is interrupted in the middle. The obverse side is engraved with a *Dhruvabhrama-yantra* and the reverse with a horary quadrant. However, the horary quadrant here does not contain *ghaṭī* scales for different seasons as in other specimens, but scales which provide the lengths of shadows cast in different seasons by the gnomon of 12 digits and by gnomon of 7 feet. Measuring time with these scales is a cumbersome process.

DHRUVABHRAMA-YANTRA

The *Dhruvabhrama-yantra* on the obverse side carries four circular scales. A thickly drawn diameter cuts through the scales at 60° and 240°. The scales commence at 240° with the result that the 21st *ghaṭī* commences at the uppermost point of the circle (0°) and not the 22nd *ghaṭī* as prescribed by Padmanābha. The four scales are as follows.

1. *Ghaṭī* scale, numbered from 1 to 60 clockwise, with the 21st *ghaṭī* commencing at 0°.
2. Zodiac signs according to their right ascensions; the names of the signs and their serial numbers are engraved clockwise as *Meṣa 1, Vṛṣa 2* and so on.
3. Zodiac signs according to their oblique ascensions; the names of the signs and their serial numbers are engraved clockwise as *Meṣa 1, Vṛṣa 2* and so on.
4. Names of the lunar mansions (initials). Only 26 cells are drawn, symmetrically on either side of the diameter. Therefore, *Citrā* and *Svāti* are accommodated in one cell. After engraving *u* for the penultimate *Uttara-bhādrapadā,* the instrument maker engraved absent-mindedly *u* in the last cell also, instead of *re* for *Revatī.* In the cell for *Uttarāṣāḍhā,* the abbreviation *u* is engraved twice. Padmanābha prescribes two scales with the lunar mansions; there is only one scale here.

Around the *ghaṭī* scale, there are slightly raised dots, approximately two per each *ghaṭī.* There are similar raised dots on the back as well. Padmanābha (verse 30 ab) recommends such protruding dots or nails along the *ghaṭī* circle so that the *ghaṭīs* can be counted by feeling the dots when reading the numbers engraved in the cells is not possible in dark nights.

A large index moves freely at the centre. Its three arms, having pointed tips and different lengths, indicate the ascendant, the culmination and the sidereal time in *ghaṭīs.*

Here Sonī Morarajī slightly deviates from Padmanābha's prescriptions and also from the general practice. The longest arm that reaches up to the *ghaṭī* scale here is the eastern arm and the western arm here points to the ascendant. The southern arm is the heaviest one and functions as the plumb, keeping the middle arm in the vertical plane and the eastern and western arms always in a horizontal position.

In the space below the circular scales are engraved the oblique ascensions (OA) of the zodiac signs in *palas* (one-sixtieth parts of a *ghaṭī* = 24 seconds) at the latitude of Bhuj.

Table L003-1 Oblique Ascensions at Bhuj

Signs	OA	Signs
Me[ṣa]	*228*	*Mī[na]*
Vṛ[ṣa]	*259*	*Ku[ṃbha]*
Mi[thuna]	*306*	*Ma[kara]*
Ka[rka]	*340*	*Dha[nuḥ]*
Si[ṃha]	*339*	*Vṛ[ścika]*
Ka[nyā]	*328*	*Tu[lā]*

Next to these oblique ascensions is engraved *caraṣaṃḍa 50 40 17.* The term *caraṣaṃḍa,* or more correctly *cara-khaṇḍa,* refers to the segments of ascensional difference, also counted in *palas*. These are added to or subtracted from the right ascensions (RA) to obtain the oblique ascensions (OA).

Table L003-2 Right Ascensions and Oblique Ascensions at Bhuj

Signs	RA	*cara*	OA
Aries Pisces	278	-50	228
Taurus Aquarius	299	-40	259
Gemini Capricorn	323	-17	306

Signs	**RA**	***cara***	**OA**
Cancer Sagittarius	323	+17	340
Leo Scorpio	299	+40	339
Virgo Libra	278	+50	328



Figure L003.2 – Horary Quadrant (photo by S. R. Sarma)

HORARY QUADRANT

The reverse side carries a horary quadrant, with five scales along the arc of the quadrant. Counting from the outside, these are

1. Degrees of altitude, divided in groups of 3° and labelled anti-clockwise as 3, 6, 12, … 90. There are also two raised dots in each division, so that these divisions can be counted in darkness by feeling the dots.
2. Shadows of the gnomon of 12 digits, corresponding to each 3° ($x = 12 / \tan \alpha$).

3. Shadows of the gnomon of 7 feet, corresponding to each 3° ($y = 7 / \tan \alpha$)

4-5. *Ghaṭīs* and *palas*, corresponding to each 3° of solar altitude, to indicate the time elapsed since sunrise (in the forenoon), or the time to come up to sunset (in the afternoon).

Because the sun's altitude varies according to the seasons, a horary quadrant should have different *ghaṭī* scales for different seasons, which is not the case here. The single scale given here can be used only at the time of the summer solstice. But the two scales of shadows show the lengths of shadows lengths corresponding to different altitudes of the sun. From these shadow lengths and the equinoctial noon shadow of the locality, it is possible to calculate the local time, for which rules are given in some Sanskrit texts. The procedure, however, is rather complicated.

The numerical data in these scales is arranged in the table below.[1369]

Table L003-3 Table of Shadows

Degrees of altitude (α)	Shadows of 12 digits (x)	Shadows of 7 feet(y)	Time *ghaṭīs palas*	
3	229	133 ½	0	33
6	114	66 ½	1	7
9	75 ¾	44 ¼	1	40
12	56 ½	33	2	14
15	44 ¾	26	2	47
18	36 ½	21 ½	3	21
21	31 ¼	18 ¼	3	55
24	27	15 ¾	4	28
27	23 ½	13 ¾	5	2
30	20 ¾	12	5	35

[1369] Cf. Verdet 1994, table 1, p. 319, where he gives the calculated values and engraved values of the shadow lengths.

Degrees of altitude (α)	Shadows of 12 digits (*x*)	Shadows of 7 feet(*y*)	Time *ghaṭīs palas*	
33	18 ½	10 ¾	6	9
36	16 ½	9 ½	6	42
39	14 ¾	8 ½	7	16
42	13 ¼	7 ¾	7	50
45	12	7	8	23
48	10 ¾	6 ¼	8	57
51	9 ¾	5 ¾	9	30
54	8 ¾	5	10	4
57	7 ¾	4 ½	10	37
60	7	4	11	11
63	6	3 ½	11	45
66	5 ¼	3	12	18
69	4 ½	2 ¾	12	52
72	4	2 ¼	13	25
75	3 ¼	2	13	59
78	2 ½	1 ½	14	32
81	2	1 1/8	15	6
84	1 ¼	0 ¾	15	39
87	0 ½	0 5/16	16	13
90	0	0	16	47

According to this table, at the time of the summer solstice, when the sun's longitude is 3^{s}, 0° 0′ (*jyaiṣṭha vadi 11*), the maximum duration of half a day is 16 *ghaṭīs* and 47 *palas*; thus the longest day at this latitude has a duration of 33 *ghaṭīs* and 34 *palas*

= 13:23,36 hours. Pivoted at the apex is an index with a longitudinal slit in the middle. The five protruding points on the index are numbered from 1 to 5 for unknown reasons.

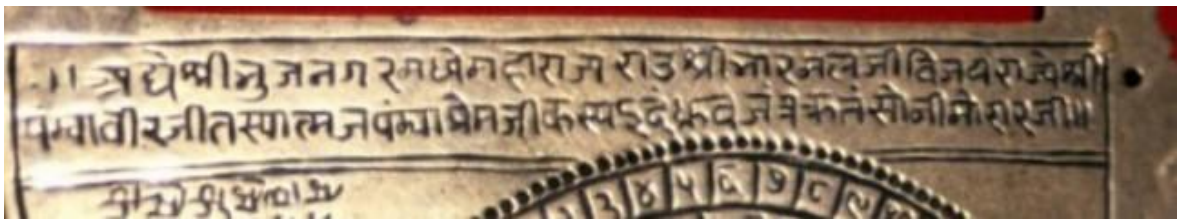


Figure L003.3 – Inscription on the front (detail of Figure L003.1)



Figure L003.4 – Inscription on the back (detail of Figure L003.2)

INSCRIPTIONS

On the front side, along the radius with the sights, is engraved the following inscription in two lines. The engraver committed many errors in transcribing the Sanskrit text:

> ‖ *adye (sic ! adya) śrībhujanagaramadhye mahārājya (sic! mahārāja) rāu śrībhāramalajī vijayarājye śrī paṃḍyā-vīrajī tasyātmaja paṃḍyā-premajīkasya idaṃ dhruvajaṃtra (sic! dhruva-yantraṃ) krataṃ (sic! kṛtaṃ) sonī morārajī* ‖
>
> ‘Today, in the city of Bhuj, during the victorious reign of Mahārāja Rāu Śrī Bhāramalajī, this *dhruvabhrama-yantra* of Paṇḍyā Premajī, son of Śrī Paṇḍyā Vīrajī, was made [by] Sonī Morārajī.’

On the reverse side is engraved the following inscription along both the radii:

> ‖ *śrīmana (sic! śrīmān) rājā vikramārkarājye saṃvata (sic! saṃvat) 1872 varṣe śālīvāhana-śāṃke (sic! śāke) 1738 pravarttamāne jyeṣṭa (sic! jyaiṣṭha) vidi (sic! vadi) 11 śukre tadine (sic! taddine) sāyano raviḥ 3|0|0|0 akṣabhā 5|0 akṣakarṇa 13 daṃkṣakrāti (sic! akṣāṃśa) 22|30 sadaiva* ‖ *kacha saurāṣṭre yaṃtram idam* ‖
>
> ‘In the Saṃvat year 1872 of the reign of the glorious king Vikramārka, in the current year 1738 of Śālivāhana era, on Friday, the eleventh day of the dark half of Jyaiṣṭha. On this day the sun’s tropical longitude (*sāyano raviḥ*) is 3|0|0|0; equinoctial shadow (*akṣabhā*) 5|0; equinoctial hypotenuse (*akṣakarṇa*) 13; terrestrial latitude (*akṣāṃśa*) 22;30. This instrument [should be employed] always in Kutch, Saurashtra.’

The instrument is made for the city of Bhuj (correct latitude 23;15° N; longitude 69;40° E), capital of the former princely state of Kutch, in the Saurāṣṭra region of Gujarat, during the reign of Maharaja Rau Bharmal-ji II (r. 1814-1819).[1370] The date of manufacture translates to 2 June 1815. ‘Equinoctial shadow’ (*akṣabhā*), the length of the shadow cast by a gnomon of 12 units at noon on the equinoxes, is a function of the latitude; so also the ‘equinoctial hypotenuse’ (*akṣakarṇa*), i.e. the hypotenuse of the

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[1370] Verdet 1994, p. 310, misunderstood *saurāṣṭra* as Surat.

right-angled triangle formed by the gnomon (12 digits), shadow (5 digits) and the hypotenuse (13 digits).[1371] The instrument maker messed up with the term *akṣāṃśa* (degree of latitude) and wrote instead *daṃkṣākrāti* which has no meaning.

PROVENANCE

The instrument was formerly in a private collection in Paris; it came up for auction at Paris in 1980 and was acquired by the Paris Observatory.

BIBLIOGRAPHY

Linton 1980, lot 230, p. 184.
Verdet 1994.

[1371] Verdet 1994, p. 310, notes that the value of 22;30 given as the latitude is confirmed by the calculation of the right-angled triangle mentioned above, because 5/13 is equal to 0,38 which is the sine of the angle 22°33′.

L004 ⊙ DHRUVABHRAMA-YANTRA & HORARY QUADRANT BY SONĪ MORARAJĪ FOR PREMAJĪ PAṆḌYĀ AT BHUJ, 1872 VS (AD 1815)

Radii 118, 114 mm; thickness 4 mm

Oxford, Museum of the History of Science (# 23,600)

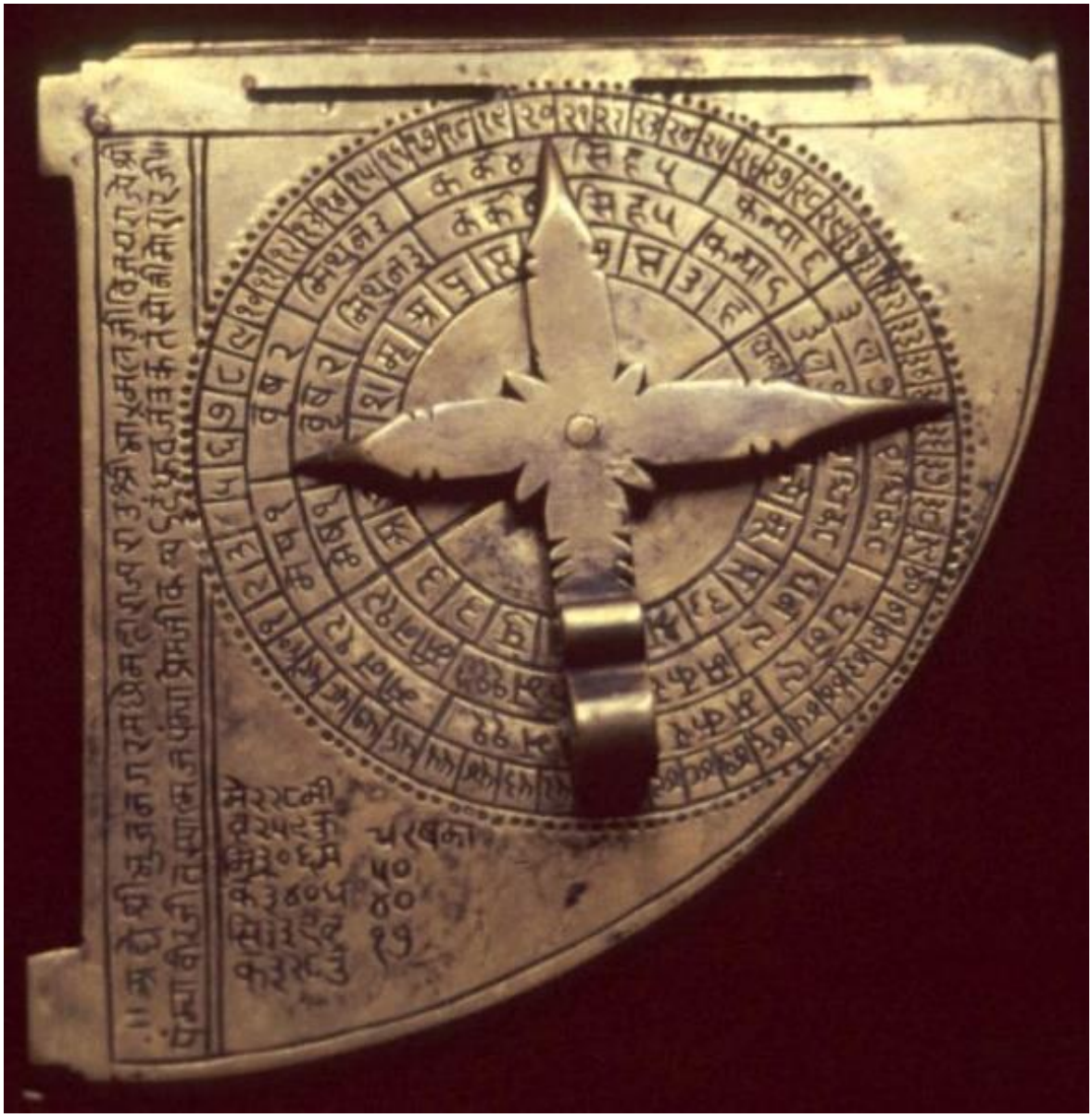


Figure L004.1 – Dhruvabhrama-yantra (photo by S. R. Sarma)

It is almost identical with the specimen at Oxford (L003), but with minor differences in the lengths of the radii. All the orthographical errors are repeated exactly as in the other specimen.

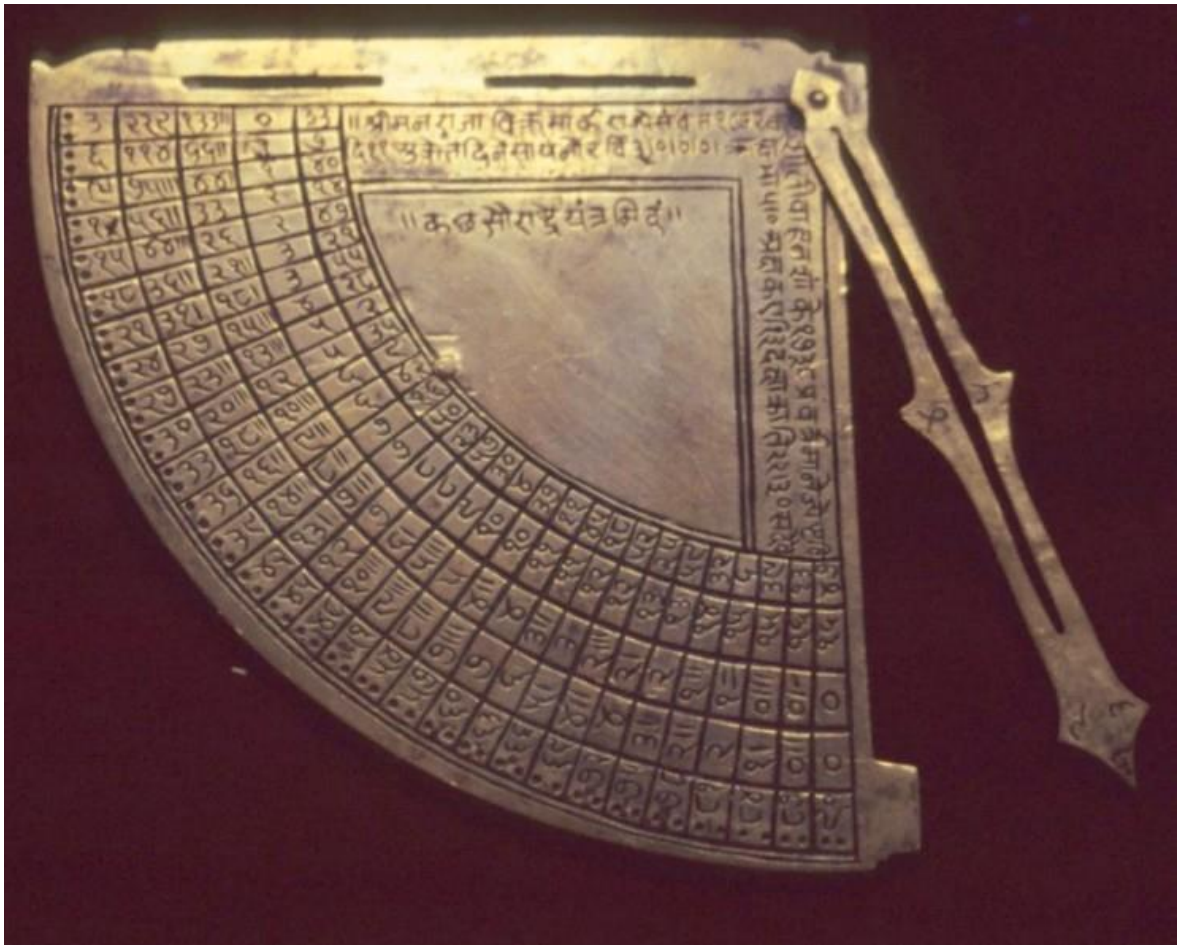


Figure L004.2 – Horary Quadrant (photo by S. R. Sarma)

PROVENANCE

Formerly in a private collection in Paris; came up for auction at Paris in 1980 and was acquired by the Museum of the History of Science. Exhibited in a special exhibition on ‘Science in India’ in connection with the Festival of India, at the Science Museum, London, from 24 March to 1 August 1982.

BIBLIOGRAPHY

Linton 1980, lot 229, pp. 183.

Anderson 1982, no. 132, p. 36.

Verdet 1994.

L005 ⊙ DHRUVABHRAMA-YANTRA BY RĀMANĀTHA JYOTIRVID OF KOTA, 1884 VS (AD 1827)

277 x 232 mm

London, Science Museum (# 1954-703)



Figure L005.1 – Dhruvabhrama-yantra (photo by S. R. Sarma)

DHRUVABHRAMA-YANTRA

Made of an oblong brass sheet, one short side of which is rounded, this instrument carries only the *Dhruvabhrama-yantra* on the front; the back is blank. There is a

horizontal slit below the rounded side. The circles and lines are drawn quite neatly; Sanskrit orthography is flowless.

There are 7 concentric circular scales which commence at 234°. Counting from the outside, these are as follows:

1. Degrees of arc, not numbered
2. Zodiac signs according to the right ascensions, marked clockwise by their serial numbers.
3. One-sixth parts of the zodiac signs in scale 2; marked but not numbered.
4. *Ghaṭī* scale, numbered from 1 to 60 clockwise; the 22nd *ghaṭīs* commences, not at 0°, but a little before it.
5. One-third parts of a *ghaṭī,* marked but not labelled.
6. Zodiac signs according to the oblique ascensions, shown by their serial numbers clockwise.
7. One-sixth parts of the zodiac signs in scale 6, marked but not numbered.

Pivoted at the centre is an elegant index, with dagger-shaped slender arms of unequal length; a plumb bob is to be tied to the shortest arm.

INSCRIPTION

An inscription in two lines is engraved at the top, one line above the slit and the second line on both sides of the slit. The metre of the verse in the first line is *Anuṣṭubh.*

1 ‖ śrī gurave namaḥ ‖ śrīmatkiśorasiṃhasya rājye yaṃtram idam kṛtam ‖ jyotirvid-rāmanāthena koṭākhye nagare vare ‖1‖

2 ‖saṃvat‖ 1884 pauṣe māse śu [slit] kle pakṣe 2 guruvāsare ‖ śrīḥ‖

‘Salutation to the glorious preceptor. This instrument was made in the kingdom of the glorious Kiśorasiṃha by Jyotirvid Rāmanātha in the excellent city by the name of Kota in Saṃvat 1884, on Thursday, the second [day] of the bright half of Pauṣa month. Glory.’

The date translates to 20 December 1827. Kota (25°11′ N; 75°50′ E), the place of manufacture, was formerly the capital of the small semi-independent principality of the same name until its merger in the federal state of Rajasthan after 1947. Kishore Singh II was the ruler between 1819 and 1827.

This instrument was exhibited in a special exhibition on ‘Science in India’ in connection with the Festival of India at the Science Museum, London, from 24 March to 1 August 1982.

BIBLIOGRAPHY

Anderson 1982, no. 133, p. 36.

L006 ⦿ DHRUVABHRAMA-YANTRA & SINE QUADRANT BY BULHOMAL, 1896 VS (AD 1839-40)

225 x 179 x 2 mm

New York, Columbia University, Butler Library (# 27-254)

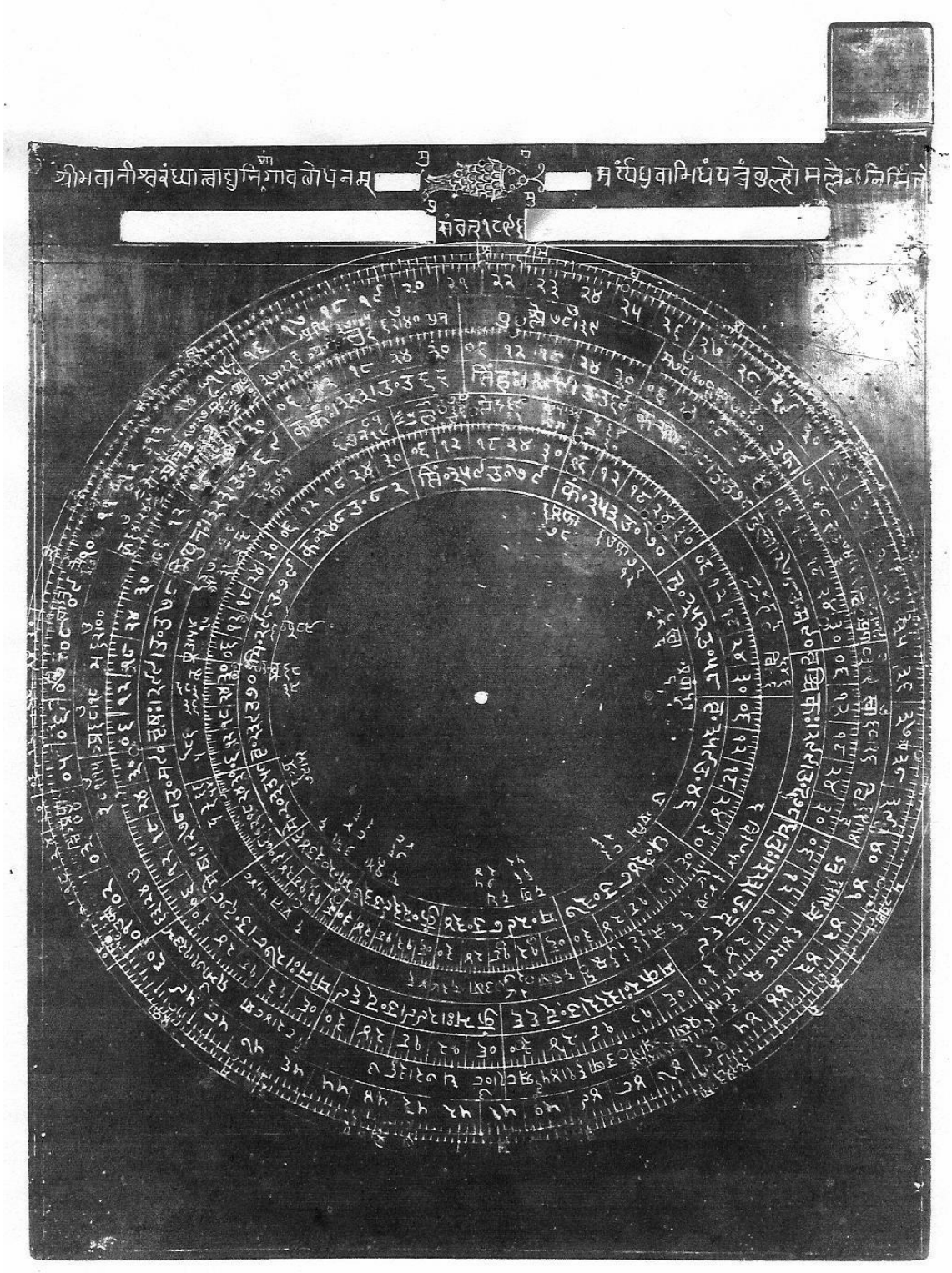


Figure L006.1 – Dhruvabhrama-yantra (courtesy Butler Library, Columbia University)

Crafted by Bhālūmal, the well-known instrument maker of the mid-nineteenth century Panjab, the instrument is filled with so much numerical data that it looks more like a miniature encyclopaedia rather than a handy tool. One of the two sights attached at the two corners at the top is broken and lost. The remaining sight has two pinholes, one for viewing the sun and the other for the stars. The index of the *Dhruvabhrama-yantra* and that of the sine quadrant are missing. The gilded plate is excellently produced and engraved.



Figure L006.2 – Polar Fish (detail from Figure L006.1)

DHRUVABHRAMA-YANTRA

There are two horizontal slits, one immediately below the other, one very short and another much longer. Both slits are interrupted in the middle by about 20 mm of space.

In the space between the two halves of the upper slit is engraved the Polar Fish (*dhruva-matsya*) with many scales on the body and two curved feelers projecting outside. The fish faces towards the right-hand side. One would expect it to be the other way round. Below the mouth of the fish is engraved *mu[kha]* (mouth) and under the tail *pu[ccha]* (tail). Again for the time when the positions of α and β Ursae Minoris become interchanged, on the top of the tail is written *mu[kha]* and on the top of the mouth *pu[ccha].* There are 12 inlaid silver points indicating the 12 stars which constitute the asterism *dhruva-matsya.* Ten of these are placed quite symmetrically on the outline of the body of the fish: one in the mouth, three at the end of the tail, three each on the upper and lower outline of the belly. Two more stars are placed above and below the curve between the body and the tail. This seems to be just a symbolic arrangement and not the actual disposition of the twelve stars. Below the fish figure, in the space between the two halves of the larger slit is written the year of manufacture: *saṃvat 1896* (= AD 1839-40).



Figure L006.3 – Scales of the Dhruvabhrama-yantra (detail of Figure L006.1)

Below these longitudinal apertures are drawn thirteen concentric circular scales. In other instruments, scales are generally constituted by two parallel lines, the space between which is graduated. But here, Bulhomal draws just a single circular line and graduates it with short vertical notches. The scales start at 234°. A thick line is drawn through all the scales at this degree. Likewise at the diametrically opposite point at 54° also a thick line cuts through all the scales, showing their midpoints. The scales contain the following elements:

1. Names of lunar mansions (initials) at irregular intervals; their actual positions are shown in scale 3.
2. Circular line, graduated in 1/6th parts of a *ghaṭī* (10 *palas* = 4 minutes = 1 arc-degree).
3. Another circular line similarly graduated. At irregular intervals are inlaid silver points to indicate the positions of the lunar mansions, whose names are written in scale 1.

4. *Ghaṭī* scale, with the 22nd *ghaṭī* at 0°. The *ghaṭī* numbers are always in two digits like 01, 02, 03, 04 …, which is evidently due to European influence.
5. Names of the lunar mansions (initials) and their meridian altitudes. *Aśvinī* commences where Taurus (*vṛṣa*) begins in scale 8. *Abhijit* is listed between *Pūrvāṣāḍhā* and *Uttarāṣāḍhā* and not between *Uttarāṣāḍhā* and *Śravaṇa.* Besides the 28 lunar mansions, three more stars are included in this scale: *Prajāpati* (δ Aurigae), *Lubdhaka* (α Canis Majoris) and *Apāṃvatsa* (θ Virginis). The engraving is much cluttered and in parts difficult to decipher. There are also inlaid silver points.
6. Degree scale
7. One-fifth parts of the zodiac signs which are shown in the scale below, numbered separately for each sign, as 06, 12, 18, 24, 30.
8. Twelve unequal divisions in which the name of the zodiac signs and their right ascensions are engraved.
9. The names of the lunar mansions (initials), their polar longitudes and the direction (*da = dakṣiṇa,* 'south) and *u = Uttara,* 'north'), written at irregular intervals. The positions of the stars are indicated by inlaid silver points. Because all the 28 could not be accommodated here, some are engraved inside the innermost circle. It is difficult decipher many names and the numerical values.
10. Degree scale.
11. One-fifth parts of the zodiac signs which are marked in the scale below, labelled separately for each sign, as 06, 12, 18, 24, 30.
12. Twelve unequal divisions in which the name of the zodiac signs (initials) and their oblique ascensions are engraved.
13. Inside the innermost circle are engraved the names of some lunar mansions (initials), their polar longitudes, and the direction, which could not be accommodated in scale 9.

Table L006-1 Lunar Mansions, their Meridian Altitudes[1372] and Polar Longitudes[1373]

	Lunar Mansions	Junction Stars	Meridian Altitudes	Polar Longitudes
1	*A[śvinī]*	β Arietis	68;18 N	79;52 S
2	*Bha[raṇī]*	41 Arietis	62;00 N	?
3	*Kṛ[ttikā]*	η Tauri	64;24 N	83;36 S
4	*Ro[hiṇī]*	α Tauri	72;21 N	75;31 S
5	*Mṛ[gaśirā]*	λ Orionis	76;15 N	? S
	Prā[jāpati]	δ Aurigae	77;05 N	70;-5 S
6	*Ā[rdrā]*	α Orionis	37;22 S	?
	Lu[bdhaka]	α Canis Majoris	37;45 S	?
7	*Puna[rvasu]*	β Geminorum	62;40 N	?
8	*Pu[ṣya]*	δ Cancri	-	
9	*[A]śle[ṣā]*	ζ Cancri	78;39 N	69;23 S
10	*Ma[ghā]*	α Leonis	78;40 N	?
11	*Pū[rva]phā[lgunī]*	δ Leonis	70;30 N	78 S
12	*U[ttara]phā[lgunī]*	β Leonis	75;48 S	72;12 S
13	*Ha[sta]*	δ Corvi	74;55 S	?
14	*Ci[trā]*	α Virginis	58;09	?
	Apāṃ[vatsa]	θ Virginis	83;09 N	51;9 S
15	*Svā[ti]*	α Bootis	68;16 N	74;54 S
16	*Vi[śākhā]*	α Librae	69;54 S	46;6
17	*Anu[rādhā]*	δ Scorpii	66;19 -	34;19 S

[1372] Engraved in scale 5.

[1373] Engraved in scales 9 and 13. Several entries are difficult to decipher.

	Lunar Mansions	Junction Stars	Meridian Altitudes	Polar Longitudes
18	*Jye[ṣṭhā]*	α Scorpii	64;28 -	32;23
19	*Mū[la]*	λ Scorpii	58;14 S	26;15 S
20	*Pū[rvā]ṣā[ḍhā]*	δ Sagittarii	65;17 S	29;27 S
22	*Abhi[jit]*	α Lyrae	51; 25 N	83;26 N
21	*U[ttarā]ṣā[ḍhā]*	σ Sagittarii	61;45 S	29;46 S
23	*Śra[vaṇa]*	α Aquilae	81;08 N	66;52 S
24	*Dha[niṣṭhā]*	β Delphini	72;36 N	75;24 S
25	*Śa[tabhiṣā]*	λ Aquarii	82;48 S	50;48 S
26	*Pū[rva]bhā[drapadā]*	β Pegasi	71;12 N	84;36 S
27	*U[ttara]bhā[drapadā]*	γ Pegasi	63;24 N	76;48 S
28	*Re[vatī]*	ζ Piscium	81;15 N	66;54 S

Table L006-2 Scales 8 & 12: Right and Oblique Ascensions of the Zodiac Signs

Scale 8 rising times (in *palas*) at the equator (*laṅkodayas*); Scale 12 rising times (in *palas*) at the observer's latitude (*svīyodayas*). The letters *u* (*udaya* = rising or *uttara* = north), *da* (*dakṣiṇa* = south), *ma* (?) and the numbers that follow are not clear.

	Signs	RA scale 8	OA scale 12
1	*Meṣa*	278 *u ma* 90	203 *u* 58
2	*Vṛṣa*	299 *u u* 78	239 *u* 70
3	*Mithuna*	323 *u u* 69	298 *u* 79
4	*Karka*	323 *u u* 66	348 *u* 82
5	*Siṃha*	299 *u u* 69	359 *u* 79
6	*Kanyā*	278 *u u* 78	353 *u* 70
7	*Tulā*	278 *u ma* 90	353 *u* 58

	Signs	RA scale 8	OA scale 12
8	*Vṛścika*	299 *u. da* 78	359 *u* 46
9	*Dhanuḥ*	323 *u da* 69	348 *u* 37
10	*Makara*	323 *u da* 66	298 *u* 34
11	*Kuṃbha*	299 *u da* 69	239 *u* 37
12	*Mīna*	278 *u da* 78	203 *u* 46

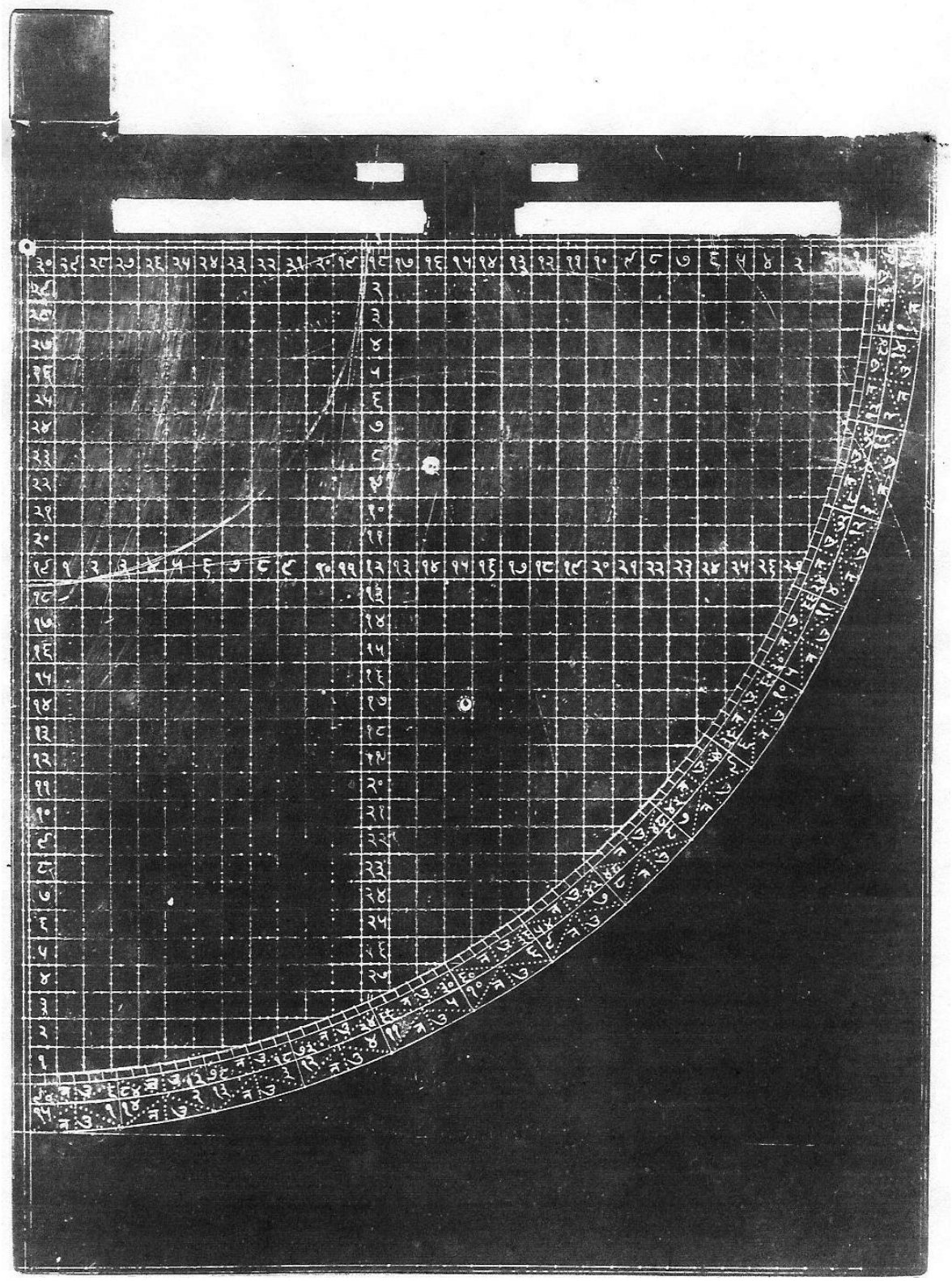


Figure L006.4 – Sine Quadrant (courtesy Butler Library, Columbia University)

SINE QUADRANT

Thirty horizontal and thirty vertical parallels produce a grid of squares. Each square in the grid is sub-divided into 9 small sub-squares, not by lines, but by dots along the horizontal and vertical lines. Thus the vertical and horizontal lines are divided into

90 parts. The columns in the uppermost horizontal row are numbered from 1 to 30, starting from the arc and reaching up to the apex. Likewise in the first column to the left, the rows are numbered from 1 to 30, starting from the arc and reaching up to the apex. An arc of the obliquity of the ecliptic is drawn a little to the right of cosine line 19. In the space between the 19th and 18th cosine lines, the sine lines are numbered from the radius up to the arc; so also in the space between the 19th and 18th sine lines, the cosine lines are numbered from the radius up to the arc.

The arc carries three scales. The innermost scale is divided into 90 degrees of arc. This scale and the other two scales are divided into 15 *ghaṭīs* and labelled from both ends, so that the *ghaṭīs* can be counted from the sunrise or up to the sunset (*unnataghaṭīs*) or up to or from the midday (*nataghaṭīs*). In the second scale, the degrees are numbered in groups of 6° and labelled in both directions in the following manner. *90 na: u 6; 84 na; u 12; 78 na: u 18 … 18 na: u 78; 12 na: u 84; 6 na: u 90.* Here *na* refers to *natāṃśa,* 'zenith distance in degrees', and *u* expands to *u[nnatāṃśa]* altitude in degrees. In the next column the *ghaṭīs* are numbered in the same style. *15 na: u 1; 14 na: u 2; 13 na: u 3 …3 na: u 13, 2 na: u 14; 1 na: u 15.* Here *na* means *na[taghaṭīs]* time interval in *ghaṭīs* between midday and time of observation, while *u* implies *u[nnataghaṭīs]* time interval in *ghatīs* between the sunrise and the time of observation or between the time of observation and the sunset.



Figure L006.5 – Maker's Signature (detail of Figure L006.1)

INSCRIPTION

On both sides of the upper slit, is engraved an inscription, in the *Anuṣṭubh* metre:

śrībhavānīśvaraṃ dhyāttvā dyuniśāṃgāvabodhanam |

turyyaṃ dhruvābhidhaṃ yantraṃ bulhomallena nirmite (sic! read °aṃ) ‖

'Having meditated upon the glorious Pārvatī and Śiva, this *Dhruvabhrama-yantra* (lit. the quadrant instrument designated as *Dhruva*), was constructed by Bhālūmal (*bulhomalla*) for knowing of the parts of the day and of the night.'

BIBLIOGRAPHY

Sarma 2015b, no. 20, pp. 279-281.

L007 ⊙ DHRUVABHRAMA-YANTRA & SINE QUADRANT ATTRIBUTABLE TO BULHOMAL

Not dated, mid-19th century

116 x 115 mm

London, Victoria and Albert Museum (# IM 11-1915)[1374]

This instrument is not signed, but because of the close resemblance between the sine quadrant on the back of this instrument and the same in Bulhomal's signed piece at the Columbia University (L006), it can be safely attributed to Bulhomal. The plate is almost square with a length of 116 and width of 115 mm. The indices on the front and on the back are lost. The plate is highly polished and appears gilded.

DHRUVABHRAMA-YANTRA

On the front side, the instrument maker introduced an innovation in the design of the *Dhruvabhrama-yantra*. Since the rising times of the six signs from Aries to Virgo repeat in the reverse order in the next six signs from Libra to Pisces, he combined the two halves of the zodiac by writing the names of the twelve signs in six pairs and the related 28 lunar mansions in 14 pairs. Accordingly the *ghaṭī* scale carries only 30 *ghatīs*. He must have suitably modified the multiple-armed index, but it is broken and lost.

There is no horizontal slit; the upper edge of the plate can be used for viewing the two stars α and β of Ursa Minor in one line. A diagonal line is drawn joining the upper right hand side corner to the centre as the starting point of the scales. There are seven concentric circular scales. Counting from the outside, these are

1. A scale of 30 units numbered from 1 to 30, starting from the diagonal and proceeding clockwise. Each division here represents 12° or 2 *ghaṭīs*. These divisions are further sub-divided, by dots on the upper line, into 6 parts of 2° or 20 *palas* (= 12 minutes).

[1374] The Victoria and Albert Museum wrote that they do not permit the publication of private photography of their objects. Therefore, I regret that I cannot add here my photos of this extraordinary specimen.

2. Each unit above is divided here into 3 parts (i.e. 4°) and labelled as 20, 30, 60 in the clockwise direction.
3. One-fourth parts of the cells in the scale above (i.e. 1°).
4. The circle is divided into 6 unequal parts and labelled at the end of each division with the names of a pair of the zodiac signs; one of these names is written straight and the other upside-down (shown here in *italics*). The names, starting from the diagonal line are *Tulā,* Meṣa; *Mīna,* Vṛṣa; *Kuṃbha,* Mithuna; *Makara,* Karka; *Dhanuḥ,* Siṃha; *Vṛsci[ka],* Kanyā.
5. Each of these signs is divided into 9 parts, on some are written the initial letters of the names of the lunar mansions,[1375] alternately upside-down and straight, starting from the diagonal and proceeding clockwise. Written first are the names from *A[śvinī]* up to *Ci[trā]* in the clockwise direction and then in reverse direction the names from *Svā[ti]* to *Re[vatī]* upside-down (shown here in *italics*): A[śvinī]; *Revatī,* Bha[raṇī]; *U[ttara-bhādrapadā],* Kṛ[ttikā]; *Pū[rva-bhādrapadā],* Ro[hiṇī]; *Śa[tabhiṣā],* Mṛ[gaśirā]; *Dha[niṣṭhā],* Ārdrā; *Abhijit,* Pu[narvasu]; *U[ttarāṣāḍhā],* Puṣya; *Pū[rvāṣāḍhā],* [A]śle[ṣā]; *Mū[la],* Ma[ghā]; *Jye[ṣṭhā],* Pū[rva-phālgunī]; *A[nurādhā],* U[ttara-phālgunī]; *Vi[śākhā],* Ha[sta]; *Svā[ti],* Ci[trā]; the twenty-third lunar mansion *Śravaṇa* is omitted.
6. Each of the six signs in scale 4 is divided here into 30 degrees.
7. Groups of 6 degrees in the above scale (which are unequal) are labelled clockwise as 6, 12, 18, 24, 30.

The instrument maker seems to have made a mistake in pairing the signs. Following the system adopted for the lunar mansions, the pairing of the signs should have been *Mīna,* Meṣa; *Kuṃbha,* Vṛṣa; *Makara,* Mithuna; *Dhanuḥ,* Karka; *Vṛścika,* Siṃha; *Tulā,* Kanyā.

The arrangement of the scales, the arrangement of the zodiac signs and lunar mansions in pairs in scales 4 and 5, and especially the absence of a distinct *ghaṭī* scale are radically different from Padmanābha's prescriptions. A circular piece with a short projecting band, which is apparently broken, is attached to the centre of the plate by

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[1375] *Aśleṣā,* however, is abbreviated as *śle.*

means of a screw. This is obviously the remnant of the index. It is not clear what kind of index this would have been; was it the usual four-armed index or of a different kind? The peculiar arrangement of scales and the absence of the index make it difficult to say how this instrument actually functioned.

SINE QUADRANT

Fortunately, there is no doubt about the instrument engraved on the back, which is clearly a sine quadrant. Because of the close similarity of this with the sine quadrant on the *Dhruvabhrama-yantra* at the Columbia University (L006), because both show extraordinarily good workmanship, and because both are highly ornate pieces, it is quite certain that the present piece is also by Bulhomal. Here also the index is missing, but the hole at the apex is clearly visible where it would have been attached.

The borders on all four sides are decorated with a series of five-petalled flowers. The entire right-hand side corner outside the arc of the quadrant is filled with a floral pattern with the outlines of three large flowers.

Inside these ornate borders, the quadrant proper is engraved with a grid of 30 horizontal and 30 vertical lines. Each square in the grid is sub-divided into 4 small squares, by dots in the middle of the horizontal and vertical lines. Thus the vertical and horizontal lines are divided into 60 parts each. The columns in the uppermost horizontal row are numbered from 1 to 30, starting from the arc and reaching up to the apex. Likewise in the first column to the left, the rows are numbered from 1 to 30, starting from the arc and reaching up to the apex. An arc of the obliquity of the ecliptic is drawn a little to the right of cosine line 19. In the space between the 19th and 18th cosine lines, the sine lines are numbered from the radius up to the arc; so also in the space between the 19th and 18th sine lines, the cosine lines are numbered from the radius up to the arc.

The arc carries four scales. Counting from the inside, these are as follows.

1. Divided in half degrees.
2. Divided in single degrees.
3. Groups of 6° are numbered and labelled in both directions in the following manner. *90 na: u 6; 84 na: u 12; 78 na: u 18 … 18 na: u 78; 12 na: u 84; 6 na: u 90.* Here *na* refers to *natāṃśa,* ‘zenith distance in degrees’, and *u* expands to *u[nnatāṃśa]* altitude in degrees.

4. Here groups of 6° are treated as single *ghaṭīs,* which are marked in the same style as in the above scale. *15 na: u 1; 14 na: u 2; 13 na: u 3 …3 na: u 13, 2 na: u 14; 1 na: u 15.* Here *na* means *na[taghaṭīs],* time interval in *ghaṭīs* between midday and time of observation, while *u* implies *u[nnataghaṭīs],* time interval in *ghatīs* between the time of observation and the sunrise or the sunset.

Below this scale, approximately below *11 na,* are written *ka 6, mī 12* (upside-down) and *vṛ 2 vṛ 8* (straight). These are clearly the initial letters of four zodiac signs and their serial numbers. Fully expanded they read *Ka[nyā]* (Virgo) 6, *Mī[na]* (Pisces) 12; *Vṛ[ṣa]* (Taurus) 2, *Vṛ[ścika]* (Scorpio) 8. It is not clear what these engravings signify.

BIBLIOGRAPHY

Anderson 1982, no. 130, p. 35.

L008 DHRUVABHRAMA-YANTRA & SINE QUADRANT, NOT SIGNED, NOT DATED

19th century

Silver inlay on a wooden plate, radius 457 mm

Hastings-on-Hudson, NY, Tesseract



Figure L008.1 – Dhruvabhrama-yantra (photo courtesy Dr David Coffeen)

DHRUVABHRAMA-YANTRA

Like the *Dhruvabhrama-yantra* made by Motīrāma in 1784 (L002), the present specimen is also made of wood with lines and letters inlaid with silver wire. An attempt is made here to modify further the innovation introduced by Bulhomal in the preceding specimen (L007). Since the rising times of the six signs from Aries to Virgo repeat in the reverse order in the next six signs from Libra to Pisces, Bulhomal combined in the previous specimen the two halves of the zodiac by writing the names of the twelve signs in six pairs and the related 28 lunar mansions in 14 pairs in circular scales. The next

logical step is to place these pairs of signs in semi-circular scales which is done in the present specimen.

Unfortunately, the silver wire came off in many places and it is impossible to decipher the numbers and letters with certainty. All that one can see is that in the outermost scale, each cell is filled with the names of a pair of zodiac signs. Apparently some of these eight semi-circular scales pertain to zodiac signs in their right ascensions and some to zodiac signs in their oblique ascensions.

There is a longitudinal slit on the diameter of the semi-circular scales for viewing the stars α and β of Ursa Minor in one line. The slit is interrupted in the middle by a hole. Probably an index modified to show the sidereal time, ascendant and culmination may have been pivoted here.



Figure L008.2 – Sine quadrant on the reverse (photo courtesy Dr David Coffeen)

SINE QUADRANT

The reverse side of this wooden board is designed as a sine quadrant with 30 vertical and 30 horizontal parallels which are, however, not numbered. The arc is divided in 1° and 6°. Groups of 6° appear to have been numbered from 1 to 15 on the edge of the quadrant.



Figure L008.3 – Graduated edge (photo courtesy Dr David Coffeen)

At the 12th division, a quarter circle is drawn to represent the circle of obliquity. There is another quarter circle drawn with a radius which is about a half of the other radius. Above the horizontal radius are three words which are indecipherable. A plumb line is suspended from the apex of the quadrant.



Figure L008.4 – Detail of the sine quadrant (photo courtesy Dr David Coffeen)

BIBLIOGRAPHY

Tesseract, Catalogue 30, lot 20

L009 ⊙ DHRUVABHRAMA-YANTRA & SINE QUADRANT, NOT SIGNED, NOT DATED

Jodhpur, 19th century

163 x 144 mm

London, Science Museum (# 1990-581)



Figure L009.1 – Dhruvabhrama-yantra (photo by S. R. Sarma)

This and the next *Dhruvabhrama-yantra* (L010) are equipped with the most flamboyant indices, but the circular scales on both the instruments are not quite correct.

The present specimen is made of a rectangular plate. To one of the shorter sides are attached two sighting vanes. A horizontal slit is cut into the plate on the same side. Below this slit is engraved on the left *akṣabhā 6* (equinoctial shadow 6 digits) and on the right *akṣāṃśa* 26 (latitude 26°). This latitude corresponds to that of Jodhpur, where the instrument may have been produced.

DHRUVABHRAMA-YANTRA

Below the horizontal slit, there are nine circular scales which commence at 234° and proceed clockwise. This point of the vernal equinox is marked with a floral design outside the circular scales.[1376] No other instrument has such a mark to show the vernal equinox. The scales, counted from the outside, are as follows:

1. One-sixth parts of a *ghaṭī,* i.e. 10 *palas* or 4 minutes; the divisions are uneven.
2. *Ghaṭī* scale, numbered from 1 to 60, with the 22nd *ghaṭī* commencing at 0°.
   Scales 3-6 pertain to the zodiac signs in their right ascensions.
3. Names of lunar mansions (initials) followed by their polar longitudes; *Aśvinī* at 12° of Aries.
4. One-third parts of the cells in the next scale, i.e. 2° of the signs.
5. Each sign marked in scale 6 is divided here into 5 parts of 6° and numbered 6, 12, 18, 24, 30.
6. Twelve equal divisions containing the names of the zodiac signs (initials), followed by serial numbers. Interestingly *Meṣa* is given the serial number 0.
   Me 0, Vṛ 1, Mi 2, Ka 3, Si 4, Ka 5, Tu 6, Vṛ 7, Dh 8, Ma 9, Ku 10, Mī 11.
   Scales 7-9 pertain to the zodiac signs in their oblique ascensions.
7. Halves of the cells in the next scale, i.e. 3°
8. One-fifth parts of the zodiac signs marked in scale 9, numbered separately for each sign as 6, 12, 18, 24, 30.
9. Twelve equal divisions containing the names of the zodiac signs according to their oblique ascensions; initial syllables followed by the serial number as in scale 6.

Actually the divisions in scales 6 and 9 ought to be unequal and different from one set to the other, but that is not the case here.

[1376] Because of patina, it is faintly visible in Figure L009.1.

Table L009-1 Scale 3: Lunar Mansions and their Polar Longitudes
The scale commences with the 28th lunar mansion *Revatī.*

	Lunar Mansions	Junction Stars	Polar Longitudes
28	*Re[vatī]*	ζ Piscium	18;46
1	*A[śvinī]*	β Arietis	26;46
2	*Bha[raṇī]*	41 Arietis	39
3	*Kṛ[ttikā]*	η Tauri	56
4	*Ro[hiṇī]*	α Tauri	67
5	*Mṛ[gaśirā]*	λ Orionis	80
6	*Ā[rdrā]*	α Orionis	84;46
7	*Pu[narvasu]*	β Geminorum	112
8	*Pu[ṣya]*	δ Cancri	124
9	*A[śleṣā]*	ζ Cancri	125
10	*Ma[ghā]*	α Leonis	157
11	*Pū[rva-phālgunī]*	δ Leonis	166
12	*U[ttara-phālgunī]*	β Leonis	173
13	*Ha[sta]*	δ Corvi	188;46
14	*Ci[trā]*	α Virginis	201
15	*Svā[ti]*	α Bootis	216
16	*Vi[śākhā]*	α Librae	230
17	*A[nurādhā]*	δ Scorpii	242
18	*Jye[ṣṭhā]*	α Scorpii	248
19	*Mū[la]*	λ Scorpii	260
20	*Pū[rvāṣāḍhā]*	δ Sagittarii	263
21	*U[ttarāṣāḍhā]*	σ Sagittarii	276
22	*A[bhijit]*	α Lyrae	279

	Lunar Mansions	Junction Stars	Polar Longitudes
23	*Śra[vaṇa]*	α Aquilae	293
24	*Dha[niṣṭhā]*	β Delphini	304
25	*Śa[tabhiṣā]*	λ Aquarii	328
26	*Pū[rva-bhādrapadā]*	β Pegasi	343
27	*U[ttara-bhādrapadā]*	γ Pegasi	355



Figure L009.2 – Index of the Dhruvabhrama-yantra (detail of Figure L009.1)

INDEX

Four arms of varying lengths are added to the circular centre which is decorated by a flower with six petals. The longest arm is given the form of a fish tail and the shortest is shaped like a face with a long nose and long eyebrows, all drawn in one line, and two round eyes. The tips of the arms are joined by thin bands bearing decorative engravings.



Figure L009.3 – Sine quadrant (photo by S. R. Sarma)

SINE QUADRANT

A sine quadrant is engraved on the reverse side. The horizontal radius is divided into 30 parts and from each point of division cosine lines are drawn parallel to the vertical radius. These are labelled in groups of three as 3, 6, 9, 12 …30. The space between the 13th and 14th cosine lines is divided to indicate the transverse position of the sine lines, and similarly numbered in groups of three.

There are three scales on the arc of the quadrant. The outermost scale is divided into 15 *ghaṭīs* and numbered serially from 1 to 15, starting from the vertical radius and reaching up to the horizontal radius with the sights. The *ghaṭī* scale is extended by two

ghaṭīs, beyond the vertical radius, which are numbered upside down as 1, 2. In the middle scale, each *ghaṭī* is divided into 3 parts (i.e. 20 *palas* or 8 minutes) and in the innermost scale into 6 parts (i.e. 10 *palas* or 4 minutes, or 1 degree of arc).

The index pivoted at the apex is broken and lost; all that remains is a short stub.

PROVENANCE

Came up for auction at Christie's in 1990, when it was acquired by the Science Museum.

BIBLIOGRAPHY

Christie's, London, auction catalogue of 27 September 1990, lot 188, p. 38.

L010 ⊙ DHRUVABHRAMA-YANTRA & SINE QUADRANT MADE FOR YĀDO JOŚĪ OF UKALA-GRĀMA

Not signed or dated, 19th century

112 x 104 mm

Pune, Raja Dinkar Kelkar Museum (# KM 31-13)



Figure L010.1 – Dhruvabhrama-yantra (photo by S. R. Sarma)

This is an elegantly made specimen with a highly ornate index. The plate is not uniformly flat on the obverse side but tapers down from the centre to the edges so that the index does not rub against the scales when it is rotated. It is also thicker where it is extended to form the two sighting vanes. On the upper side where the sighting vanes are, a long horizontal slit is cut in the plate.

On the obverse side, above the slit is engraved *akṣabhā 4|20* (equinoctial shadow 4;20), to the left of the slit *mukha* (mouth [of the Polar Fish]) and below that *paḷāṃśa 20* (latitude 20°); to the right of the slit *puccha* (tail [of the Polar Fish]) and below that *ayanāṃśa 19/10* (degrees of precession 19;10).[1377] These indicate that this *Dhruvabhrama-yantra* was prepared for the latitude of 20° where the noon equinoctial shadow (*akṣabhā*), that is the shadow thrown at the equinoxes by a gnomon of 12 digits (*aṅgulas*), measures 4 digits (*aṅgulas*) and 20 sub-digits (*vyaṅgulas*), at a time when the precession is 19;10°. On the reverse side, above the horizontal slit, is engraved *ukala-grāma-sthita yādo josi* (sic!), 'Yādo Jośī, resident of Ukala village.' Yādo Jośī must be the astronomer who prepared the technical design of the instrument and got it fabricated by an artisan. It is likely that Ukala, his place of residence, is identical with the modern Akola which lies roughly on the latitude of 20 degrees (more exactly, lat. 20° 42′ N, long. 77° 02′ E).

The obverse side is fashioned as the *Dhruvabhrama-yantra* and the reverse side as the sine quadrant. However, neither side is correctly designed. In the *Dhruvabhrama-yantra,* the scale 4 and 7 carry the names of the zodiac signs. The former should be divided in 12 unequal parts according to the right ascensions, but it is divided in 12 equal parts. Scale 7 appears to be divided into 12 unequal divisions according to oblique ascensions. On the reverse side, the sine quadrant carries 24 vertical parallels instead of 30 and these are partially obliterated for reasons unknown.

DHRUVABHRAMA-YANTRA

Below the horizontal slit, there are seven circular scales, all commencing at 234° and proceeding clockwise. Counting from the outside, these are as follows:

1. *Ghaṭī* scale, numbered from 1 to 60, with the 22nd *ghaṭī* starting at 0°.
2. Names of the lunar mansions (initials) followed by their polar longitudes (*dhruvaka*).
3. One-fifteenth parts of the zodiac signs, which are shown in the next scale.

[1377] According to Pingree 1996, p. 181, the noon equinoctial shadow of 4;20 corresponds to a latitude of 19;52°, i.e. almost 20°. Therefore what the instrument calls *paḷāṃśa* means in effect *akṣāṃśa*.

4. Twelve equal divisions in which are engraved the names of the zodiac signs (initials), followed by their meridian altitudes and their directions (*da* = *dakṣiṇa* , south*; u* = *uttara,* north).
5. Names of the lunar mansions (initials), beginning with *Uttara-bhādrapada,* followed by the polar longitudes (*dhruvaka*) and meridian altitudes (*madhyonnatāṃśa*).
6. One-fifteenth parts of the zodiac signs, which are shown in the next scale.
7. Twelve unequal divisions in which the names of the zodiac signs (initials) are engraved.
8. blank.

Table L010-1 Scale 2: Lunar mansions and their Polar Longitudes
The scale commences from the twenty-eighth lunar mansion *Revatī.*

	Lunar Mansions	Junction Stars	Polar Longitudes
28	*Re[vatī]*	ζ Piscium	19;10
1	*A[śvinī]*	β Arietis	27;10
2	*Bha[raṇī]*	41 Arietis	40;10
3	*Kṛ[ttikā]*	η Tauri	57;10
4	*Ro[hiṇī]*	α Tauri	68;10
5	*Mṛ[gaśirā]*	λ Orionis	81;10
6	*Ā[rdrā]*	α Orionis	85;10
7	*Pu[narvasu]*	β Geminorum	113;10
8	*Pu[ṣya]*	δ Cancri	125;10
9	*A[śleṣā]*	ζ Cancri	126;10
10	*Ma[ghā]*	α Leonis	148;10
11	*Pū[rva-phālgunī]*	δ Leonis	167;10
12	*U[ttara-phālgunī]*	β Leonis	174;10
13	*Ha[sta]*	δ Corvi	189;10
14	*Ci[trā]*	α Virginis	202;10

	Lunar Mansions	Junction Stars	Polar Longitudes
15	*Svā[ti]*	α Bootis	217;10
16	*Vi[śākhā]*	α Librae	231;10
17	*A[nurādhā]*	δ Scorpii	243;10
18	*Ja [*sic! *Jyeṣṭhā]*	α Scorpii	249;10
19	*Mū[la]*	λ Scorpii	261;10
20	*Pū[rvāṣāḍhā]*	δ Sagittarii	274;10
21	*A[bhijit]*	α Lyrae	277;10
22	*U[ttarāṣāḍhā]*	σ Sagittarii	280;10
23	*Śra[vaṇa]*	α Aquilae	294;10
24	*Dha[niṣṭhā]*	β Delphini	305;10
25	*Śa[tabhiṣā]*	λ Aquarii	329;10
26	*Pū[rva-bhādrapadā]*	β Pegasi	344;10
27	*U[ttara-bhādrapadā]*	γ Pegasi	356;10

Table L010-2 Scale 4: Zodiac signs and their Meridian Altitudes

	Zodiac Signs	Modern Names	Meridian Altitudes
1	*Me[ṣa]*	Aries	76 S
2	*Vṛ[ṣa]*	Taurus	87 S
3	*Mi[thuna]*	Gemini	87 N
4	*Ka[rka]*	Cancer	88 N
5	*Siṃ[ha]*	Leo	86 S
6	*Ka[nyā]*	Virgo	75 S

	Zodiac Signs	Modern Names	Meridian Altitudes
7	*Tu[lā]*	Libra	64 S
8	*Vṛ[ścika]*	Scorpio	53 S
9	*Dha[nuḥ]*	Sagittarius	47 S
10	*Ma[kara]*	Capricorn	48 S
11	*Kuṃ[bha]*	Aquarius	54 S
12	*Mī[na]*	Pisces	65 S

Table L010-3 Scale 5: Lunar Mansions, their Polar Longitudes and Meridian Altitudes

The scale commences from the twenty-seventh lunar mansion *Uttara-bhādrapada.* The polar longitudes given here differ from those in scale 2.

	Lunar Mansion	Junction Stars	Polar Longitudes	Meridian Altitudes
27	*U[ttara-bhādrapadā]*	γ Pegasi	6	8 S
28	*Re[vatī]*	ζ Piscium	19	76 -
1	*A[śvinī]*	β Arietis	31	89 N
2	*Bha[raṇī]*	41 Arietis	44	84 N
3	*Kṛ[ttikā]*	η Tauri	59	87 N
4	*Ro[hiṇī]*	α Tauri	66	87 N
5	*Mṛ[gaśirā]*	λ Orionis	77	83 -
6	*Ā[rdrā]*	α Orionis	82	82 S
7	*Pu[narvasu]*	β Geminorum	115	83 N
8	*Pu[ṣya]*	δ Cancri	125	89 N
9	*A[śleṣā]*	ζ Cancri	133	83 -
10	*Ma[ghā]*	α Leonis	148	84 S

	Lunar Mansion	Junction Stars	Polar Longitudes	Meridian Altitudes
11	*Pū[rva-phālgunī]*	δ Leonis	171	88 S
12	*U[ttara-phālgunī]*	β Leonis	179	84 S
13	*Ha[sta]*	δ Corvi	185	57 S
14	*Ci[trā]*	α Virginis	207	61 S
15	*Svā[ti]*	α Bootis	230	85 N
16	*Vi[śākhā]*	α Librae	231	51 S
17	*A[nurādhā]*	δ Scorpii	242	48 S
18	*Jye[ṣṭhā]*	α Scorpii	248	45 S
19	*Mū[la]*	λ Scorpii	258	38 S
20	*Pū[rvāṣāḍhā]*	δ Sagittarii	272	41 S
21	*U[ttarāṣāḍhā]*	σ Sagittarii	278	41 S
22	*A[bhijit]*	α Lyrae	299	- -
23	*Śra[vaṇa]*	α Aquilae	305	79 N
24	*Dha[niṣṭhā]*	β Delphini	318	67 S
25	*Śa[tabhiṣā]*	λ Aquarii	339	60 S
26	*Pū[rva-bhādrapadā]*	β Pegasi	343	86 S

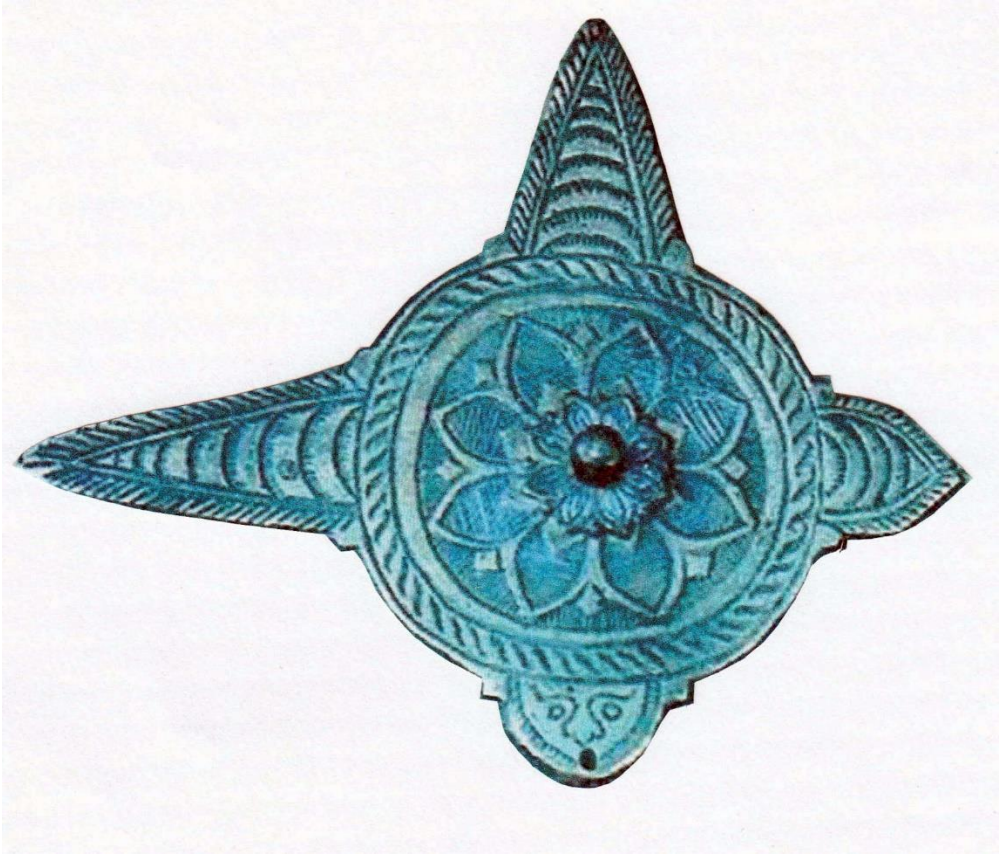


Figure L010.2 – Index of the Dhruvabhrama-yantra (detail of Figure L010.1)

INDEX

At the centre is pivoted a beautifully crafted four-armed index. In the middle of the index is engraved a lotus with eight petals in each of the four layers. The washer is also shaped like a lotus. The shortest arm, on which a face is engraved, has a hole at the bottom for suspending the weight which keeps it always in a vertical position.

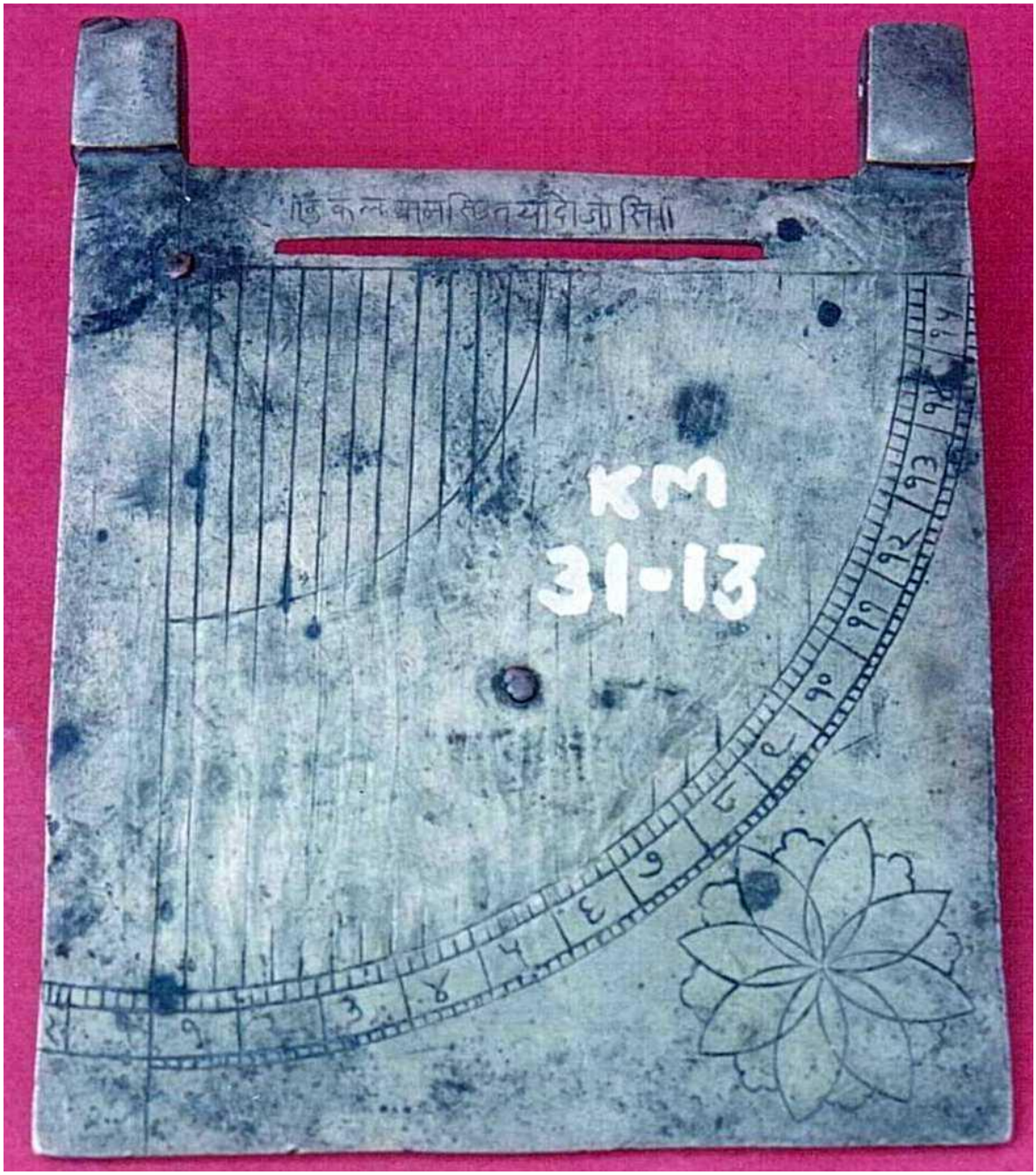


Figure L010.3 – Sine quadrant on the reverse (photo by S. R. Sarma)

Sine Quadrant

On the reverse side is the sine quadrant where 24 vertical lines are drawn (instead of 30); these are partly obliterated, but retained inside a quarter circle drawn at half the radius. There are three scales along the arc of the quadrant. The outer scale consists of single degrees. The middle scale is marked for each 6° and numbered anti-clockwise from 1 to 15. In the inner scale, each of these divisions of 6° are subdivided into 5 units of 1.2 degrees each. The purpose of such a sub-division is not known. Beyond the arc is the elegant outline of an eight-petalled lotus which matches with the lotus on the index

on the observe side. Originally there was an index on this side also, but it is now lost. The copper pin which held the index can be seen at the apex of the quadrant.



Figure L010.4 – Inscription on the reverse (detail of Figure L010.3)

INSCRIPTION

‖ *ukala-grāma-sthita-yādo-josi* ‖

‘Yādo Jośī, resident of the Ukala village.’

L011 DHRUVABHRAMA-YANTRA & SINE QUADRANT, NOT SIGNED, NOT DATED

19th century

222 x 220 mm

PLU; ex-London, Sotheby's 2010



Figure L011.1 – Dhruvabhrama-yantra (courtesy Sotheby's, London)

This is a well-crafted specimen. The scales are carefully divided and the orthography is excellent. The *Dhruvabhrama-yantra* on the obverse is so made that it can show sidereal time with an accuracy of 4 minutes and the ascendant and culmination with an accuracy of 2 degrees of arc.



Figure L011.2 – Dhruvabhrama-yantra without the index (courtesy Sotheby's, London)

DHRUVABHRAMA-YANTRA

It is an oblong brass plate with a narrow horizontal slit close to and parallel to a shorter side. Below the slit are drawn eight concentric circular scales, which commence at 234°. A diameter is drawn from this point up to 54° which is the midpoint of all scales. Counting from outside, the scales are as follows:

1. *Ghaṭī* scale, numbered from 1 to 60, with the 22nd *ghaṭī* commencing at 0°.
2. One-sixth parts of a *ghaṭī,* i.e. 10 *palas* or 4 minutes.
3. Names of the 28 lunar mansions (initials) as related to the signs shown in scale 5.
4. One-fifteenth parts of the zodiac signs shown in scale 5.

5. Names of the zodiac signs (according to their right ascensions), labelled as *Meṣaḥ, Vṛṣaḥ, Mithunaḥ, Karkaḥ, Siṃhaḥ, Kanyā, Tūlā* (sic! *Tulā*), *Vṛścikaḥ, Dhanuḥ, Makaraḥ, Kuṃbhaḥ* and *Mīnaḥ.*
6. Names of the 28 lunar mansions (initials) as related to the signs shown in scale 8.
7. One-fifteenth parts of the zodiac signs shown in scale 8.
8. Names of the zodiac signs (according to their oblique ascensions), labelled as in scale 5.

Inside the innermost circular scale are engraved the initial syllables of the Sanskrit names of the 28 lunar mansions together with their meridian altitudes (*madhyonnatāṃśa*) in nine continuous lines.

Table L011-1 Lunar Mansions and their Meridian Altitudes

	Lunar Mansions	Junction Stars	Meridian Altitudes
1	*A[śvinī]*	β Arietis	87
2	*B[haraṇī]*	41 Arietis	80;39
3	*Kṛ[ttikā]*	η Tauri	83
4	*Ro[hiṇī]*	α Tauri	86;54
5	*Mṛ[gaśirā]*	λ Orionis	87;20
6	*Ā[rdrā]*	α Orionis	84;30
7	*Pu[narvasu]*	β Geminorum	80;56
8	*Pu[ṣya]*	δ Cancri	87;31
9	*Ā[śleṣā]*	ζ Cancri	83;10
10	*Ma[ghā]*	α Leonis	83;15
11	*Pu*(sic! *pū*)*[rva-phālgunī]*	δ Leonis	87;32
12	*U[ttara-phālgunī]*	β Leonis	86
13	*Ha[sta]*	δ Corvi	56;8
14	*Ci[trā]*	α Virginis	59;56

	Lunar Mansions	Junction Stars	Meridian Altitudes
15	*Svā[ti]*	α Bootis	84;35
16	*Vi[śākhā]*	α Librae	51;37
17	*A[nurādhā]*	δ Scorpii	48;6
18	*Jye[ṣṭhā]*	α Scorpii	46;4
19	*Mū[la]*	λ Scorpii	39;53
20	*Pū[rvāṣāḍhā]*	δ Sagittarii	42;51
21	*U[ttarāṣāḍhā]*	σ Sagittarii	43;16
22	*A[bhijit]*	α Lyrae	68;47
23	*Śra[vaṇa]*	α Aquilae	80;53
24	*Dha[niṣṭhā]*	β Delphini	88;51
25	*Śa[tabhiṣā]*	λ Aquarii	64;4
26	*Pū[rva-bhādrapadā]*	β Pegasi	53;4
27	*U[ttara-bhādrapadā]*	γ Pegasi	45;20
28	*Revatī*	ζ Piscium	80

Loosely pivoted to the centre of the plate is an index with four arms of different lengths.

Sine Quadrant

On the back of the plate is engraved a sine quadrant with a radius of 192 mm. The horizontal radius at the top is divided into 30 parts and from the points of division 30 lines are drawn parallel to the vertical radius, starting from the horizontal radius and reaching up to the arc of the quadrant. The arc of the quadrant carries a degree scale with single degrees marked on the inner band and groups of 6 degrees on the outer band. The latter are labelled serially from 1 to 15 starting from the vertical side.



Figure L011.3 – Sine quadrant (courtesy Sotheby's, London)

Two unusually long pillar-like sights, topped by decorative finials, are attached above the horizontal radius for viewing the heavenly bodies. At the apex of the quadrant is pivoted a rather thick index with a square cross section.

BIBLIOGRAPHY

Sotheby's, London, *Arts of the Islamic World,* auction catalogue, 14 April 2010, lot 125, pp. 90-91.

L012 ⦿ DHRUVABHRAMA-YANTRA & SINE QUADRANT, NOT SIGNED, NOT DATED

19th century

155 x 131 mm

Varanasi, Banaras Hindu University, Bharat Kala Bhavan (# 3/9490)

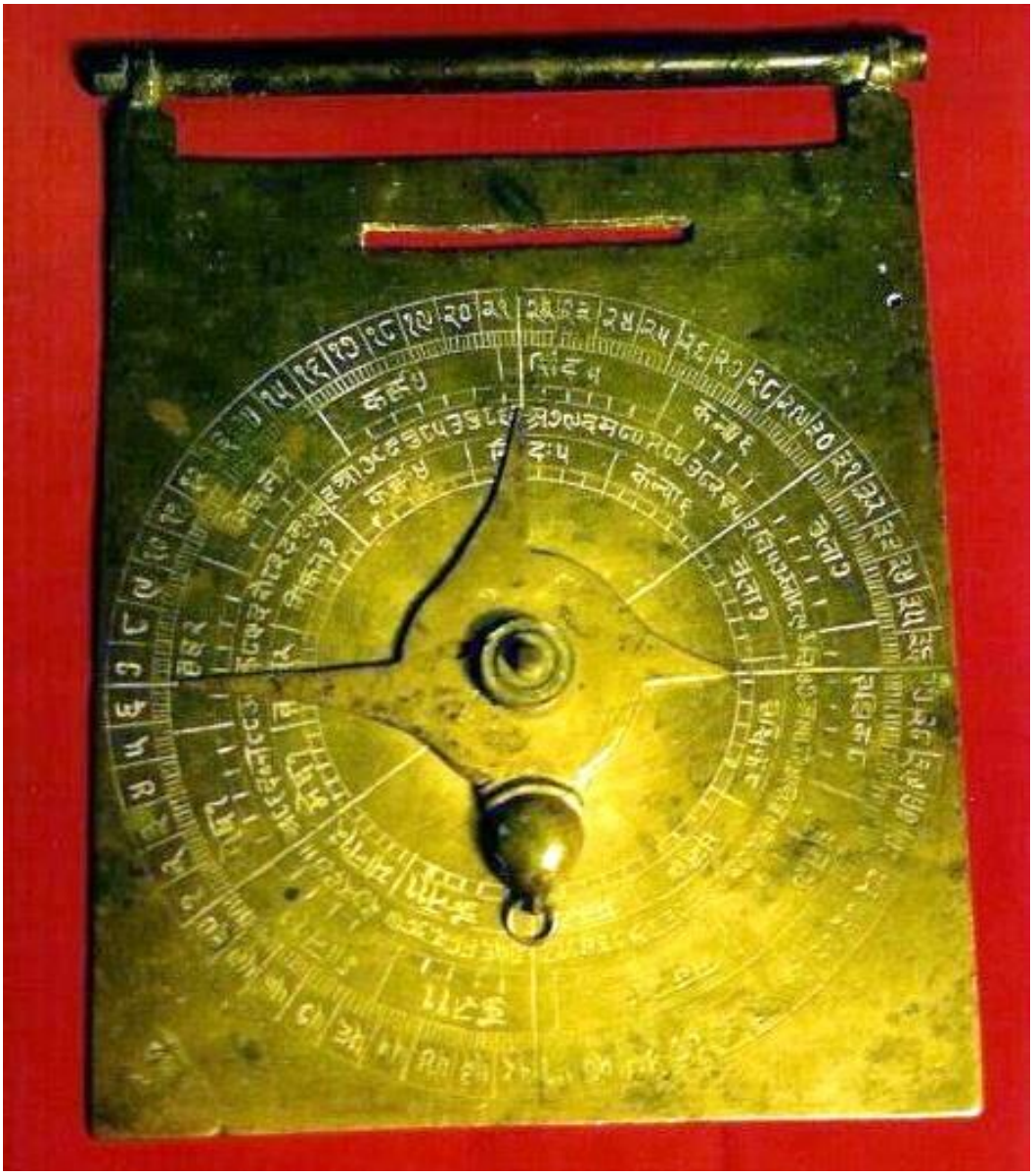


Figure L012.1 – Dhruvabhrama-yantra (photo by S. R. Sarma)

This is a well-crafted specimen with an elegant index. The letters and the numerals are neatly engraved; they betray western Indian provenance. The rectangular plate is so cut that there are two projections on one of the shorter sides. To these projections are welded two rings through which a sighting tube is inserted. On the same short side, a long slit is made parallel to the sighting tube.

DHRUVABHRAMA-YANTRA

Below the horizontal slit, there are seven circular scales, on which horizontal and vertical diameters are drawn; also a third diameter joining the points at 234° and 54°. The scales commence from 234° and proceed clockwise. Counting from the outside, the seven scales are as follows:

1. *Ghaṭī* scale with 60 numbered divisions; the 22nd *ghaṭī* commences at 0°.
2. One-sixth parts of a *ghaṭī,* i.e. 10 *palas* or 4 minutes. The divisions are not drawn uniformly.
3. Names of the zodiac signs according to their right ascensions, engraved with the serial numbers as *Meṣa 1* and so on.
4. One-sixth parts of the zodiac signs shown in scale 3, marked but not numbered.
5. Names of the lunar mansions (initials), followed by their meridian altitudes and their direction: *u[ttara],* 'north' or *da[kṣiṇa],* 'south'. In many cases, however, these directions are not mentioned.
6. Names of the zodiac signs according to their oblique ascensions, engraved with the serial numbers.
7. One-sixth parts of the zodiac signs shown in scale 6, marked but not numbered.

Table L012-1 Scale 5: Lunar Mansions and their Meridian Altitudes

	Lunar Mansions	Junction Stars	Meridian Altitudes
1	*A[śvinī]*	β Arietis	86 S
2	*Bha[raṇī]*	41 Arietis	88 N
3	*Kṛ[ttikā]*	η Tauri	89 S
4	*Ro[hiṇī]*	α Tauri	83 S
5	*Mṛ[gaśirā]*	λ Orionis	79 S
6	*Ā[rdrā]*	α Orionis	78 S
7	*Pu[narvasu]*	β Geminorum	85 N
8	*Pu[ṣya]*	δ Cancri	86 S
9	*A[śleṣā]*	ζ Cancri	79 S

	Lunar Mansions	Junction Stars	Meridian Altitudes
10	*Ma[ghā]*	α Leonis	80 -
11	*Pū[rva-phālgunī]*	δ Leonis	84 -
12	*U[ttara-phālhgunī]*	β Leonis	82 -
13	*Ha[sta]*	δ Corvi	53 -
14	*Ci[trā]*	α Virginis	57 -
15	*Svā[ti]*	α Bootis	89 N
16	*Vi[śākhā]*	α Librae	49 -
17	*A[nurādhā]*	δ Scorpii	44 -
18	*Jye[ṣṭhā]*	α Scorpii	41 -
19	*Mū[la]*	λ Scorpii	34 -
20	*Pū[rvāṣāḍhā]*	δ Sagittarii	37 -
21	*U[ttarāṣāḍhā]*	σ Sagittarii	37 -
22	*A[bhijit]*	α Lyrae	76 N
23	*Śra[vaṇa]*	α Aquilae	73 -
24	*Dha[niṣṭhā]*	β Delphini	71 N
25	*Śa[tabhiṣā]*	λ Aquarii	56 -
26	*Pū[rva-bhādrapadā]*	β Pegasi	82 -
27	*U[ttara-bhādrapadā]*	γ Pegasi	89 -
28	*Re[vatī]*	ζ Piscium	72 S

INDEX

From a circular base project three arms of different lengths which reach up to the scale of *ghaṭīs,* the scale of right ascensions and the scale of oblique ascensions

respectively. The weighted arm in the south is shaped like a parrot's head with a large ring attached to the beak.



Figure L012.2 – Sine Quadrant on the Back (photo by S. R. Sarma)

SINE QUADRANT

The arc of the quadrant consists of two bands; the narrow inner band is divided in single degrees of arc; in the outer band groups of 6° are numbered serially from 1 to 15, starting from the vertical radius and reaching up to the horizontal radius with the sighting tube. The horizontal radius is divided into 30 parts and numbered from 1 to 30, starting from the vertical radius and reaching up to the arc. From each division a vertical parallel is drawn. There are no horizontal parallels. The index is missing.

L013 ⦿ DHRUVABHRAMA-YANTRA & SINE QUADRANT, NOT SIGNED, 1935 VS (AD 1878-79)

236 x 226 mm

Jaipur, PC



Figure L013.1 – Dhruvabhrama-yantra (photo by S. R. Sarma)

In the front, at the lower right hand corner of this oblong plate, is engraved *palabhā 6|6*, 'noon equinoctial shadow thrown by a gnomon of 12 digits [is] 6;30 digits'. This shadow length corresponds to the terrestrial latitude of 26;57°, which is roughly the

latitude of Jaipur.[1378] On the back, along the left edge, towards the bottom, is engraved *Saṃvat 1935* which corresponds to AD 1878-79. There is no other inscription mentioning the name of the maker or of the owner. It is a neatly crafted piece; the graduations are engraved carefully and accurately. It has now become rather rusty.

DHRUVABHRAMA-YANTRA

Below the narrow horizontal slit are six concentric circular scales. Starting from the outside, these are

1. *Ghaṭī* scale, numbered from 1 to 60, with the 22nd *ghaṭī* commencing at 0°.
2. One-sixth parts of the above, i.e. 10 *palas* or 4 minutes.
3. Zodiac signs according to their right ascensions. The extent of each sign is divided into 5 parts and in the first part, the first syllable of the name of the respective sign is engraved; the other parts are blank.
4. One-sixth parts of the zodiac signs shown above.
5. Zodiac signs according to the oblique ascensions, engraved in the same manner as in scale 3 above.
6. One-sixth parts of the cells above.

At the centre is pivoted a four-armed index. The four arms, at right angles to one another, project from a circular centre. The southern arm has a distinct design lending it extra weight. The other three arms of varying lengths terminate in pointed ends as in the alidades of astrolabes.

SINE QUADRANT

The back is engraved as a sine quadrant, with a grid of 30 vertical and 30 horizontal equi-distant parallels. The arc of the quadrant bears three bands; the inner scale is divided in single degrees; groups of 6° are numbered from 6 to 90 in the middle band; in the outer band, the same divisions as above are numbered serially from 1 to 15 in the reverse direction. This allows for counting the degrees and *ghaṭīs* in both directions.

[1378] Cf. Pingree 1996, esp. Appendix C: latitudes corresponding to noon equinoctial shadow on pp. 217-220.



Figure L013.2 – Sine quadrant on the back (photo by S. R. Sarma)

A sighting tube is attached directly to the upper edge of the plate, just above the horizontal slit. There are also two sights attached above the sighting tube. An ungraduated index is pivoted at the apex of the quadrant.

L014 ⊙ DHRUVABHRAMA-YANTRA & SINE QUADRANT, NOT SIGNED, NOT DATED

Anon, nd

Copper, 193 x 175 x 3 mm

Jaipur, Museum of Indology



Figure L014.1 – Dhruvabhrma-yantra (photo by S. R. Sarma)

DHRUVABHRAMA-YANTRA

The outline of the Polar Fish is engraved around the horizontal slit. Above the slit, there are two vertical bars attached to the edge of the plate which support a sighting tube. Below the horizontal slit, there are eight circular scales, which commence at 234° and proceed clockwise. Counting from the outside, these scales are as follow:

1. *Ghaṭī* scale, numbered from 1 to 60, with the 22nd *ghaṭī* commencing at 0°.
2. One-sixth parts of a *ghaṭī*, i.e. 10 *palas* or 4 minutes.
3. Names of the lunar mansions (initials) as related to the zodiac signs in scale 5.
4. One-thirtieth parts of the zodiac signs shown in the scale below.
5. Names of the zodiac signs according to their right ascensions.
6. Names of the lunar mansions (initials) as related to the zodiac signs in scale 8.
7. One-thirtieth parts of the zodiac signs shown in the scale below.
8. Names of the zodiac signs according to their oblique ascensions.

At the centre, a four-armed index is pivoted. One of the arms is short. A weight is to be attached to this arm. The other three arms are of equal length and reach up to the outermost *ghaṭī* scale. The tips of these arms are rounded. Therefore accurate measurement with these arms is not possible.

SINE QUADRANT

On the back is engraved a sine quadrant. There are 30 vertical lines. Horizontal lines are not drawn in full. These are marked only on two vertical columns 12 and 13. Inside the quadrant, the arc of the obliquity of the ecliptic is drawn with the radius of 12.5 of the units. There are two bands along the arc of the quadrant. In the inner band are marked single degrees. The outer band exhibits groups of 6° which are labelled serially as 1, 2, 3, … 15. The index is missing.



Figure L014.2 – Sine Quadrant on the back (photo by S. R. Sarma)

L015 ⦿ DHRUVABHRAMA-YANTRA & SINE QUADRANT, NOT SIGNED, NOT DATED

19th century

Copper, 160 x 159 mm

New Delhi, National Museum (# 56.155/4)



Figure L015.1 – Dhruvabhrama-yantra (photo by S. R. Sarma)

This and the next specimen appear to have been produced by the same instrument maker. Both are made of square plates, equipped in the front with the same type of four-armed indeces and, surprisingly, the *Dhruvabhrama-yantra* engraved on the front in both is incomplete or flawed. However, the letters and numerals are carefully engraved and the workmanship is good.

DHRUVABHRAMA-YANTRA

There is no horizontal slit, but the the upper edge of the plate can be used for sighting the stars α and β of Ursa Minor in one line. Ten concentric circular scales are engraved on the plate, but these are not filled completely. The scales commence at 234° and proceed clockwise.

1. *Ghaṭī* scale, numbered from 1 to 60; the 22nd *ghaṭī* commences at 0°.
2. One-sixth parts of a *ghaṭī,* i.e. 10 *palas* or 4 minutes.
3. Twelve divisions, marked but not labelled.
4. Twelve divisions, marked but not labelled.
5. One-fifteenth parts of the divisions in scales 3 and 4.
6. Twelve divisions, congruent with those in scales 3 and 4, but labelled with the names of the zodiac signs as *Meṣa* etc.
7. Again twelve divisions, not congruent with the previous divisions, marked but not labelled.
8. The same as in scale 7. At the zero point is engraved '*svā*' (?).
9. One-fifteenth parts of the divisions in the scale 7 and 8.
10. Twelve divisions congruent with those in scale 7, now labelled with the initial letters of the names of the signs.

Thus these scales are incomplete. Scales 3-6 should pertain to the zodiac signs in their right ascensions. Likewise, scales 7-10 should pertain to the zodiac signs in their oblique ascensions.

The index consists of a large circle to which are added four arms of unequal length. There is a small hole in the shortest arm for attaching the plumb bob.

SINE QUADRANT

Unlike the *Dhruvabhrama-yantra* on the front, the sine quadrant on the back has been fully and carefully executed. Here the sine-cosine grid is formed by 30 unnumbered vertical and horizontal parallels. There is an arc of the obliquity of the ecliptic at 12.25 divisions.

Along the arc of the quadrant, there are as many as nine scales. Counting from the inside, these are



Figure L015.2 – Sine quadrant on the back (photo by S. R. Sarma)

1. Degree scale with 90 divisions.
2. Groups of 6°, numbered from 6 to 90 anti-clockwise.
3. Blank.
4. Names of the zodiac signs, written in pairs, in clockwise direction: *Meṣa Mīna; Vṛṣa Kuṃbha; Mithuna Makara; Karka Dhanu; Siṃha Vṛścika; Kanyā Tulā.*
5. One-fifth parts of the zodiac signs, numbered clockwise for each sign separately as 6, 12, 18… 30.
6. One-sixth parts of the above divisions, i.e. 1° of arc.
7. Thin blank strip.
8. One-sixth parts of the divisions in the next scale, i.e. ½ °.
9. The scale is divided into 30 units (of 3°) and numbered clockwise from 1 to 30.

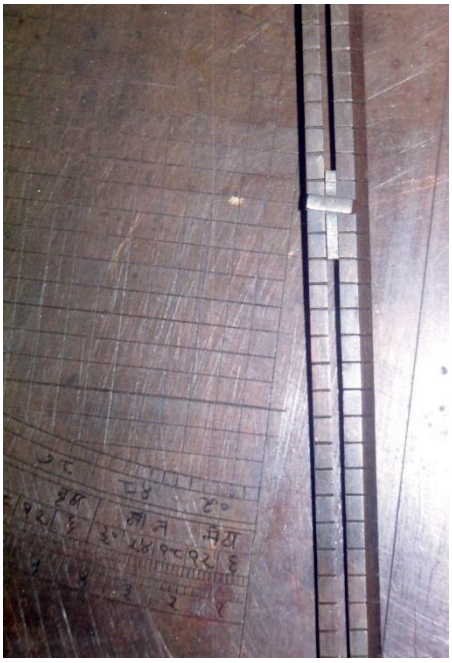


Figure L015.3 – Index of the sine quadrant (photo by S. R. Sarma)

The index has a length of 167 mm and a width of 9 mm and is divided into 42 divisions which are of the same size as the divisions on the vertical and horizontal lines. These divisions are not numbered. There is a slit running through the entire length of the index. A cruciform cursor slides in the slit which can be used to point to a specific reading.

Three rings, roughly of the shape of shackles of the astrolabe, are attached to the three corners of the plate, so that a sighting tube can be inserted into two of these so that the tube is either parallel to the horizontal radius or to the vertical radius of the quadrant. However, the sighting tube can only be placed in one position. The position in which it is mounted at present, as can be seen in Figure L015.2, is not useful for observation, because the moment the quadrant is tilted by raising the corner on the left to view a heavenly body, the index will hang outside the graduated arc and cannot be used for reading the altitude and other parameters on the arc. It is the same construction flaw as in K001. For proper observation, the sighting tube must be mounted in a position perpendicular to the present position.

L016 DHRUVABHRAMA-YANTRA, NOT SIGNED, NOT DATED

19th century

Dimensions ?

PLU; ex-Marblehead, Mass, USA

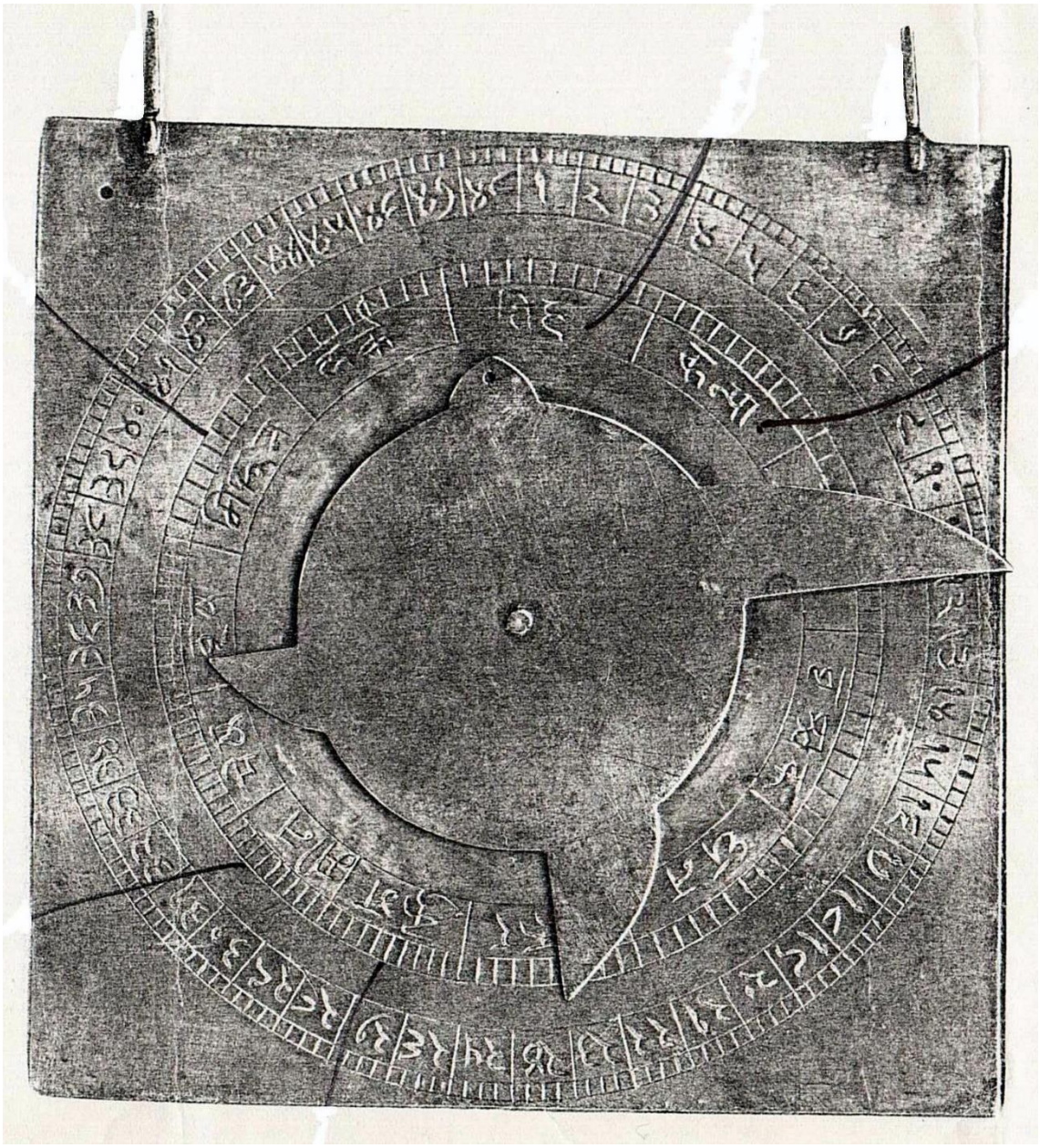


Figure L016.1 – Dhruvabhrama-yantra (courtesy Professor David Pingree)

The late Professor David Pingree passed on to me the photo of this specimen in 1992. It was sent to him for identification by a dealer of scientific instruments, Saul Moskowitz, President of Historical Technology, Inc., Marbelhead, Mass. It has not been possible to get any other particulars like the size, the nature of engravings on the reverse, and so on.

Like in the previous specimen (L015), the plate is almost square. There is no horizontal slit for viewing the stars α and β of Ursae Minor. Two sights are attached to the upper side. On the top left hand corner is a hole at which the index of the quadrant on the back would have been fixed. The index is now missing.

The *Dhruvabhrama-yantra* carries the following five circular scales.

1. One-fourth parts of the *ghaṭīs* shown in the next scale.
2. *Ghaṭī* scale, divided into 48 divisions instead of the standard 60 and numbered from the topmost point (0°) onwards.
3. Blank.
4. One-tenth parts of the zodiac signs (3° of arc) shown in the next scale.
5. Twelve equal divisions in which the names of the zodiac signs are written, the scale starts roughly from 234°.

Clearly the instrument is flawed. The *ghaṭī* scale is divided into 48 *ghaṭīs* instead of 60; the scale starts at 0° instead of at 234°. There is only one scale of zodiac signs, with divisions of equal length.

The index is similar to that in the previous specimen (L015).

L017 ⦿ DHRUVABHRAMA-YANTRA & SINE QUADRANT, NOT SIGNED, NOT DATED

19th century

Radius 384 mm

Jaipur, PC



Figure L017.1 – Dhruvabhrama-yantra (photo by S. R. Sarma)

This is the largest specimen known so far. The brass plate is cut in the shape of a quarter circle with a radius of 384 mm. There are two heavy sights measuring 36 x 26 x 13 mm attached to the horizontal radius. The instrument has become rusty with the age and it is difficult to decipher some of the engravings.

DHRUVABHRAMA-YANTRA

The *Dhruvabhrama-yantra* on the front is not completed. There is no horizontal slit. There are the following six circular scales, very close to the circumference:

1. Thirty divisions, numbered from 1 to 30, starting from the top centre. Each cell corresponds to 2 *ghaṭīs,* 48 minutes or 12°.
2. One-sixth parts of the above, i.e. 8 minutes or 2°.
3. Half of the above, i.e. 4 minutes or 1°.
4. One-sixth parts of the cells below.
5. 12 divisions (zodiac signs according to their right ascensions?).
6. 12 divisions (zodiac signs according to their oblique ascensions?).

Scales 2-6 are not labelled. No attempt was made to pivot an index at the centre. There is no hole at the centre.

SINE QUADRANT

The sine quadrant on the back is completely engraved. The two radii are divided into 30 parts each and from every point of division parallels are drawn to the other radius. The vertical parallels are further sub-divided into 6 parts each. The divisions in the two radii are not numbered, but those in the 12th vertical column are numbered from 1 to 27, starting from the horizontal radius and reaching up to the arc. The arc of the quadrant is engraved with four bands. The two inner bands are divided into 15 cells which are numbered from 1 to 15, once clockwise and in the next band in the reverse direction. Then there are two more lines with the names of the zodiac signs engraved on them, but these are difficult to decipher.

The index is divided into 30 parts. The tip of the index is bent backwards to touch the other side of the plate so that the curved part of the index slides over the edge of the quadrant.



Figure L017.2 – Sine quadrant on the back (photo by S. R. Sarma)

L018 ⊙ DHRUVABHRAMA-YANTRA, NOT SIGNED, NOT DATED

19th century

Diameter 132 mm

London, Victoria & Albert Museum (**#** 471.5-1924) [1379]

The *Dhruvabhrama-yantra* is engraved on a circular brass disc on which a long narrow slit is made at the top. The reverse side is blank. There are five concentric scales all starting from 234° and proceeding clockwise. Counting from the outside, the scales are as follows:

1. Scale divided into 120 divisions, each representing ½ *ghaṭī*
2. *Ghaṭī* scale, numbered from 1 to 60, with the 22nd *ghaṭī* commencing at 0°.
3. Blank
4. One-tenth parts of the zodiac signs shown in scale 6.
5. One-fifth parts of the zodiac signs, labelled 6, 12, …30, separately for each sign, in clockwise direction
6. Twelve unequal divisions, engraved with the names of the zodiac signs (initials) followed by their serial numbers: *me 1, vṛ 2* and so on.

The index has three arms; two are formed like acute triangles, one diagonally opposite the other. The third arm, formed like a club, is the plumb line. Since there is only one scale with zodiac signs, obviously of the oblique ascensions, the two arms of the index will indicate sidereal time in *ghaṭīs* and the ascendant.

This *Dhruvabhrama-yantra* is stored along with a compendium (V001) which consists of a circular brass casket containing some instruments. Interestingly the circular lid of the compendium casket carries on its surface nearly the same circular scales as on this *Dhruvabhrama-yantra,* the only difference being that the outermost scale shows one-fourth parts of a *ghaṭī.* However, this *Dhruvabhrama-yantra* does not fit inside the casket, being slightly larger than the casket. Perhaps the *Dhruvabhrama-yantra* and the compendium casket were made by the same instrument maker.

[1379] The Victoria and Albert Museum wrote that they do not permit the publication of private photography of their objects. Therefore I did not add my photos to this entry.

L019 ⊙ DHRUVABHRAMA-YANTRA & HORARY QUADRANT, NOT SIGNED, NOT DATED

19th century

Diameter 242 mm

Jaipur, Shri Sanjay Sharma Museum & Research Institute



Figure L019.1 – Dhruvabhrama-yantra (photo by S. R. Sarma)

This specimen is made of brass, now dark with patina. It has a circular body, which is surmounted by another smaller circle. On this smaller circle is engraved the face of

the sun with radiating rays. On the right and left, small strips join and hold together these two circles, creating thus triangular spaces to the left and right of the point where the two circles meet. A shackle, originally attached to the top of the smaller circle, is now broken; only the circular bases of the shackle remain on both sides.

DHRUVABHRAMA-YANTRA

The front is designed as a *Dhruvabhrama-yantra*. The triangular spaces between the two circles are meant to serve as the sights to view the two stars α and β of Ursa Minor in one straight line.

There are seven concentric circular scales which start from 234° and proceed clockwise. Counting from the outside, these are as follows:

1. *Ghaṭī* scale, numbered from 1 to 60; the 22nd *ghaṭī* starts at 0°.
2. Names of the zodiac signs according to their right ascensions.
3. One-sixth parts of the zodiac signs, labelled separately for each sign as 5, 10, 15, 20, 25, and 30.
4. One-thirtieth parts of the zodiac signs shown in scale 2.
5. One-fifth parts of the zodiac sign shown in scale 7 and labelled separately for each sign as 6, 12, 18, 24 and 30.
6. One-thirtieth parts of the signs shown in scale 7.
7. Names of the zodiac signs according to their oblique ascensions; not clearly visible due to the large index.

At the centre is pivoted a rather large index, in the form of a stepped up rectangle, with pointed tips in the four cardinal directions. On the three arms are written rather carelessly the parameters to be indicated by arms: north *daśama bhāva gasa* (?)'; east '*lagna nakṣa*[*tra*]', and west '*ghaṭī vavu* (?).' Thus the arms indicate, for any moment of the night, the culmination (*daśama-bhāva*), the ascendant and the related *nakṣatra* (*lagna-nakṣatra*) and the sidereal time in *ghaṭīs,* respectively.

To the southern arm are attached two formed strips of metal, with large slits in the middle. The two strips are joined by a hinge so that the second one can be folded back when not in use or stretched out for use. These two strips weight the southern point. In the middle of the index, two circles are drawn and between these two circles, three arcs are cut out. There does not seem to be a scale beneath these cut out portions. Possibly these were made to reduce the weight of the index and allow it to rotate freely.

HORARY QUADRANT

The back is designed as a horary quadrant, or rather an assemblage of four hoary quadrants forming a full circle, as was done by Sawai Madho Singh in an instrument which he designed and designated as *Yantrādhipati* (T001); it will be described along with the other instruments designed by this prince in Section T. At the centre is pivoted a crude alidade, the sights of which are now missing. There must also have been a plumb line at the centre, which is also missing. In this type of horary quadrant, the sun is sighted through the alidade. Where the plumb-line touches the appropriate scale for the season is the time elapsed since sunrise or the time to come up to the sunset.

There are four circular scales. Counting from the outside, these are as follows:

1. Calibrated for groups of 6°, and labelled for each quadrant separately, starting from the east and west points and reaching up to the north and south points, as 6, 12, 18, … 90.
2. Scale of single degrees, corresponding to the previous scale. With these two scales, the sun's altitude can be measured in degrees by means of the alidade.

3-4. Contain 8 *ghaṭī* scales, two in each quadrant. These are labelled, as in scale 1, separately for each quadrant, starting from the east and west points and reaching up to the north and south points. Because the surface has become very dark, it could not be ascertained whether there are any labels indicating which of these 8 *ghatī* scales are to be used in which solar month.

Inside these scales are engraved four words, one in each quadrant: *dīnamāna …sūryā dīnāṃ yaṃtra …* ('measure of the day, of the sun and others, instrument…').[1380]

[1380] In the museum, this instrument is wrongly labelled as 'Sūrya-divā-yantra.' There is no such name. The word '*sūryādīnām'* is genitive plural and means 'of the sun and others'.



Figure L019.2 – Horary Quadrant on the Back (photo by S. R. Sarma)

L020 ⦿ DHRUVABHRAMA-YANTRA & SINE QUADRANT, NOT SIGNED, NOT DATED

19th century

Inferior metal, diameter 147 mm, height 177 mm

Jaipur, Shri Sanjay Sharma Museum & Research Institute



Figure L020.1 – Dhruvabhrama-yantra (photo by S. R. Sarma)

This instrument is made of some inferior light metal, now dark with age. It has a circular, astrolabe-like shape, with a crown, a shackle and a ring.

DHRUVABHRAMA-YANTRA

The front is designed as a *Dhruvabhrama-yantra*, but without a horizontal slit. There are 8 concentric circular scales, all starting from 0° and proceeding clockwise. Counting from the outside, these scales are as follows:

1. *Ghaṭī* scale, numbered from 1 to 60.
2. One-sixth parts of the above, i.e. 10 *palas,* 4 minutes, or 1° of arc.
3. Names of the 28 lunar mansions (initials) as related to the zodiac signs in scale 5.
4. One-sixth parts of the zodiac signs, shown in the scale below.
5. Names of the zodiac signs (initials) according to their right ascensions.
6. Names of the 28 lunar mansions (initials) as related to the zodiac signs in scale 8.
7. One-sixth parts of the zodiac signs, shown in the scale below.
8. Names of the zodiac signs (initials) according to their oblique ascensions.

The instrument is non-functional because there is no provision for observing the two stars α and β of Ursa Minor in one line and because all the scales commence from 0° and not from 234°. At the centre is pivoted a bird like index, its beak, tail and an upraised wing serving as the three pointers. From the belly issues a longish strip, which served as the weight; now it is broken.

SINE QUADRANT

On the back is engraved a sine quadrant, with its apex a little below the point where the shackle is attached to the body. There are 30 horizontal and 30 vertical parallels. The arc has a double scale, the inner one of single degrees, the outer with intervals of 6° and labelled as 6, 12, … 84, 90. No provision has been made for an index at the apex of the quadrant, nor for the sights at either of the radii. Given the location of the engraved quadrant on the circular body, it would indeed be impossible to install the sights along either radius. Thus the design of the quadrant is flawed and it too is non-functional.

Below the quadrant are engraved the following two lines, which are partly undecipherable:

> *dhruva bhrama kā yaṃtra jyotiṣa*
> *kova (?) bhā ra (va?) lagna samaya jāṇajā.*
> ‘Dhruvabhrama instrument, astronomy, to know astrological houses, ascendant and time’.



Figure L020.2 – Sine Quadrant on the back (photo by S. R. Sarma)

L021 ⊙ DHRUVABHRAMA-YANTRA, NOT SIGNED, NOT DATED

20th century

141 x 119 x 2.5 mm

Vadodara, M. S. University of Baroda, Sanskrit Mahavidyalaya



Figure L021.1 – Dhruvabhrama-yantra (photo by S. R. Sarma)

This is one the instruments commissioned at the beginning of the twentieth century for use in the classrooms of the traditional astral science (*Jyotiṣa*) at the Sanskrit Mahavidyalaya.

One side of the plate is fashioned as the *Dhruvabhrama*-yantra and the other side is blank. It is a neatly made instrument, but does not contain all the scales prescribed by Padmanābha.

The square portion of the plate is demarcated by a line. In the middle of the remaining portion, there is a 78 mm long slit, parallel to the shorter side of the plate. The slit is of uniform width, but has ornate terminals at both ends, as in the alidades of some Mughal astrolabes.

There are three circular scales below the slit. The outer one is divided in single degrees. In the middle scale, groups of 6°, each representing 1 *ghaṭī,* are numbered clockwise from 1 to 60 in such a manner that the 22nd *ghaṭī* commences at 0°. Like the middle scale, the inner scale is also divided in 60 parts, but not numbered.

Two diameters, drawn along the diagonals of the square part of the plate, intersect at right angles at the centre. The first diagonal passes through the starting points of *ghaṭīs* 15 and 45, the second through the starting points of *ghaṭīs* 30 and 60.

Surprisingly there are no other scales on the plate. Scales of right ascensions and oblique ascensions are not drawn. Therefore, with this dial only the sidereal time can be measured, but not the ascendant and culmination. In spite of this, there is a three-armed index in the middle. The arms are of equal length of 57 mm and are at right angles to each other. At the fourth point, there is a large ring to which a weight can be tied with a rope. The centre of the index is artistically fashioned with small circles.

BIBLIOGRAPHY

Sarma 2009a, pp. 11-14, plates 3-4.

L022 DHRUVABHRAMA-YANTRA BY SAKHĀRĀMA JOŚĪ, 1790-96

Dimensions ?
PLU

Dikshit 1963, p. 233n, mentions a *Dhruvabhrama-yantra* made between the Śaka years 1712 and 1718 (AD 1790 and 1796) by Sakhārāma Jośī, a resident of Koḍolī (16;52,48° E. 74;12° N) near Kolhapur; but its present location is unknown.

L023 DHRUVABHRAMA-YANTRA EXHIBITED AT THE LAHORE EXHIBITION 1864

Dimensions ?

PLU

In 1864, the British Colonial Government organised an exhibition at Lahore for promoting the manufacturing industry in Punjab. The exhibits are described by B. H. Baden Powell in his *Handbook of the Manufactures and Arts of the Punjab.* The astronomical instruments displayed at this exhibition were listed in 'Class XXIV: mathematical and philosophical instruments exhibited in the Lahore Exhibition of 1864.' These exhibits include a *Dhruvabhrama-yantra,* which is described thus:

> 11. Dhruv Bhraman yantram [sic! *Dhruvabhrama-yantra*]. A square plate, having circles inscribed on it and an index rod, by means of this the time is ascertained at night, by the polar star.

Its present location is not known.

BIBLIOGRAPHY

Powell 1872, pp. 259-263.

Sarma 2015b, p. 301.

L024 ⊙ SHABNUMĀ-WA-RŪZNUMĀ BY NADHĪR AL-DĪN ḤUSSAYN, 1218 AH (AD 1803) AT BAREILLY[1381]

Copper, 178 x 174 mm

Patna, Khuda Bakhsh Oriental Public Library

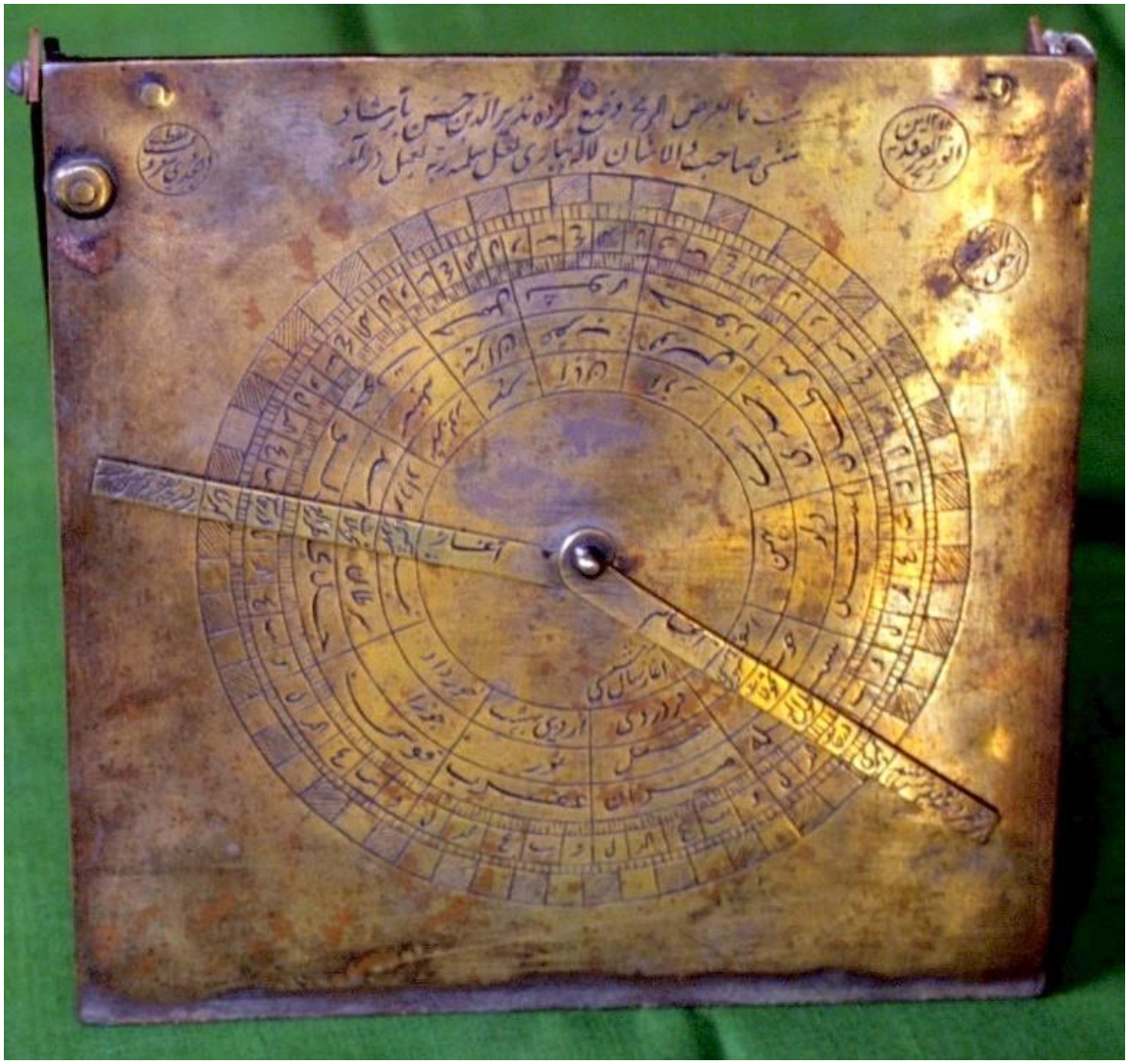


Figure L024.1 – Shabnumā (photo by S. R. Sarma)

The inscriptions on this instrument state that it was made by Nadhīr al-Dīn Ḥussayn in *Rabiᶜ al-awwal* 1218 AH (= 20 June-19 July 1803) for the latitude of 27;48°, which is roughly the latitude of Bareilly (modern values 28;22° N and 79;27° E) in the

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[1381] This is an abridged version of Sarma & Bagheri 2011; the translations from the Persian are by Bagheri.

federal state of Uttar Pradesh in India. The instrument is made out of a rectangular brass plate; the workmanship is neat and the instrument is well preserved.

SHABNUMĀ

The obverse side of the plate is engraved as the *Shabnumā,* the 'night indicator'. On it are drawn eight concentric circles to form seven annuli. At the centre are pivoted two indices, measuring 95 and 90 mm respectively. On these are engraved the arguments of the annuli, i.e. labels explaining the divisions marked on the seven annuli. On the shorter index is written *āghāz,* 'beginning,' above these labels and 'to be placed on the degree of the [sun's] true longitude' below the labels. The longer index carries *akhbām,* 'end,' above the labels and 'to be placed opposite the degree of the [sun's] true longitude,' below the labels.

Counting from the outside, the circular scales contain the following:

1. Label *gahrī* (Sanskrit, *ghaṭī*). The circle is divided into 60 *ghaṭīs.* Every alternative cell is hatched with fine lines parallel to the diagonal to facilitate the counting of the *ghaṭī*s. The cells are not numbered.
2. One-fourth parts of a *ghaṭī*, i.e. 15 *palas* or 6 minutes.
3. Label *darjāt* (degrees). The circle is divided into 12 signs, and each sign is further sub-divided into 5 units of 6° each. These 5 units are numbered 6, 12, 18, 24, 30 in the clockwise direction.
4. Degree scale. Each group of 6° in the previous scale is further sub-divided into single degrees.
5. Label *ṭawāli*^{c} (ascendants). The circle is divided into 12 cells and filled with the names of the zodiac signs in clockwise direction. The first sign *Ḥamal* starts at 325°. The significance of this starting point is not known.
6. Label *taḥwīlāt* (sun's passages from one sign to another). The circle is divided into 12 cells and filled with the names of the zodiac signs in clockwise direction. The signs here are separated from those in scale 5 by six signs.
7. Label *shahūr shamsī* (solar months). The circle is divided into 12 cells and filled with the names of the Iranian solar months in clockwise direction. The starting point is the same as in the previous scale, because the solar months are based on the sun's entry into each zodiac sign. Above the name of the first Iranian month

Farvardīn is engraved *āghāz sāl shamsī,* 'the beginning of the solar year'. The elements of the three scales 5, 6 and 7 are shown in the following table.

Table L024-1 Scales 5, 6 and 7

	ṭawāli **ascendants**[c]	***taḥwīlāt*** **transits**	***shahūr shamsī*** **solar months**
1	*Mīzān* (Libra)	*Ḥamal* (Aries)	*Farvardīn*
2	[c]*Aqrab* (Scorpio)	*Thawr* (Taurus)	*Urdībihisht*
3	*Qaws* (Sagittarius)	*Jawzā'* (Gemini)	*Khurdād*
4	*Jadī* (Capricorn)	*Saraṭān* (Cancer)	*Tīr*
5	*Dalw* (Aquarius)	*Asad* (Leo)	*Murdād*
6	*Ḥūt* (Pisces)	*Sunbulah* (Virgo)	*Shahrīvar*
7	*Ḥamal* (Aries)	*Mīzān* (Libra)	*Mihr*
8	*Thawr* (Taurus)	[c]*Aqrab* (Scorpio)	*Abān*
9	*Jawzā'* (Gemini)	*Qaws* (Sagittarius)	*Ādhar*
10	*Saraṭān* (Cancer)	*Jadī* (Capricorn)	*Day*
11	*Asad* (Leo)	*Dalw* (Aquarius)	*Bahman*
12	*Sunbulaḥ* (Virgo)	*Ḥūt* (Pisces)	*Isfandār*

INSCRIPTIONS

The obverse side constituting the *Shabnumā* carries the following inscriptions. On the top of the instrument is an inscription that states:

> 'Night[-time] indicator (*Shabnumā*) for the [terrestrial] latitude 27 [degrees and] 48 [minutes], designed by Nadhīr al-Dīn Ḥussayn and prepared under the guidance of the esteemed Munshī (secretary/ clerk) Ṣāḥibwālā-Sha'n (honourable) Lāleh Piārī La[c]l —may his God save him.'

To the left of the above inscription, there is a circle containing the label *al-jadī m[c]arūf ba-quṭb,* 'Polaris known as the Pole [Star],' i.e. α Ursae Minoris. To the right of the inscription, there are two circles containing the labels: *Anwar al-Farqadayn,* 'the

brighter one of the two Guards [of the Pole]', i.e. β Ursae Minoris and *Akhfā al-Farqadayn,* 'the fainter one of the two Guards [of the Pole]', i.e. γ Ursae Minoris.

METHOD OF OBSERVATION WITH THE SHABNUMĀ

A plumb line is suspended from the centre. At night the instrument is held in a vertical plane and tilted so that α and β or α and γ Ursae Minoris are visible just above the upper edge above the small circles carrying their names.[1382] Then the position of the plumb line on the *ghaṭī* scale is noted. Let it be *A*. From the almanac the sun's true longitude is noted for this moment and the shorter index on which is written 'beginning' and 'to be placed on the degrees of the [sun's] true longitude' is moved to the point of the sun's true longitude as can be seen on the circle marked *taḥwīlāt.* Let the point at which this index intersects the *ghaṭī* scale be *B*. The longer index on which is written 'end' and 'to be placed opposite the degree of the [sun's] true longitude' should be moved to a point opposite *B*. Here 'opposite' does not mean at a distance of 180 arc-degrees, but at a distance of 6 signs on the circle of *taḥwīlāt.* In this circle, all the signs do not occupy the uniform distance of 30 arc-degrees. Therefore the distance of 6 signs can be sometimes more than 180°, sometimes less and sometimes equal to 180, depending on the sun's longitude. Let the point where the second index intersects the *ghaṭī* scale be *C*. Then *C* indicates the previous sunset, i.e. the beginning of the current night; *CA* shows the number of *ghaṭī*s elapsed since the previous sunset. *B* indicates the end of the current night, i.e. the next sunrise. *AB* indicates the number of *ghaṭī*s to elapse up to the next sunrise. Therefore *CAB* is the duration of the night. The point where the plumb line touches the scale of the *ṭawāli*^{c} shows the ascendant for the moment of observation. Likewise the point where the plumb line touches the scale of *taḥwīlāt* indicates the *taḥwīl.*

This procedure is illustrated in Figure L024.3. Here the sun's longitude is taken to be the first point of Virgo; the corresponding point on the *ghaṭī* scale is *B*. The index marked *X* on which is written 'to be put on the degrees of the [sun's] true longitude' is moved to *B* and the index marked *Y* to the point *C* which is removed by 6 signs from *B*.

[1382] The Rampur *Shabnumā* (L025), to be described below, clearly states that α and β Ursae Minoris or α and γ Ursae Minoris should be above the edge. While the *Dhruvabhrama-yantra* employs only α and β Ursae Minoris, the *Shabnumā* takes also γ Ursae Minoris into account.

Now *C* indicates the previous sunset, i.e. the beginning of the current night. *CA* shows the number of *ghaṭī*s elapsed since the previous sunset, which in the present case is 14 ¾ *ghaṭīs* (= 5 hours and 54 minutes). *B* shows the end of the current night, i.e. the next sunrise. *AB* are the number of *ghaṭī*s to elapse up to the next sunrise, viz. 17 ¼ *ghaṭīs* (= 6 hours and 54 minutes). The time of observation, therefore, is 5 hours and 54 minutes after sunset or 6 hours and 54 minutes before sunrise. The ascendant at this moment is 18° Scorpio and the *taḥwīl* is Taurus 18°.

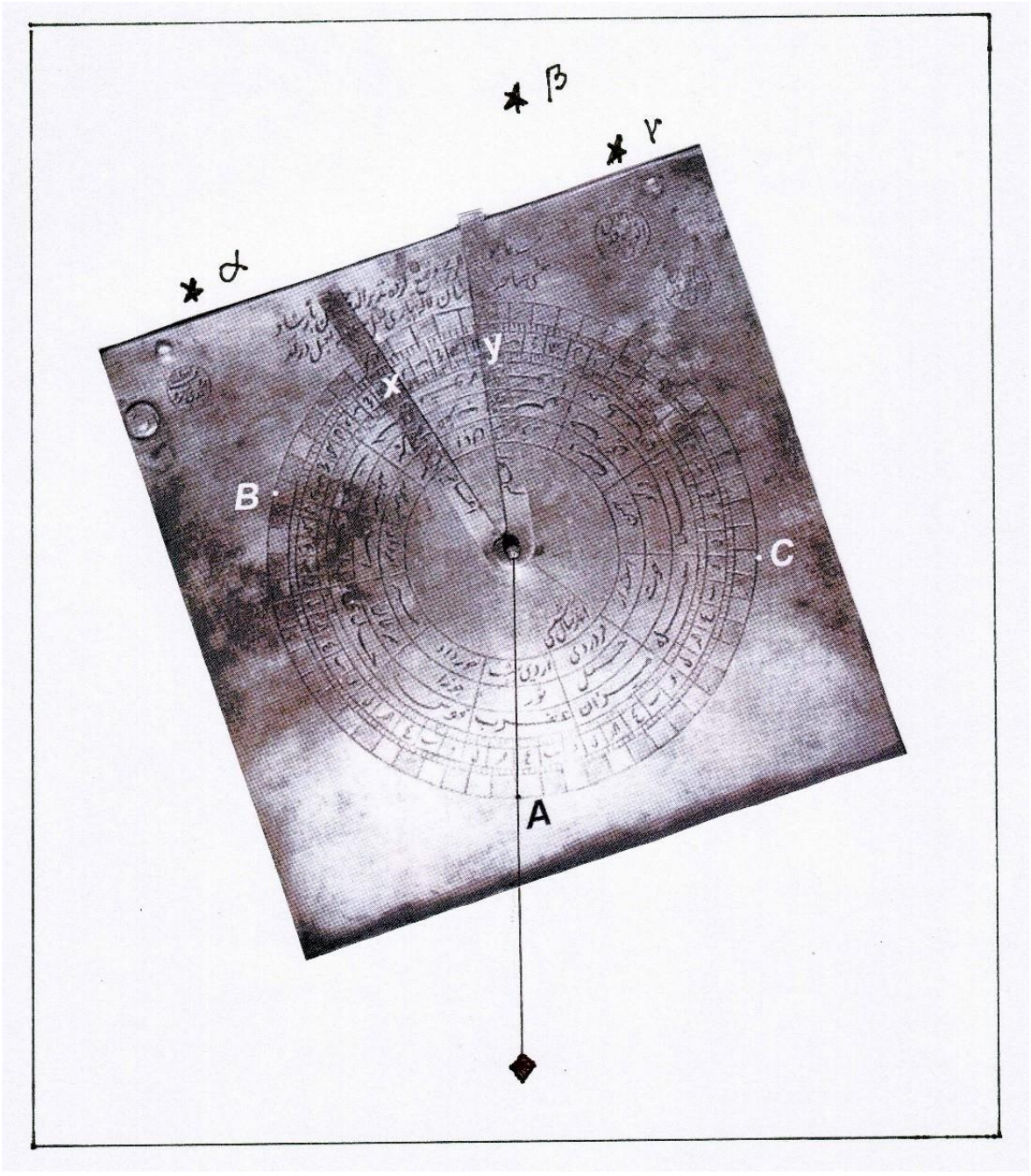


Figure L024.2 – Measuring time with the Shabnumā at night

RŪZNUMĀ

The reverse side of the plate, designated *Rūznumā,* is actually a sine quadrant (*rubᶜ al-mujayyab*). A thick bar is welded to the top of the plate, the ends of which are bent at right-angles to the surface of the plate. These two bent portions, each containing two small pinholes, constitute the sights of the quadrant. The upper pinhole is larger for sighting the stars at night. The smaller pinhole is meant for sighting the sun.



Figure L024.3 – Rūznumā on the back (photo by S. R. Sarma)

The horizontal radius of the quadrant is divided into 31 equal units (it ought to have been exactly 30 units) and from each point of division a line is drawn perpendicular to the radius. Two horizontal lines are drawn parallel to the radius, cutting these perpendiculars at right angles. The upper one is labelled *ẓill aqdām ma'kūs,* 'umbra versa in [seven] feet', the lower one *ẓill aṣābiᶜ maᶜkūs,* 'umbra versa in [twelve] digits'. On these horizontal lines the perpendiculars are numbered in *Abjad* letters, on the upper line from 1 to 30 and on the lower line from 1 to 28 (in both cases starting from the

vertical radius). Horizontal parallels are not drawn, but they are marked on the two vertical scales (i.e. nos. 7 and 12, as counted from the vertical radius). On these vertical scales, the horizontal parallels are numbered in common Arabic/Persian numerals. The seventh vertical parallel is labelled *ẓill aqdām mustawī,* 'umbra recta in [seven] feet,' and the twelfth parallel *ẓill aṣābiʿ mustawī,* 'umbra recta in [twelve] digits'. Thus the sine quadrant incorporates the shadow squares of 7 feet and 12 digits which are usually engraved on the back of an astrolabe.

The arc of the quadrant is divided into single degrees; every 6° are marked numbered from 6 to 90.

Below the arc of the quadrant is drawn a curved table of six columns and three rows where zodiac signs are grouped according to their right ascensions. In the second row are written the names of the six signs thus: *Jawzā', Thawr* and *Ḥamal* are written so that the letters stand upright when the apex of the quadrant is upwards; these are followed by the three names *Mīzān, ʿAqrab* and *Qaws* upside down. In the next row are written *Saraṭān, Asad* and *Sunbulah* upside down; *Ḥūt, Dalw* and *Jadī* in upright fashion. There is a degree scale in the first row. The first cell above *Jawzā'* and *Saraṭān* occupies 3° of the arc above. It is divided into three parts and numbered in common Arabic/Persian numerals as 10, 20, 30. The next four cells occupy 6° each. Each cell is divided into 5 divisions and numbered both in Arabic/Persian numerals and in *Abjad* notation as 6, 12, 18, 24, 30. The sixth cell above *Qaws* and *Jadī* occupies, like the first cell, just 3° and is divided and labelled like the first.

On other instruments, zodiac signs with the same right ascensions are arranged more conveniently in three columns in the following manner.[1383]

Jawzā'	*Thawr*	*Ḥamal*
Saraṭān	*Asad*	*Sunbulah*
Mīzān	*cAqrab*	*Qaws*
Ḥūt	*Dalw*	*Jadī*

[1383] B024, C001 and J002.

INDEX

A 176 mm long graduated index is pivoted at the centre of the quadrant. The index carries two scales. One scale is divided into 12 units, numbered in common Arabic/Persian numerals. At the end is the label *niṣf al-nahār,* 'midday'. In the other scale there are 7 serially numbered divisions, followed by the label *yak-pās,* 'one quarter of the day'; again 7 serially numbered divisions are followed by the label *do-pās,* 'two quarters of the day'. The term *pās* corresponds to Sanskrit *prahara,* which denotes one quarter of a seasonal day or of a night; *do-pās* then corresponds to Sanskrit *dvi-prahara* or Hindi *du-pahar,* 'midday'.

INSCRIPTIONS

At the top of the quadrant, it is explained how to use this instrument at latitudes other than the latitude for which it was made:[1384]

> 'Day[-time] indicator (*Rūznumā*) for [the terrestrial] latitude of 28 [degrees]. In other localities where [the terrestrial] latitude is less than 28 [degrees], the amount of the difference [from 28 degrees] should be added to the maximum altitude [of the sun at the terrestrial latitude] of 28 [degrees] up to a sum of 90 [degrees]; and [whenever the sum exceeds 90 degrees,] the amount of the excess over it (i.e. over 90 degrees) should be subtracted from 90 [degrees]. 'If the [terrestrial] latitude is more than 28 [degrees], the amount of the excess should be subtracted from the maximum altitude [of the sun at the terrestrial latitude] of 28 [degrees].'

Below the arc, to the right of the two scales, is an inscription which reads

> *rabīʿ al-awwal sanah 1218 ḥijrī fī baladah barelī*
>
> '[Made in the month of] *rabīʿ al-awwal* of the year 1218 of Hijrī [era] in the city of Bareilly.'

The month *rabīʿ al-awwal* in the Hijrī year 1218 lasts from 20 June to 19 July 1803. Therefore, the instrument was completed during this period.

[1384] Padmanābha also proposes a similar method for using the *Dhruvabharma-yantra* at latitudes other than that for which it is calibrated.

BIBLIOGRAPHY

Sarma 1999c.

Sarma & Bagheri 2011.

L025 ⊙ SHABNUMĀ-WA-RŪZNUMĀ BY MĪRZĀ FAḌL ᶜALĪ ᶜĀMIL[1385]

19th Century

Painted wood, 263 x 255 x 9 mm

Rampur, Rampur Raza Library (# 9395)



Figure L025.1 – Shabnumā (courtesy Rampur Raza Library)

This specimen at the Rampur Raza Library is more elaborately designed. The *Shabnumā* contains more circular scales than that at Patna. These include the scales

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[1385] This is an abridged version of Sarma & Bagheri 2011; the translations from the Persian are by Bagheri.

containing the Sanskrit names of the zodiac signs and of the lunar mansions, the names of the English months (all these transcribed in Arabic/Persian script) and also scales to measure time in *ghaṭīs* as well as in hours and minutes. The *Rūznumā* here is not a sine quadrant, but a horary quadrant, with separate scales for different solar months. The instrument was made by Mīrzā Faḍl ᶜAlī ᶜĀmil. No date is mentioned, but it is likely that it was made in the nineteenth century, possibly some time after the specimen at Patna was manufactured.

The instrument is made out of an oblong wooden board. Two iron struts with pinholes in the middle, jutting out of one of the shorter sides, serve as the sights. The board is painted light brown in oil colour, on which the circles and legends are drawn in black. At the centre of the circular scales in the *Shabnumā,* there is a short nail. To this nail must have been attached the two indices as in the specimen at Patna, but these are missing now. There must also have been a plumb line which too is absent now. On the reverse side, at one of the top corners, is the apex of the quadrant. There is a hole into which the pin of the index for the quadrant must have been inserted. Both the pin and the index are now lost. There must have been a plumb line on this side also which is now missing. The paint on the wooden board is chipped off all along the edges. Many of the legends and inscriptions are difficult to read.

SHABNUMĀ

On the obverse side, which is designed as the *Shabnumā*, there are several concentric circular scales. At the right hand side of the topmost edge, just below the sight, there is a small circle inside which is written *Anwar al-Farqadayn* (β Ursae Minoris). A little below to the right, there is another circle enclosing the writing *Akhfā al-Farqadayn* (γ Ursae Minoris). In the corner opposite, i.e., at the left edge, there was originally a similar circle; now only a small fraction of its circumference is visible. It is likely that here was written the name of the Pole Star as in the specimen at Patna.[1386]

[1386] In the same corner, just below the partly visible circle, there is some writing in Urdu in ink. It is now faded and illegible. In the diagonally opposite corner (i.e., lower right) is written in ink ‘S. T. 688 / dt. 19.9.95.’ Thus these two inscriptions in ink must have been written by the librarian on 19.9.1895 when the instrument was acquired or accessioned.

The instrument proper consists of eleven concentric circular scales. Counting from the outside, these scales are as follows:

1. Contains 108 cells (these are probably the ¼ parts of the 27 lunar mansions called *nakṣatra-pāda* in Sanskrit) filled with some letters, but these are not the *Abjad* symbols.
2. Same number of cells, congruent with the above, but filled with different letters; here there occurs occasionally the *Abjad* symbol for 20 and the common Arabic/Persian numerals 2, 7 and 8.
3. Twenty-seven equal divisions containing the Sanskrit names of the lunar mansions, …, *Bahranī, Kartikā, Rūhnī, marksirā, …*, starting from about 145° and proceeding clockwise.[1387]
4. Twelve equal divisions containing the Sanskrit names of the zodiac signs, *Mekh, Barkh, Mithun ….*
5. Twenty-eight Arabic names of the lunar mansions, *Sharaṭayn, Buṭayn …Rishā',* starting from 135° and proceeding clockwise.
6. Names of the twelve English months, starting roughly from 60° and proceeding clockwise.
7. Black and white cells (12 x 12), to indicate hours and 1/12th parts thereof, i.e. 5 minutes.
8. Larger black and white cells (30 + 30), to indicate the 60 *ghaṭī*s.

9-11. These three scales are the same as the three scales 5, 6, 7 in the Patna instrument, and start roughly from 160°. Scale 9 here contains the Arabic names of the zodiac signs with a prefix *ṭulū*^{c} (rising) meaning signs in ascendance.

INSCRIPTION

In the circular space inside the scales is written a long inscription in Persian in 8 lines, which reads as follows:

طریق دیدن شب‌چنانست که بقطب و یکی از فرقدین که قریب است
بقطب شاخ شب نما را بنگاه راست کند بوضعی که منظر بر دو
نقطه گذارند پس نظر کند که تار شاقول‌بکدام خط رسید آنرا

[1387] Unlike in the other lists of Sanskrit lunar mansions, here *Abhijit* (α Lyrae) is omitted.

نگاهدارد و آفتاب در هر درجه از بروج دوازده گانه که باشد آنجا شمار کهر ابتداء کند یکی سیاه و دیگر سفید تا خط ریسمان مذکور آید بتحقیق همان قدر شب گذشته باشد و یا باقیمانده است دایره منطقه البروج و معدل النهار را از پشت حجره اسطرلاب اخذ کرده بر چوب هذا ثبت نموده اند بعمل میرزا فضل علی عامل

'The method of observation at night.

It is so that the upper edge of the "night-instrument" is to be aligned with the [North] Pole (*quṭb*) and one of the two *Farqadayn* which is closer to the Pole, so that the two points are seen in one direction. Then one should see to which line (*khaṭṭ)* the plumb line (*tār-i shāqūl*) reaches, and should keep it [there]. Then one should start counting the *kahar*s (*ghaṭīs*) which are alternately black and white from the relevant degree of any of the twelve zodiacal signs where the sun lies up to where the above mentioned plumb line reaches, exactly the same amount has passed from the night (*guzashteh*) or remains from it (*bāqī māndeh*). The zodiac circle (*manṭaqat al-burūj*) and the celestial equator (*muᶜaddil al-nahār*) are taken from the back of the mater of the astrolabe and registered on this board. Made by Mīrzā Faḍl ᶜAlī ᶜĀmil.'

At night, the board is so held that the two required stars are visible in one line just above the upper edge of the board. The plumb line which hangs vertically touches all the eleven scales at different points. These points provide the readings on these scales for the moment of observation.

RŪZNUMĀ

On the reverse side of the board is drawn the *Rūznumā* in the form of a horary quadrant. The quadrant consists of eight concentric quarter-circle scales. The outermost scale is graduated in single degrees and numbered in Arabic/Persian numerals from 1 to 90. On this scale, the altitude of the sun can be measured in degrees. Below this are seven *ghaṭī* scales for different solar months as detailed below:

1. *Saraṭān* (Cancer), 1-17 *ghatīs.*
2. *Jawjā' wa Asad* (Gemini and Leo), 1-17 *ghaṭīs.*
3. *Thawr wa Sunbulah* (Taurus and Virgo), 1-16 *ghaṭīs*.
4. *Ḥamal wa Mīzān* (Aries and Libra), 1-15 *ghaṭīs.*

5. *ᶜAqrab wa Ḥūt* (Scorpio and Pisces), 1-14 *ghaṭīs*.
6. *Qaws wa Dalw* (Sagittarius and Aquarius), 1-13 *ghaṭīs*.
7. *Jadī* (Capricorn), 1-12 *ghaṭīs*.



Figure L025.2 – Rūznumā (courtesy Rampur Raza Library)

Each of these scales is used for one or two months. Depending on the length of the day in the corresponding solar month, these scales are divided into so many number of *ghaṭī*s as there are in half a day of that month. Thus when the sun is in Cancer, the day is the longest. It has the duration of 34 *ghaṭī*s (= 13 hours 36 minutes). The scale for this month is divided into 17 *ghaṭī*s, which is the length of half a day. When the sun is in

Capricorn, the days are the shortest: 24 *ghaṭī*s (= 9 hours 36 minutes). Accordingly the scale is divided into 12 *ghaṭī*s.

A plumb line is fixed to the centre of the quadrant and the quadrant is held so that the sun's rays pass through the holes in the two iron struts. Where the plumb line touches the outermost scale, it will show the sun's altitude in degrees. Where it touches the scale of the zodiac sign in which the sun is situated, it will show the number of *ghat ī*s that elapsed since sunrise or the *ghaṭī*s that still remain up to sunset.

INSCRIPTIONS

The area between the apex of the quadrant and the *ghaṭī* scales is filled by a diagram and several inscriptions.

At the upper right corner, close to the centre of the quadrant are three lines in Persian which read as follows:

> Aries (*Ḥamal*), Libra (*Mīzān*), Capricorn (*Jadī*) [and] Cancer (*Saraṭān*) are tropical (*muqalāb*); Taurus (*Thawr*), Leo (*Asad*), Scorpio (*cAqrab*) [and] Aquarius (*Dalw*) are fixed (*sābit*); Gemini (*Jawzā'*), Virgo (*Sunbulah*), Sagittarius (*Qaws*) [and] Pisces (*Ḥūt*) are bicorporal (*zūjasadayn*).[1388]

The remaining legible Persian phrases are not adequate for a consistent and meaningful restoration. The same problem exists for the long inscription in two lines along the arc of the quadrant.

BIBLIOGRAPHY

Sarma 2003, pp. 85-88.
Sarma & Bagheri 2011.

[1388] Cf. Bīrūnī 1934, p. 380: 'The first sign of each season is called tropical as it is the turning point, second fixed, because when the sun is in it the season is established, and the third bicorporal. Each one of them is related by quartile to the others of its kind, and thus Aries, Cancer, Libra and Capricorn form the tropical tetragone, the indications of which are gentleness, purity and sociability with a tendency to science and details. Then Taurus, Scorpius, Aquarius and Leo form the fixed tetragone, the indications of which are mildness, thoughtfulness and justice, in many cases of litigiousness and pugnacity, and sometimes of endurance in adversity and patience in trouble and injustice. Gemini, Virgo, Sagittarius and Pisces, the bicorporal tetragone, indicate amilability, levity, playfulness, thoughtlessness, discord in business, capriciousness and duplicity.'

M. PHALAKA-YANTRA OF BHĀSKARA II

INTRODUCTION

Bhāskara II, who is popularly known as Bhāskarācārya, announces his invention of the *Phalaka-yantra* in the following words in his *Siddhānta-śiromaṇi* of 1150:

> Because others have not attempted to determine the apparent time (*sphuṭa-kāla*) easily from the vertical circle passing through the zenith and the planet (*dṛṅ-maṇḍala*), I have done so. I shall now explain lucidly the instrument named *Phalaka-yantra* which represents the essence of all computations (*gaṇitasya sāra*) pertaining to the true principles of Spherics (*sadgola-yukti*).[1389]

The instrument, according to his description,[1390] consists of a rectangular board measuring 180 x 90 units (*aṅgula*). A chain (*śṛṅkhalā*) is attached at the centre of the long side with which the plate can be suspended in the vertical plane. From the place of the chain a vertical line (*lamba*) is drawn which divides the plate in two equal halves. Perpendicular to this vertical line are drawn 90 equidistant horizontal parallels, called sines (*jīvā*). At the middle of the 30th sine-line is inserted a pin (*śalākā*), which is designated as the axis (*akṣa*). With the pin as the centre, a circle is drawn with a radius of 30 units and the circle is divided in 60 *ghaṭikās* and 360 degrees. To the pin is pivoted an index, 60 units long and divided in 60 parts. The instrument is used first to measure the altitude of the sun by direct observation and then to ascertain graphically the corrections for ascensional difference in order to determine time.[1391]

This *Phalaka-yantra* is a forerunner of the sine quadrant and was eclipsed by the latter when it was introduced into India in the following centuries from the Islamic world. Therefore, very few astronomers seem to have used the *Phalaka-yantra* for actual

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1389 Bhāskarācārya, *Siddhānta-śiromaṇi, Golādhyāya, Yantrādhyāya,* verse 16:
dṛṅmaṇḍale 'tra sphuṭakāla uktaḥ sukhena nānyair yatitaṃ mayātaḥ |
sadgolayukter gaṇitasya sāraṃ spaṣṭaṃ pravakṣye phalakākhyayantram ||
See also Sarma (forthcoming).

1390 Bhāskarācārya, *Siddhānta-śiromaṇi, Golādhyāya, Yantrādhyāya,* verses 16-27.

1391 On the exact procedure and its rationale, see Wilkinson & Sastri 1861, pp. 213-218; Rai 1985, pp. 328-332; Ôhashi 1994, pp. 286-290, Fig. 53.

observation. There exist just four specimens, or rather — reports of three specimens being made between 1790 and 1876 and a photo of an astrolabe of 1895, on the back of which a *Phalaka-yantra* is incorporated.

The *Phalaka-yantra* is also represented, among others, on five compendia; these will be discussed in section V below (Figure V002.6, Figure V004.1, Figure V005.4 and Figure V006.4).

M001 PHALAKA-YANTRA BY SAKHĀRĀMA JOŚĪ, 1790-96

Dimensions ?

PLU

Dikshit 1981, p. 233n, mentions a *Phalaka-yantra* and other instruments made between the Śaka years 1712 and 1718 (AD 1790 and 1796) by Sakhārāma Jośī, a resident of Koḍolī (16;52,48° N and 74;12° E) near Kolhapur. Their present location is unknown.

M002 PHALAKA-YANTRA EXHIBITED AT THE LAHORE EXHIBITION 1864

Dimensions ?

PLU

In 1864, the British Colonial Government organised an exhibition at Lahore in order to promote the manufacturing industry in Punjab. The exhibits are described by B. H. Baden Powell in his *Handbook of the Manufactures and Arts of the Punjab.* The astronomical instruments displayed at this exhibition were listed in 'Class XXIV: mathematical and philosophical instruments exhibited in the Lahore Exhibition of 1864.' The exhibits included a *Phalaka-yantra* which was described thus:

> 18. 'Falk yantra [sic! *Phalaka-yantra*] — A graduated oblong plate, with inscribed circle and bar to give the shadow — for measurement of hours, angular distances, &c.'

Its present location is unknown.

BIBLIOGRAPHY

Powell 1872, pp. 259-263.

Sarma 2015b, p. 302.

M003 PHALAKA-YANTRA PRESENTED BY THE MAHARAJA OF BENARES TO THE PRINCE OF WALES, 1876

Dimensions ?

PLU

When the Prince of Wales (the future Edward VII) visited the Maharaja of Benares, Sir Ishwari Prasad Narayan Singh, GCSI, on 5 January 1876, the Maharaja presented him a set of traditional Indian astronomical instruments. There survives a list meticulously prepared by Bapu Deva Sastri. The list includes, aside from small replicas of the masonry instruments erected by Sawai Jai Singh in his observatories, the following instruments made according to the descriptions given by Bhāskarācārya: *Gola-yantra, Cakra-yantra, Cāpa-yantra, Turīya-yantra* and *Phalaka-yantra.* The list expressly mentions that the *Phalaka-yantra* was invented by Bhāskarācārya and that the details about all these instruments can be found in the *Siddhāntaśiromaṇi* and refers to the Bibliotheca Indica edition by 'Lancelot Wilkinson, Esq.'

These instruments are not with any public museum in UK; they may be in some uncatalogued collection of the British royal family.

BIBLIOGRAPHY

William Howard Russel, *The Prince of Wales' Tour: A Diary in India; with some account of the visits of His Royal Highness to the courts of Greece, Egypt, Spain, and Portugal*, with illustrations by Sydney F. Hall, M.A., Artist in the Suite of H.R.H. The Prince of Wales, second edition, Sampson Low, Marston, Searle & Rivington, London 1877 pp. 389-91; 616-17.
https://archive.org/details/princeofwalestou00russuoft
[also https://goo.gl/V8sHM3, last accessed in June 2017].

Sarma 1996c.

Sarma 2014b.

M004 PHALAKA-YANTRA ENGRAVED ON THE BACK OF AN ASTROLABE DESIGNED BY GAṄGĀSAHĀYA AND MADE BY RĀMAPRATĀPA

1895, Tonk, Rajasthan

Diameter 334 mm

PLU

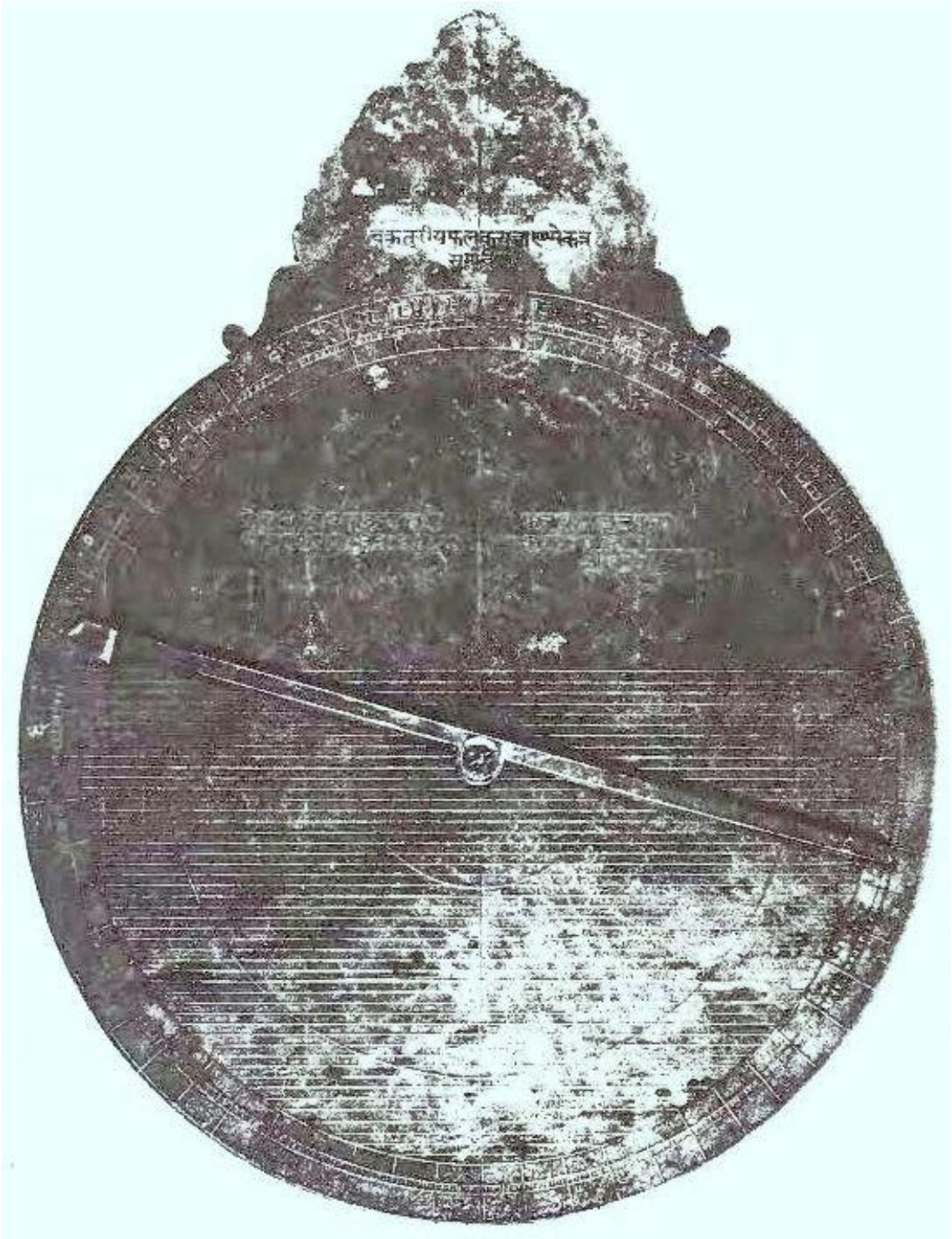


Figure M004.1 – Phalaka-yantra on the back of the astrolabe D091
(courtesy of Museum of History of Science, Oxford)

In the archives of the Museum of the History of Science at Oxford, there are photos of the front and back of an interesting astrolabe, which is described under D091. An inscription on the front side of the suspension bracket informs that a certain Gaṅgāsahāya caused this astrolabe to be made by the artisan Rāmapratāpa at Tonk in Rajastan in 1895. On the back of the *kursī* is an inscription which reads *cakra-turīya-phalaka-yantrāṇām ekatra samāveśaḥ,* '[Here are] assembled at one place the *Cakra-yantra,* the *Turīya-yantra* and the *Phalaka-yantra*'.

A *Turīya-yantra* (i.e. a quadrant) is normally incorporated on the back of the astrolabe for measuring the altitudes of the heavenly bodies. The back of the astrolabe can also function as the *Cakra-yantra,* which is a graduated circle with an upright peg at the centre. For using it as a *Phalaka-yantra,* starting a little above the centre, about 45 equidistant horizontal parallels (i.e., 1 for each 2 prescribed by Bhāskara II) are drawn up to the lower periphery on this astrolabe. Two concentric circles with different radii are drawn from the centre; these could be the equatorial circle and the Tropic of Cancer. The alidade of the astrolabe can, of course, function like the index required for the *Phalaka-yantra,* and can also measure the altitude of the sun. However, there is no circle divided into 60 *ghaṭikās* and 360 degrees of arc.

There are two more inscriptions providing the necessary parameters for using the *Phalaka-yantra.* An inscription on the upper left quadrant reads *ṭoṃkanagare phalaka-yantra-yogya | paramā yaṣṭiḥ 36|34,* 'In the city of Tonk, the maximum *yaṣṭi* appropriate for the *Phalaka-yantra* is 36|34.' The upper right quadrant bears the inscription *phalaka-yantra carajyā-khaṇḍāḥ 3|2|2 6|18|2,* 'the segments of the sines of accensional differences for the *Phalaka-yantra* are 3|2|2 and 6|18|2.'

Therefore Gaṅgāsahāya's attempt of using the back of the astrolabe as a *Phalaka-yantra* is historically very valuable. Unfortunately, the present location of the actual astrolabe is unknown.

N. PALABHĀ-YANTRAS & EQUINOCTIAL SUNDIALS IN SANSKRIT

INTRODUCTION

Every culture must have made use of the shadow cast by the gnomon, i.e. a straight stick erected vertically on a level ground, to measure time. The simplest form of the gnomon is that of a man standing upright and his shadow indicating the time. A reminiscence of this practice can be seen in the Sanskrit terms *nara-bhā* or *nṛ-bhā* employed in the sense of the 'gnomon shadow' but whose literal meaning is the 'shadow of a man (*nara, nṛ*); and also in the terms *pauruṣī* (man's length) and *tripauruṣī* (thrice man's length) employed to describe the shadow in Kauṭilya's *Arthaśāstra* which will be discussed below. Likewise the custom of mentioning the height of the gnomon as seven feet in Islamic astronomy goes back to a period when the human body was used as the gnomon and the ideal height of a man was considered to be seven times the length of his foot.

From such simple sticks erected on the ground, sundials evolved gradually which consist of a gnomon that casts a shadow upon a graduated dial on which the position of the shadow is translated into units of time. This basic form gave rise to diverse varieties in the course of centuries, some with vertical gnomons and horizontal dials, others with horizontal gnomons and vertical dials or curved dials and so on.

SUNDIALS IN ANTIQUITY

The earliest extant sundials are two fragments from Egypt, datable to about 1500 and 1000 BC respectively. Sundials were also cultivated in Greek antiquity, but more actively in the Roman empire, where large decorative sundials were set up at public places and in private palaces.[1392] The Roman engineer Vitruvius describes as many as fifteen different kinds of sundials in his book *Architectura.*[1393] Sharon L. Gibbs, in her pioneering study of 1976, *Greek and Roman Sundials,* described 257 sundials. [1394] Subsequently several more were discovered. About five hundred specimens are said to

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[1392] Turner 1998; see also Turner 1993c.

[1393] Vitruvius, Book IX, chs. 8-9.

[1394] Gibbs 1976.

exist today in various collections. These Greek and Roman sundials display seasonal hours.

A large number of these dials have the shape of a half-cone with the gnomon affixed at the vertex of the cone and the dial engraved on the concave surface, in such a way that the axis of the cone is parallel to the axis of the earth. The hour lines radiating from the vertex are intersected by three concentric semi-circles which are parallel to the equator; the lowermost semicircle represents the summer solstice, the one in the middle the equinoxes and the upper semi-circle the winter solstice.[1395] An example can be seen in Figure N.1 below which shows a Roman sundial excavated at Athens.



Figure N.1 – Roman sundial at the National Archaeological Museum, Athens
(photo by S. R. Sarma)

[1395] Catamo et al 2000.

Christian monasteries adopted the sundial for indicating the times of their prayers from the fifth century onwards. The individual prayers offered in the daytime are named after the respective hours: Matins (before dawn); Prime (at sunrise); Terce (third hour after sunrise); Sext (sixth hour after sunrise); None (ninth hour after sunrise); Vespers (sunset) and Nocturnes (after sunset in the night). To facilitate these prayers, vertical sundials with horizontal gnomons were added to the south-facing walls of churches. Since the prayers called Terce, Sext and None were particularly important, crosses were added to the third, sixth and ninth hour-lines. Sometimes, only these three hours lines are marked on the dial and the rest are omitted. Such specimens are called 'mass dials' or 'tide dials'. There are said to be some 3000 specimens surviving in the UK.[1396]

As Islam spread in the seventh century into areas which were formerly under the Greco-Roman domain, and as the Muslim astronomers came into contact with Greco-Roman sundials, they began to modify them by adding lines to indicate the times of Islamic prayers. Thus some highly sophisticated sundials were created in the Islamic world, some of which were transmitted westwards to Europe and eastwards to India. The development of these Islamic sundials will be discussed in the introduction to the section Q on the Indo-Persian sundials.

In Europe, after the development of mechanical clocks, seasonal hours were gradually replaced by the equal hours in the religious and civil life from the fourteenth century onwards, and the sundials also were marked in equal hours.

In the St. Mary's Church in the small German town of Homberg an der Efze, the walls are adorned both with a tide dial ('Gebetsuhr' in German) (Figure N.2) and a dial marked with equal hours (Figure N.3); the former is equipped with an horizontal gnomon and the latter with an inclined gnomon. The church was constructed originally in the fourteenth century, but many additions and modifications were made in the subsequent centuries. Therefore, it is not possible to date either of the dials accurately. However, the hour-lines in the common sundial are numbered with a mixture of the Roman (I, V, VI, VII, VIII, X, XI, XII) and the so-called Arabic (2, 3, 4) numerals; such a combination can be dated to the late sixteenth or seventeenth century.

[1396] Rumley.



Figure N.2 – Tide Dial in the St. Mary's Church, Homberg an der Efze
(photo by Dr. Klaus Lambrecht - Own work, CC BY-SA 3.0,
https://commons.wikimedia.org/wiki/File:Untere_Gebetsuhr.jpg
[also: https://goo.gl/jrTXy8, last accessed in December 2017]



Figure N.3 – Sundial marked with equal hours in the St. Mary's Church,
Homberg an der Efze (photo by S. R. Sarma)

Even though the production of mechanical clocks gradually gained importance in later centuries in Europe, sundials continued to be produced in great numbers, either as stationary objects for the decoration of urban spaces or tombstones, or as small portable items of diverse designs and in diverse materials.[1397]

Sundials in India

Gnomon in Kauṭilya's Arthaśāstra

In India, the first mention of measuring time by means of the shadow cast by the sun occurs in the *Arthaśāstra* of Kauṭilya which was composed and redacted between the second century BC and the third century AD. Kauṭilya lays down that a king should divide his day into eight parts and the night into another eight parts, by means of the water clock (*nālikā*) or by the length of the gnomon's shadow (*chāyā-pramāṇa*), and devote each part for a specific administrative or personal task.

> 'He should divide the day into eight parts as also the night by means of *nālikās,* or by the measure of the shadow (of the gnomon). (A shadow measuring three *pauruṣas,* one *pauruṣa,* (and) four *aṅgulas* and the midday when the shadow disappears are the four eighth parts of the day. By them are explained the later (four).'[1398]

The water clock will be discussed in section R below. The simplest form of the gnomon is that of a man standing upright and his shadow indicating the time and this is suggested by the terms *pauruṣī* and *tri-pauruṣī*. But probably Kauṭilya envisages an actual gnomon in the form of a straight wooden stick erected vertically on the level ground with markings on the ground which divide the time between the sunrise and sunset into eight parts.

From the *Brāhma-sphuṭa-siddhānta* of Brahmagupta (AD 628) onwards, Sanskrit texts of the type *Siddhānta,* usually devote the third chapter for the gnomonics; the chapter is entitled *Tri-praśna-adhyāya* (chapter on three questions or topics) and

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1397 On the variety and classification of the European sundials, cf. Higgins 1953; Zinner 1979, pp. 46-135; Turner 1993c.

1398 Kauṭilya, *Arthaśāstra*, 1.19.6-8: *nālikābhir ahar aṣṭadhā rātriṃ ca vibhajet chāyā-pramāṇena vā | tripauruṣī pauruṣī caturaṅgulā naṣṭacchāyo madhyāhna iti catvāraḥ pūrve divasasyāṣṭabhāgāḥ | taiḥ paścimā vyākhyātāḥ |* translation by Kangle; see also Abraham 1981.

discusses the determination of *diś* (cardinal direction), *deśa* (locality, i.e., terrestrial latitude) and *kāla* (time) by means of the gnomon (*śaṅku*). As in the *Arthaśāstra,* here also a straight staff is set up temporarily on a level ground on which lines are drawn for the determination of the three parameters. The staff, whatever may be its actual length, is divided into 12 *aṅgulas*, and this unit of length is employed in measuring the shadow.

The *Brāhma-sphuṭa-siddhānta* describes several other instruments of permanent nature in the twenty-first and twenty-second chapters and so do several subsequent texts. Although many types of instruments are described in these texts for measuring time by the sunlight, those that are represented by extant specimens are just three:[1399] the horizontal dial with a triangular gnomon (*Palabhā-yantra*), the column dial with a horizontal gnomon (*Kaśā-yantra*) and the graduated ring in which sunlight enters through an aperture (*Cūḍā-yantra*). These are relatively late and are described in Sanskrit texts only from the fifteenth century onwards. Besides these three varieties of Sanskrit sundials, there are extant a few Indo-Persian sundials. The horizontal dials will be described in the present section N, the ring dials in section O, the column dials in section P and the Indo-Persian dials in section Q.[1400]

PALABHĀ-YANTRA

In the *Palabhā-yantra,* the horizontal sundial with a triangular gnomon, the hypotenuse of the gnomon points to the north pole. About its origin Berggren writes as follows:

> ‘A surprising feature of Ibn al-Shatir’s dial (made in the second half of the fourteenth century for the Umayyad Mosque in Damascus) was that its gnomon was parallel to the polar axis. In fact, it was inclined to the horizon at an angle of 33½°, a common medieval value for latitude of Damascus. This was the first known proof that it was the Muslims, and not the

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[1399] The great diversity noticeable in the innumerable sundials extant in Europe and the much greater complexity of design presented in the Arabic texts such as the one by al-Marrākushī is not reflected either in the Sanskrit texts or in the extant specimens.

[1400] The reason for this arrangement is purely pragmatic (and not chronological) so that the smallest number of specimens receives the code numbers beginning with O (which so closely resembles 0).

> Europeans of the Renaissance, who introduced the sundial with the gnomon aligned to parallel the earth's axis.'[1401]

However, the horizontal dial in Ibn al-Shāṭir's sundial is highly complex and is unlike the simple dials found in India or in Europe. On the other hand, no other Islamic sundial has been discovered which corresponds to the Indian or European horizontal dials. Even so, it is fairly certain that the original prototype was developed in the Islamic world and thence transmitted westwards to Renaissance Europe and eastwards to India. Because of the simplicity of construction, it was produced hundreds of times in Europe and also in North America, where it became a popular garden ornament.

In India it was absorbed in the Sanskrit repertoire of instruments under the title of *Palabhā-yantra.* Here *palabhā* denotes the noon equinoctial shadow, i.e., the length of the shadow thrown at noon by a gnomon of 12 units (*aṅgulas*) on the days of the equinox. The length of the shadow is dependent on the latitude of the place. A *palabhā-kṣetra* then is a right triangle where the length of the shadow forms the base and the height of the gnomon (i.e. 12 digits) the vertical. The hypotenuse of this triangle subtends an angle which is equal to the terrestrial latitude of the place. The *Palabhā-yantra* is a horizontal sundial on which a triangular gnomon is set up in a plane perpendicular to that of the dial. The gnomon has the form of the *palabhā-kṣetra,* where the angle between the base and the hypotenuse is equal to the terrestrial latitude of the locality.

For measuring time, the instrument is so set up that the gnomon rests on the north-south line. Then the hypotenuse will point to the celestial north pole and its surface will become parallel to the earth's axis. The shadow of the gnomon will follow the sun's passage across the sky and show the time on the horizontal dial. For this purpose the dial is divided into time units, either in the traditional units of *ghaṭīs* (= 24 minutes) and *palas* (= 24 seconds), or in modern units of hours and minutes. These units will be unequal when projected on a horizontal dial. Since the gnomon is fashioned according to the terrestrial latitude of a specific locality, it can be used only on that latitude, and not elsewhere.

[1401] Berggren 2001, p. 12, where a sketch of Ibn al-Shāṭir's dial is reproduced.

The *Palabhā-yantra* is described probably for the first time in the *Yantraprakāra* which was compiled between 1716 and 1724 at the court of Sawai Jai Singh of Jaipur.[1402] This text teaches how to calculate the angles between the hour-lines on a horizontal dial for the latitude of Delhi at 28;39° and for that of Amber at 27°. In 1771 Nandarāma Miśra of Kāmyakavana (Kamon, near modern Mathura in UP) described the instrument in twelve verses at the beginning of his *Yantrasāra.* While the *Yantraprakāra* offers a trigonometric formula for computing the angles between the hour lines, Nandarāma teaches a geometrical procedure.[1403] Around 1799-1800 Viśveśvara Mahāśabda Puṇḍarīkayājin composed a *Palabhā-yantra*.[1404]

Palabhā-yantra in the Yantraprakāra

The Yantraprakāra describes the Palabhā-yantra thus:[1405]

> 'Now the method of the *Palabhā-yantra.* Multiply the shadow cast by a horizontal gnomon (*viloma-cchāyā*) at any given hour angle (*nata-kāla*) by the Rsine of the local latitude (*akṣa-jyā*) and divide by the Radius (*tri-jyā*). For the result thus obtained, locate the corresponding arc in degrees in the table of shadows cast by the horizontal gnomon (*vilomacchāyā-sāraṇī*). These will be the degrees of horizon (*kṣitijāṃśa*).[1406]
>
> 'Example. In Delhi, the latitude is 28;39°. [Let] the hour angle be 1 *ghaṭī* which is equal to 6°. Its tangent (*vilomacchāyā*) is 1;18,22,30. This is multiplied by the Rsine of the latitude 28;46,2,53,52 and divided by Radius 60. The quotient is 3;1,24,53,31,8. The arc corresponding to this in the table

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1402 Sarma 1986-87b, pp. 26 (text), 76-77 (translation and commentary).

1403 Unpublished. I use MS Nos. 851/1884-87 (copied in 1802) and 504/1892-95 (copied in 1830) of the Bhandarkar Oriental Research Institute, Pune. Independent manuscripts containing just the *Palabhā-yantra* from Nandarāma Miśra's *Yantrasāra* are also in circulation. Thus 9223 of the Oriental Institute, Vadodara, and 2672 of the Rajasthan Oriental Research Institute, Udaipur, contain the extract on the *Palabhā-yantra* from the *Yantrasāra* without identifying it as such. The latter manuscript contains several other texts on instruments. Manuscript no. 3185 of the Oriental Institute, Vadodara, offers the same trigonometric formula as the *Yantraprakāra,* but in six verses.

1404 Cf. Pingree 2003, p. 126, no. 243.

1405 Cf. Sarma 1986-87b, pp. 76-77; slightly modified.

1406 This can be expressed as $\tan \alpha = \sin \varphi \cdot \tan \beta$, where α is the angle between the hour line and the horizon, and β the time unit expressed as arc degrees.

of tangents is 2;53°. These are degrees of horizon (*kṣitijāṃśa*), i.e., the angle between the horizon and the line for the first *ghaṭī.* Thus calculate the angles for each *ghaṭī,* or half *ghaṭī,* or quarter *ghaṭī,* or any other fraction thereof.

Then draw a circle of any radius on an even ground. On it mark the cardinal points. Graduate the circle in degree and minutes. [In the circle], mark off the degrees obtained in the computation from the horizon (i.e., the east-west line) onwards. Draw a line from the centre up to that mark. This is the line of the first *ghaṭī.* Thus draw lines for each *ghaṭī.*

Next set up a [triangular] gnomon on the north point of the circle [in such a way that] from the foot of the gnomon up to the centre of the circle lies the base of the equinoctial triangle (*palabhā-bhuja*), from the top of the gnomon up to the centre is the equinoctial hypotenuse (*chāyā-karṇa*). Or [let] the Rsine of latitude (*akṣa-jyā*) be the base, Rsine of the colatitude (*lamba-jyā*) the perpendicular and Radius (*tri-jyā*) the hypotenuse. Prepare such a triangle and set it up there. The hour angle, expressed in *ghaṭīs,* at any moment is measured from the point where the shadow of the triangle, so set up, falls on the circle, up to the line of midday (*madhyāhna-rekhā*) (i.e., up to the north point).'

'Here is the table of *Palabhā-yantra* for the latitude of Delhi (*Indraprastha*) [at 28;39° and for the latitude of Amber (*Ambāvatī*) at 27°].'

Hour angle in *ghaṭikās*	**Degrees of horizon**	
	Delhi	Amber
1	2;53	2;45
2	5;59	5;34
3	8;51,30	8;29
4	12;3	11;33
5	15;28,30	14;50,30
6	19;12,45	18;27
7	23;21	22;27,30
8	28;2	27;1
9	33;25,30	32;17,30
10	39;25,30	38;29,50

11	47;7	45;53
12	55;52,30	54;43
13	66;5,30	65;9,30
14	77;38	77;7
15	90;0	90;0

Extant Specimens of the Palabhā-yantra

The instrument appears to have been popular in Rajasthan. Since the present study is limited to museum specimens, I did not explore the *Palabhā-yantras* set up in public places, except in a few cases. In Sawai Jai Singh's Observatory at Jaipur, a *Palabhā-yantra* is incorporated at the top of the *Nāḍīvalaya-yantra* (N001). The Observatory also owns a *Palabhā-yantra* made by Gokula Nātha Śarmā in 1882 (N002).

Elsewhere in Jaipur there are other specimens in the Maharaja Man Singh II Museum, in the Sanjay Sharma Memorial Museum and in the Museum of Indology. In Amber Fort near Jaipur, there is a *Palabhā-yantra.* There is also one in the Jaisalmer Fort (N004). The Rao Madho Singh Museum of Kota has two *Palabhā-yantras* in stone, presumably designed for the latitude of Kota (N011 and N012).[1407] There must have been several others erected in public places. In a few cases, these have been removed and preserved in museums. But a large majority must have been irretrievably lost.

The *Palabhā-yantras* made in the eighteenth century were engraved with lines to measure time in *ghaṭīs* (N001). But gradually these yielded place to sundials with hour-lines in the nineteenth century. The *Palabhā-yantra* in Jai Singh's Observatory at Ujjain (N002), like the one at the Observatory at Jaipur (N001), must have been engraved originally with lines to measure *ghaṭīs,* but in course of repairs the original marble dial was replaced by another carrying hour lines.

[1407] Cf. Sharma 2000, pp. 233-244, esp. 243-244, figs. 6-7.

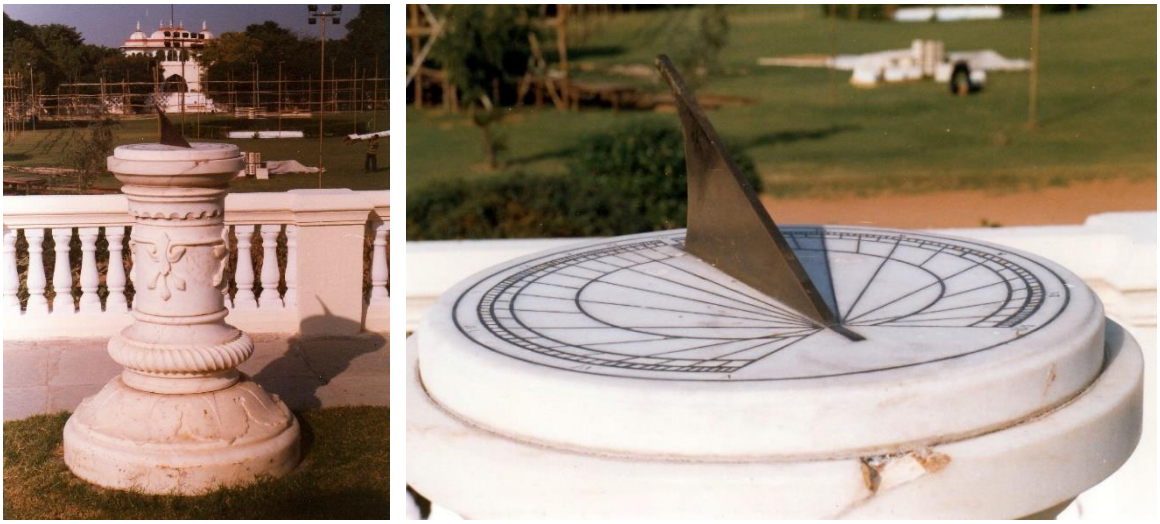


Figure N.4 – English sundial at Sujan Rajmahal Palace Hotel, Jaipur,
former Residency of the British Political Agent (photos by S. R. Sarma)

English Colonial Sundials

During the British colonial times, many sundials were set up with horizontal dials and triangular gnomons; these resembled the *Palabhā-yantras* in design, but carried lines to measure hours which are numbered either in Roman numerals or in modern international numerals. One of the earliest such sundial was set up in 1784 at the British garrison in the Chunar Fort near Allahabad. There is one in the residency of the British Political Agent who represented the British Governor-General at the Princely State of Jaipur, which is now converted into a hotel (Figure N.4). Similar English sundials are to be found in the British Viceroy's summer residence at Shimla (now converted into the Indian Institute of Advanced Study), in the Allahabad Fort and many other places. Since these do not belong to the traditional repertoire of Indian astronomical instruments, these are not included in this catalogue.

Palabhā-yantra as Urban Sculpture

Following the European fashion, large sundials are being set up as urban sculptures in public places. In the Inter-University Centre for Astronomy and Astrophysics (IUCAA) at Pune, there are sculptures of 'Isaac Newton under an Apple Tree' and of Bhāskarācārya, besides a clumsy imitation of Sawai Jai Singh's equinoctial sundial *Samrāṭ-yantra.* There are said be to also sundials set up as army memorials. A notable specimen is a sundial in the shape of the *Palabhā-yantra* set up recently near the Barapullah Flyover in New Delhi by the Delhi Development Authority (DDA). In this sundial, the brass gnomon has a height of 12.7 metres and a length of 24.5 metres.

The hour lines are laid out in coloured marble and numbered in large Devanagari numerals.



Figure N.5 – Sundial near Barapullah Flyover, New Delhi (photo by Debasish Das)

Mention may also be made, in this connection, on a sundial set up in Antwerp in Belgium. It was designed by the artist Hubert Minnebo. Its connection to India lies in the fact that the well-travelled artist who spent several years in India and Nepal, numbered the hours in large nicely shaped Devanagari numerals.



Figure N.6 – The sundial with Devanagari numerals (left); the artist Hubert Minnebo, the central figure at the base of the gnomon (right) (photos courtesy Jan de Graeve)

EQUINOCTIAL SUNDIALS

In the *Palabhā-yantra,* the *ghaṭī* lines or the hour lines on the dial are not equally spaced around the gnomon. The angles have to be calculated separately for each line. This problem is overcome in the equinoctial (also called equatorial) sundials where the

dial plate is parallel to the plane of the equator and the gnomon, which points to the pole, is perpendicular to it. In Jai Singh's Observatories, two masonry instruments, viz. the *Nāḍī-valaya-yantra*[1408] and the *Samrāṭ-yantra*[1409] are constructed on this principle. Moreover, in the *Samrāṭ-yantra* the gnomon is shaped like a right triangle with its hypotenuse pointing to the north pole. There exist two large portable specimens made in the style of the *Samrāṭ-yantra,* which appear to have created at the time of Sawai Jai Singh (N015 and N016). The Adler Planetarium at Chicago holds an equinoctial sundial with Devanagari numerals which is clearly modelled after a European specimen (N017).

[1408] Sharma 2016, pp. 171-173.

[1409] Sharma 2016, pp. 97-101, 133-141.

N001⊙ PALABHĀ-YANTRA SET UP ON TOP OF THE NĀḌĪVALAYA-YANTRA

Ca. 1734

Diameter 763 mm

Jaipur, Jai Singh's Observatory



Figure N001.1 – Palabhā-yantra (photo by S. R. Sarma)

This *Palabhā-yantra* was set up on a circular platform on the top of the *Nāḍīvalaya-yantra* in the observatory established by Sawai Jai Singh around 1734. The dial is made of a slab of red sandstone. The triangular brass gnomon is 130 mm high; its base measures 242 mm and the hypotenuse 275 mm. The base and the hypotenuse form an angle 28;15°, which is quite unsuitable for Jaipur with its latitude, roughly, of 27°. The dial is marked with lines for *ghaṭīs.* The rim of the dial is divided in 10 minutes of arc.[1410]

BIBLIOGRAPHY

Sharma 2016, p. 175.

[1410] Sharma 2016, p. 175, thinks such a scale is unnecessary: 'A horizontal sundial with a triangular gnomon does not require an evenly divided circular scale. It is possible that the circular dial was inscribed so that the instrument may also function as an Agrā yantra. A conical projection atop the vertical edge of the triangular gnomon might have also been provided for this purpose.' But even in a *Palabhā-yantra,* a degree scale is necessary on the rim for measuring the angles between the *ghaṭī* lines.

N002 PALABHĀ-YANTRA SET UP ON TOP OF THE DAKṢIṆOTTARA-BHITTI-YANTRA

Ca. 1734

Diameter 460 mm

Ujjain, Jai Singh's Observatory



Figure N002.1 – Palabhā-yantra (photo by Dr Jean-Michel Delire)

In the observatory established by Sawai Jai Singh at Ujjain around 1734, an *Agrā-yantra* and a *Palabhā-yantra* were set up on the top of the *Yāmyottara-bhitti-yantra* (lit. 'South-North Wall Instrument,' mural quadrant). In his report of 1799, William Hunter describes the *Palabhā-yantra* thus:

> 'On the top of the mural quadrant […] about the middle of the wall the parapet to the eastward is increased in thickness, and on this part is constructed a horizontal dial called *Puebha Yunter* (sic! *Pulabha Yunter*). Its length (height ?) is 2 feet four inches and a half, but the divisions on it are totally effaced.'[1411]

[1411] Hunter 1799, p. 197.

Almost two centuries later, Virendra Nath Sharma writes the following on the same *Palabhā-yantra*:

> 'The Palabhā, a sundial, is located on a masonry column close to the Agrā. The column is topped with a marble slab 46 cm in diameter. The instrument has a triangular gnomon similar to the one in Jaipur. The Palabhā scale is divided into hours and minutes such that its least count is 5 min. The scale continues beyond the two 6 o'clock marks on either side of the gnomon by 45 minutes. The inscription is written in Devanagari.'[1412]

The original dial of the *Palabhā-yantra* must have been divided in *ghaṭīs,* which was completely effaced when Hunter saw it around 1797. Apparently this dial was replaced in the twentieth century with a new marble dial divided in hours, as can be seen in the Figure above.

BIBLIOGRAPHY

Hunter 1799.
Sharma 2016.

[1412] Sharma 2016, p. 230.

N003 PALABHĀ-YANTRA BY LEHNA SINGH MAJITHIA, 1909 VS (AD 1852)

Dimensions ?

Amritsar, Golden Temple

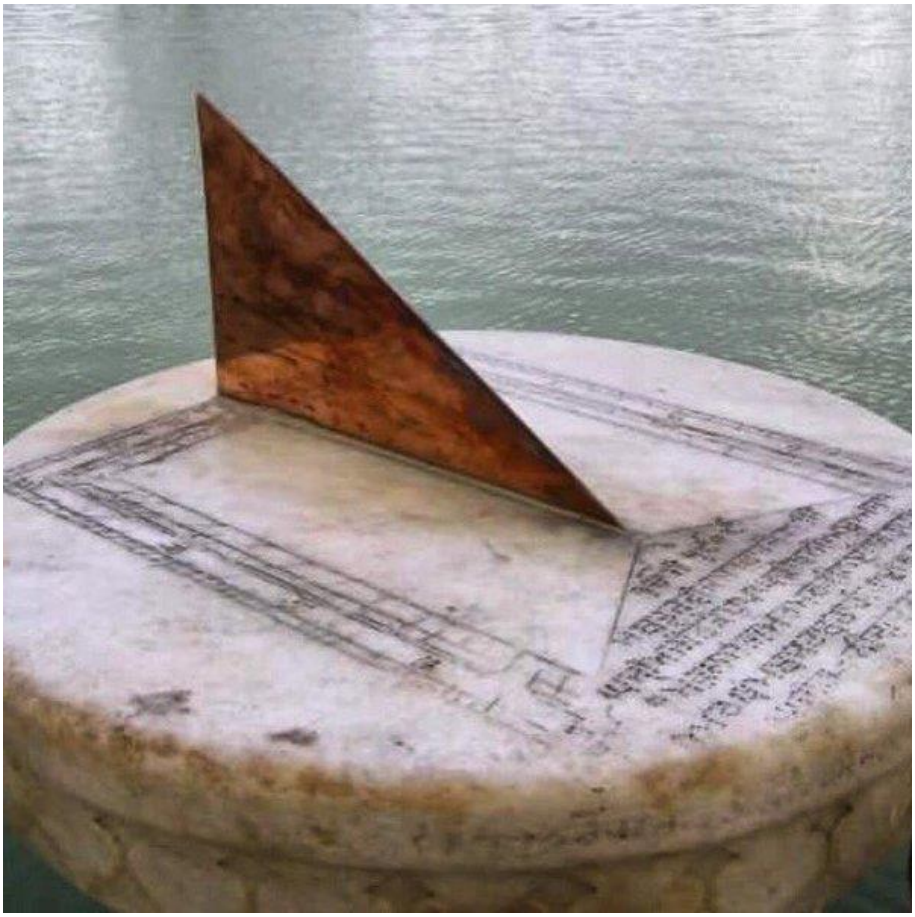


Figure N003.1 – Palabhā-yantra in Gurmukhi (photo by Basanta Rajkumar (@basantark))[1413]

LEHNA SINGH MAJITHIA

In the introduction to section G, a reference has been made to the illustrated manuscript of the Sanskrit work *Sarva-siddhānta-tattva-cūḍāmaṇi* (British Library, Or.5259) which carries the horoscope of Lehna Singh Majithia (*ca.* 1806-1854). He was one of the generals of Maharaja Ranjit Singh and was greatly interested in mechanical arts and scientific subjects. Sir Lepel Griffin writes the following about him:

> 'Lehna Singh was known as *Hasmuddaula,* the Sword of the State, and was a man of considerable ability. He was a skillful mechanist and an original inventor. He much improved the Sikh ordnance, and some very beautiful

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[1413] I am highly obliged grateful to Basanta Rajkumar for his kind permission to use his photo.

> guns of his manufacture were taken at Aliwal and elsewhere. Among other things he invented a clock which showed the hour, the day of the month, and the changes of the moon. He was fond of astronomy and mathematics and master of several languages. As an administrator he was very popular.'[1414]

About the guns made by him, Colonel Baird Smith, a member of the Asiatic Society, remarked that 'Nothing could surpass the whole design and details of these guns, and while they were ornamented with great taste, they were at the same time good working guns, and had been vigorously used during the day.' [1415]

PALABHĀ-YANTRA

It is not known what happened to the 'clock which showed the hour, the day of the month, and the changes of the moon.' He also produced an iron column dial (P023); its present location is also unknown. But a *Palabha-yantra* designed by him in 1852 is extant *in situ* in the Golden Temple at Amritsar. Its exact location is described thus by Jagjit Singh:

> 'The bridge connects the gate-way with the Temple proper, 240 feet long and 21 feet wide, it is built in water with ten arched spans. There are other 38 small spans to support the larger ones. On either side of the bridge are fixed ten marble lamp-posts with gold lanterns on them. A fine marble railing runs throughout the length between the lamp-posts. On the northern side a lamp-post bears a sun-dial instead of lantern. It was built by Sardar Lehna Singh Majithia in 1852. The pavement was laid with coloured marble by Maharaja Ranjit Singh in 1835.'[1416]

The dimensions of the *Palabhā-yantra* are not available. Presumably the hypotenuse of the gnomon forms an angle of about 32° corresponding to the latitude of Amritsar at 31;38°. The Gurmukhi inscription at the base of the gnomon cannot de deciphered in the available photo; the first line appears to carry the year 1909 in

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1414 Sir Lepel Griffin, *Ranjit Singh,* (Rulers of India Series), Oxford 1892, pp. 130-131.

1415 *Journal of the Asiatic Society of Bengal,* 23 (1860) 426-427; see also P023.

1416 Jagjit Singh, *Temple of Spirituality or Golden Temple, Amritsar,* The Sikh Religious Tract Society, Tarn Taran, 1935, p. 64.

Vikrama Saṃvat. There seem to be two scales in the rectangular border; the outer one of modern hours, with sub-divisions marked for 30 minutes and 10 minutes, and the inner one of the traditional *ghatis* (of 24 minutes), subdivided in ½ *ghaṭīs*.

BIBLIOGRAPHY

Journal of the Asiatic Society of Bengal, 23 (1860) 426-427.

Sir Lepel Griffin, *Ranjit Singh*, (Rulers of India Series), Oxford 1892.

Jagjit Singh, *Temple of Spirituality or Golden Temple, Amritsar*, The Sikh Religious Tract Society, Tarn Taran 1935.

N004 PALABHĀ-YANTRA BY GAJADHAR SARŪP KHEMĀṆĪ, 1916 VS (AD 1859)[1417]

Diameter 365 mm

Jaisalmer Fort, Raj Mahal Palace Museum

This sundial, a circular disc carved out of yellow sandstone, was designed by Gajadhar Sarūp Khemāṇī at the instance of the ruling prince Māharāwal Raṇajīt Singh (r. 1846-1864) and was set up on the roof of the Jaisalmer Fort. The dial is calibrated in *ghaṭīs* and the lines are numbered from 1 to 17 in the forenoon and again from 1 to 17 in the afternoon, in Devanagari numerals. A groove is cut in the vertical radius for the gnomon, but it is missing now.

It is said that at the completion of each *ghaṭī,* an attendant would strike on a large bell and thus broadcast the passage of time. At some later point, the stone disc was removed and dumped in a store room. In 1993, when a part of the fort was converted into a museum called Raj Mahal Palace Museum, the sundial was retrieved and installed at the present location on the roof of the museum, but slightly off the meridian line.

INSCRIPTION

There is an inscription engraved around the rim in Rajasthani language and Devanagari script:

> *mahārājādhirāj rāj-rājesar mahārāval-jī śrī śrī 108 śrī raṇajīt-simḥ-jī bahādar jantar lagā karāyo haste gajadhar sarūp-jī khemāṇī saṃ. 1916 2 mitī māgasarasa 61*
>
> 'At the behest of Mahārājādhirāj Rāj-rājesar Mahārāwal-jī śrī śrī 108 śrī Raṇajīt Singh-jī Bahādur, this instrument was installed by Gajadhar Sarūp-jī Khemāṇī in [Vikrama] Saṃvat 1916, on the second day of Margasira [month].'

The inscription does not mention whether it is the waxing half (*śukla-pakṣa* or *sudi*) or waning half (*kṛṣṇa-pakṣa* or *vadi*) of the lunar month of *Mārgaśira.* In the

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[1417] Entry based on Pandya et al 2017.

former case, the date would correspond to 27 November 1859; in the latter to 12 November 1859.[1418]

At the end of the inscription, there is the number 61; its significance eludes us.

[1418] Pandya et al 2017, p. 139, convert the date erroneously to 26 November 1861.

N005⊙ PALABHĀ-YANTRA BY GOKULANĀTHA ŚARMĀ, 1939 VS (AD 1882-83)

Diameter 238 mm

Jaipur, Jai Singh's Observatory



Figure N005.1 – Palabhā-yantra (photo by S. R. Sarma)

The *Palabhā-yantra* is engraved on a block of pink sandstone with a diameter of 238 mm. The triangular gnomon, made of the same kind of stone, subtends an angle of 27°, roughly the latitude of Jaipur. On either side of the gnomon, lines are drawn for *ghaṭīs* 17, 16, …1, …16, 17.

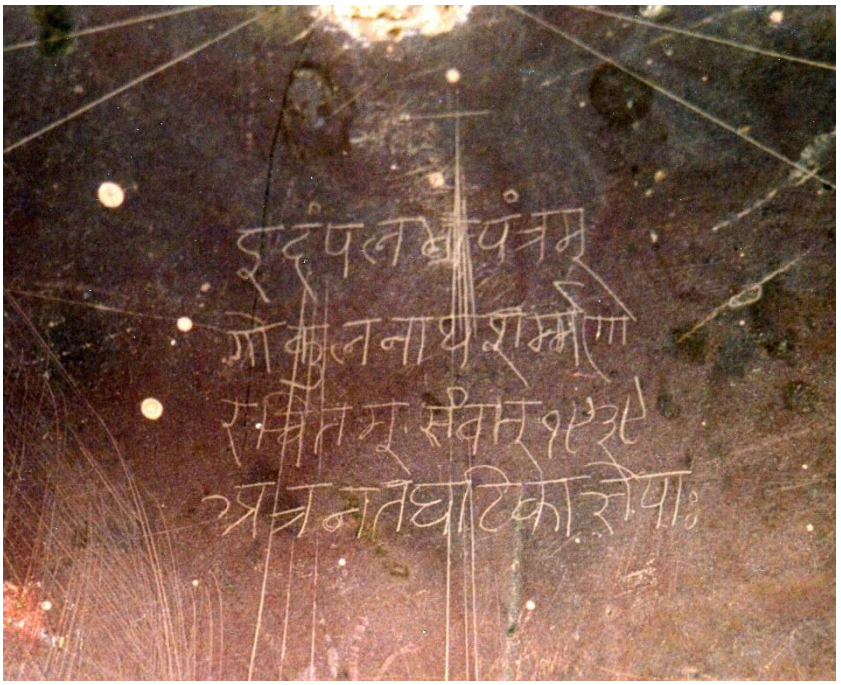


Figure N005.2 – Inscription (photo by S. R. Sarma)

INSCRIPTION

There is an inscription in 4 lines which reads:

idaṃ palabhāyaṃtram
gokulanātha-śarmmaṇā
racitam. saṃvat 1939
atra nataghaṭikā jñeyāḥ

'This is a *Palabhā-yantra*, made by Gokula Nātha Śarma. Saṃvat 1939 (= AD 1882-83). [The time divisions marked] here should be known as *nata-ghaṭikās* (i.e., *ghaṭikās* measured from the noon).'

N006⊙ PALABHĀ-YANTRA, NOT SIGNED, NOT DATED

19th century

Diameter ca. 400 mm

Jaipur, City Palace, Maharaja Sawai Man Singh II Museum



Figure N006.1 – Palabhā-yantra (photo by S. R. Sarma)

This *Palabhā-yantra* is made of a circular slab of grey stone; the triangular gnomon is also made of the same material and is apparently designed for the latitude of Jaipur at 27°. The *ghaṭī* lines drawn on the dial are not numbered.

N007 PALABHĀ-YANTRA, NOT SIGNED, NOT DATED

19th century

Diameter ?

Jaipur, Museum of Indology

Circular marble base with a brass triangular gnomon, calibrated for the latitude of Jaipur at 27°. No other details are available.

N008⊙ PALABHĀ-YANTRA, NOT SIGNED, NOT DATED

19th century

Diameter 213 mm

Jaipur, Museum of Indology

This is an incomplete *Palabhā-yantra.* The dial consists of a nearly semi-circular copper plate, with a diameter of 213 mm on which lines for hours are drawn and each hour is subdivided into 5 parts of 12 minutes each. The place where the gnomon should be affixed is indicated by engraved lines, but there are no signs of a gnomon ever having been affixed here.

N009⊙ PALABHĀ-YANTRA, NOT SIGNED, NOT DATED

19th century

Diameter 404 mm

Jaipur, Shri Sanjay Sharma Museum & Research Institute



Figure N009.1 – Palabhā-yantra (photo by S. R. Sarma)

Marble dial with a brass gnomon, made for the latitude of Jaipur at 27°. The dial is marked in hours and numbered clockwise from 5 [am] to 7 [pm] in Devanagari numerals. Each hour is subdivided into 4 parts (= 15 minutes), and each of these again into 3 parts (= 5 minutes).

N010⦿ PALABHĀ-YANTRA, NOT SIGNED, NOT DATED

19th century

Diameter ca. 200 mm

Jaipur, Shri Sanjay Sharma Museum & Research Institute

It is made of dark wood, apparently for the latitude of Jaipur at 27°; it could not be taken out of the display case for photography.

N011 PALABHĀ-YANTRA, NOT SIGNED, NOT DATED

19th century

Dimensions?

Kota, Rao Madho Singh Museum

Sharma 2000, p. 243, Fig.6, illustrates a *Palabhā-yantra,* apparently made for the latitude of Kota at 25°. The dial appears to be engraved on a square metal plate which is imbedded in a block of dark stone. No other details are mentioned.

N012 PALABHĀ-YANTRA, NOT SIGNED, NOT DATED

19th century

Dimensions?

Kota, Rao Madho Singh Museum.

Sharma 2000, p. 244, Fig.7, illustrates a second *Palabhā-yantra,* apparently made for the latitude of Kota at 25°. The dial appears to be engraved on a square metal plate which is imbedded in a block of dark stone. No other details are given.

N013⊙ PALABHĀ-YANTRA, NOT SIGNED, NOT DATED

19th century

490 x 490 mm

Varanasi, Banaras Hindu University, Bharat Kala Bhavan

Sandstone sundial with a triangular gnomon, calibrated for the altitude of 25°; found in the vicinity of Varanasi.

N014⊙ PALABHĀ-YANTRA, NOT SIGNED, NOT DATED

Early 20th century

170 x 112 x 3 mm

Vadodara, M. S. University of Baroda, Sanskrit Mahavidyalaya



Figure N014.1 – Palabhā-yantra (photo by S. R. Sarma)

This *Palabhā-yantra,* made in the early twentieth century as a teaching aid, is a neatly crafted specimen, consisting of a smooth rectangular plate of reddish brass, supported by four cylindrical legs of 10 mm height. At the middle of the plate is affixed a triangular gnomon with a base (*bhuja*) of 98 mm, hypotenuse (*karṇa*) of 106 mm, and thickness 3 mm. The third side which is to be the perpendicular (*koṭi*) to the base is not straight, but is artistically curved inside. The hypotenuse subtends an angle of 22° at the base, which is exactly the latitude of Vadodara (22;00° N, 73;16° E).

On the base plate is engraved a rectangular scale in four columns. The outermost column is graduated to measure *ghaṭīs,* and is numbered in Devanagari from 15 to 1 and then from 1 to 15. The next column is divided to show half *ghaṭīs* (12 minutes). The following column is graduated to measure the hours and is labelled from 6 to 1 and then from 1 to 6. In the innermost column each hour is further subdivided into 5 units of 12 minutes each. Thus this *Palabhā-yantra* is sensitive up to 12 minutes and can measure time from 6 hrs (or 15 *ghaṭīs* before noon) in the morning to 6 hr (or 15 *ghaṭīs* after noon) in the evening.

N015⊙ EQUINOCTIAL SUNDIAL, NOT SIGNED, NOT DATED

Early 18th century

Height ca. 1800 mm

Jaipur, Jai Singh's Observatory



Figure N015.1 – Equinoctial sundial (photo by Sanjay Parmar)

This equinoctial sundial is almost similar in its construction to the masonry *Samrāṭ-yantra* with which all the observatories of Sawai Jai Singh are equipped. It is difficult to say whether it was made as a model before the *Samrat-yantra* was erected in masonry or whether it was fabricated as small-scale replica. Whatever the case maybe, it is equipped with a graduated dial so that time can be measured with it.

It consists of a triangular gnomon made of iron; its base measures 1911 mm and the vertical side 873 mm. The angle between the base and the hypotenuse is 27;10°

which is roughly the latitude of Jaipur (26;54°) . The semi-circular dial is made out of a 20 mm thick and 135 wide sheet of brass; it is divided in 30 *ghaṭīs* and each *ghaṭī* into parts of 10 *palas.*

The gnomon and the dial are set up on an iron ring supported by four legs.

BIBLIOGRAPHY

Sharma 2016, pp. 187-188.

N016⊙ EQUINOCTIAL SUNDIAL, NOT SIGNED, NOT DATED

Early 18th century

Diameter of the base ca. 500 mm

PLU; ex-Rockford, Time Museum (# 1174)



Figure N016.1 – Equinoctial sundial (courtesy Time Museum, Rockford)

This simple but very elegant equinoctial dial is similar in its construction to the previous specimen O003 and may have been made about the same time; however, it is much smaller in size and is without the legs. The circular base is made of iron; the triangular gnomon, the semi-circular dial and the two uprights that support it are of

brass. The hypotenuse of the gnomon makes an angle of 28;30° to the base, which is roughly the latitude of Delhi. The semi-circular dial is marked in *ghaṭīs* and numbered from 1 to 17 and 17 to 1 in Devanagari numerals. Each *ghaṭī* is divided in 6 parts of 10 *palas* each and each of these parts in 4 units of 2.5 *palas,* which correspond to 1 minute.

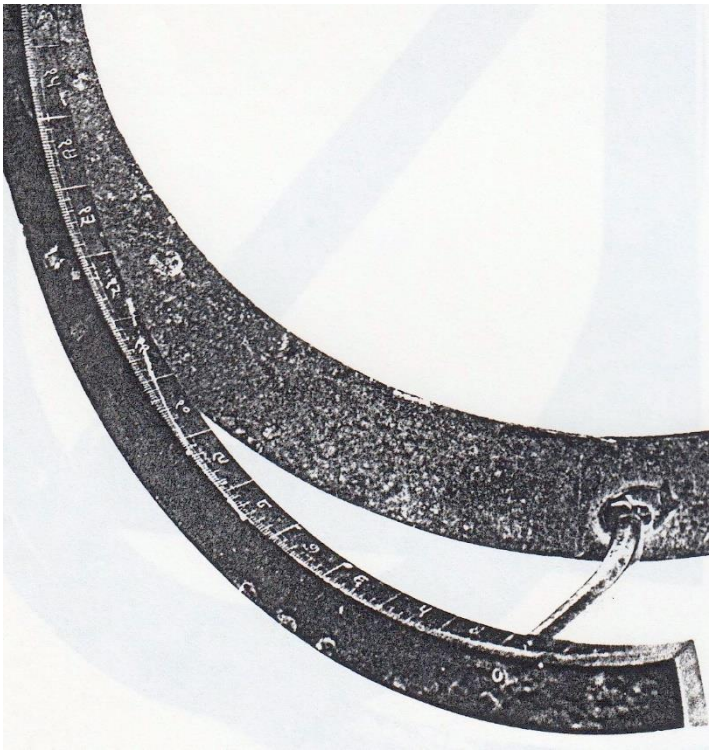


Figure N016.2 – Detail of the *ghaṭī* scale (courtesy Time Museum, Rockford)

N017⊙ UNIVERSAL EQUINOCTIAL SUNDIAL, NOT SIGNED, NOT DATED[1419]

19th century

Inner diameter of the base 530 mm

Chicago, Adler Planetarium (# A-256)

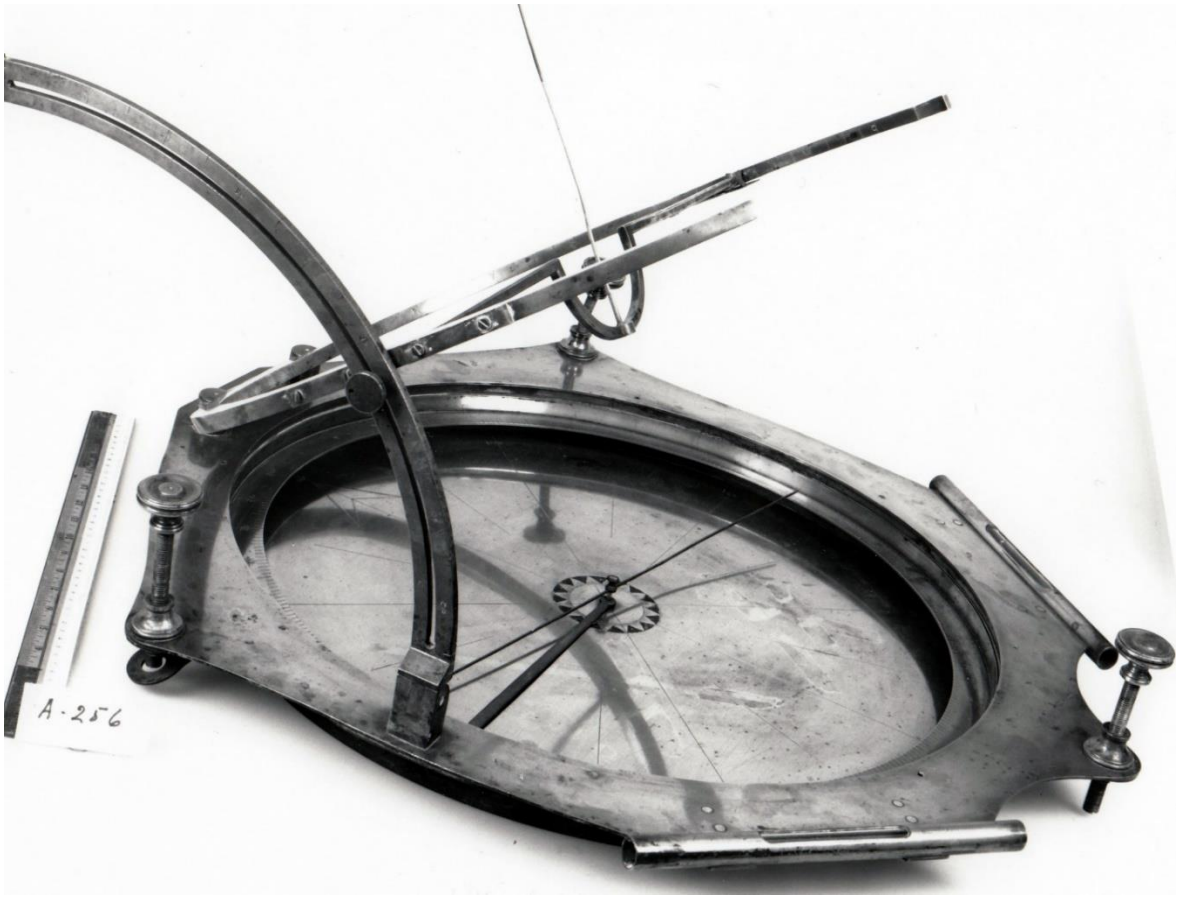


Figure N017.1 – Universal equinoctial sundial (courtesy Mrs & Mr Webster)

This large and ingeniously constructed device consists of a circular base with a diameter of 530 mm, at the centre of which a magnetic compass is affixed. Around this base is a raised circular rim, graduated in 1°; groups of 10° are numbered clockwise from 0 to 350 in Devanagari numerals. At a slightly higher level, there is another wider rim with nine sides, three of these are straight and the rest curved. To this rim are attached two bubble-levels and three adjustable screws for setting up the device correctly in horizontal level.

[1419] I remember with great pleasure the late Mrs & Mr Webster showing this sundial to me in early 1993 and gifting me the photos reproduced here. The sundial was acquired in December 1986 from Christie's, New York. It was not catalogued in Pingree 2009.

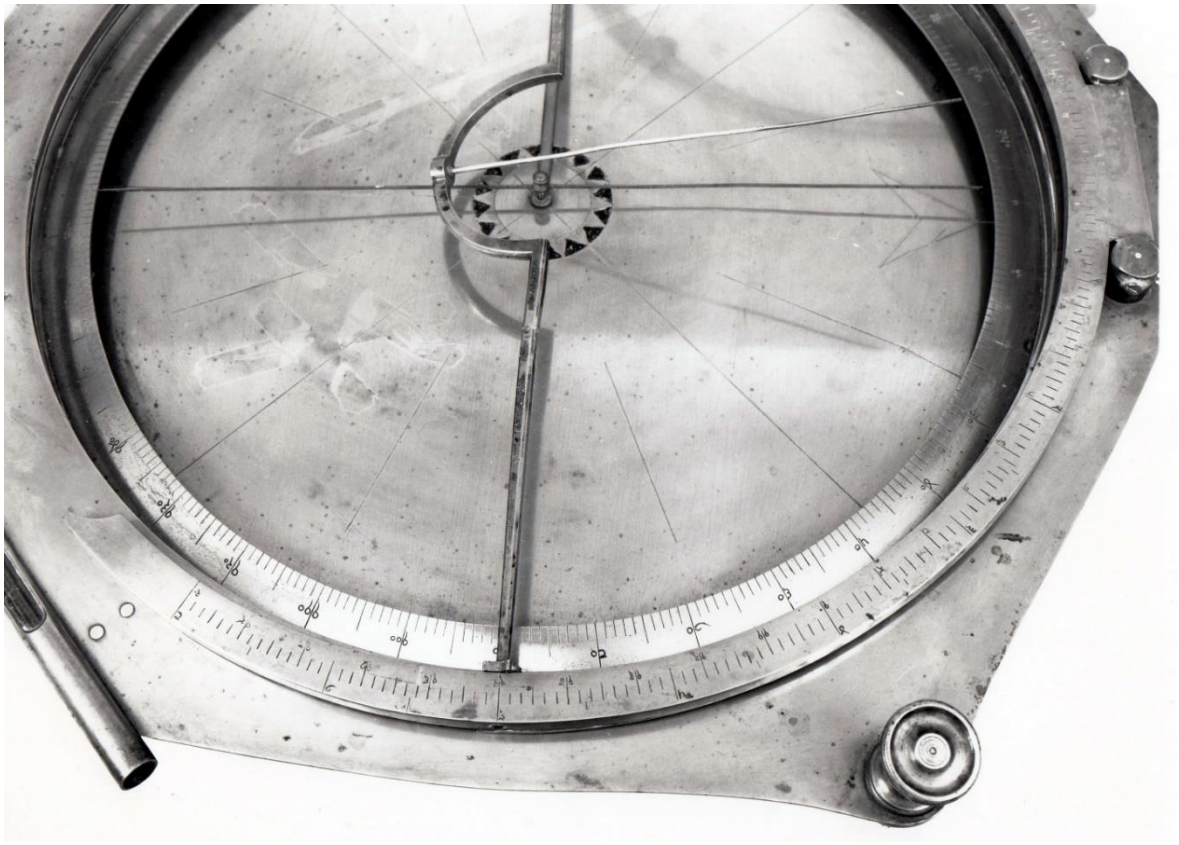


Figure N017.2 – Sundial with the component folded back.
At the bottom can be seen the semi-circular dial marked in hours and in *ghaṭīs.* Above is the graduated rim. The north point is marked on the base by a large arrow on the right (courtesy Mrs & Mr Webster)

The dial for measuring time is made in the shape of a semi-circular arc, with its centre hinged to the north point of the base. At the west point of the base is affixed an arc with a groove running its entire length. This groove is calibrated in 1° and numbered in 10s from 10 at the top to 90 at the base. A screw attached to the semi-circular time-measuring dial runs through this groove; it can be tightened at any desired point so that the instrument corresponds to the terrestrial latitude of the place of observation.

The semi-circular time-measuring dial carries three scales; two on the surface and the third along the thickness. The outer scale and the inner scale on the thickness are both marked for hours 4, 5, 6, … 12, 1, … 8 in Devanagari numerals; that is from 4 am to 8 pm. The middle scale is marked for *ghaṭīs*: 20, 19, 18, ….1, 0, 1, … 18, 19, 20 also in Devanagari numerala; these *ghaṭīs* are counted from the midday, from 20 *ghaṭīs* before midday (= 4 am) to 20 *ghaṭīs* after midday (= 8 pm).

The gnomon, in the form of a thin rod, is affixed to the semi-circular dial so that it is perpendicular to the plane of the semi-circular dial and points to the north pole. When the device is properly set up, the thin rod throws its shadow on the semi-circular dial and indicates the apparent local time in hours as well as in *ghaṭīs.*

When not in use, the gnomon, the semi-circular dial and the arc with the scale of latitudes can be folded back flush with the level of the base, as can be seen in Figure N017.2.

The device is apparently designed after a European model, possibly one like the French sundial of about 1875, formerly in the private collection of Leonard Linton.[1420] The workmanship is excellent.

[1420] Linton 1980, no. 131, p. 39.

O. CŪḌĀ-YANTRAS

INTRODUCTION

In a ring dial, a small hole in the breadth of the ring allows the sunlight to pass through and fall upon the inner concave surface on the opposite side, which is graduated in degrees to measure the altitude. Local time can also be measured directly if the inner surface is provided with separate scales for each solar month, and each scale is divided into so many *ghaṭīs* as there are in a half day (from the sunrise to the noon) in that month.

In India, the ring dial was first described by Āryabhaṭa about the beginning of the sixth century in his *Āryabhaṭa-siddhānta*. He calls it *Cakrayantra* and recommends that its circumference be divided in 360 degree and that two holes are made in the breadth at diametrically opposite points.[1421] The instrument is described by Varāhamihira also, in the middle of the sixth century, in his *Pañcasiddhāntikā*. He does not give it a name, but provides only a single hole and intends it to be used for measuring the sun's meridian zenith distance:

> Take a circular hoop, on whose circumference the 360 degrees are marked, whose diameter is equal to one *hasta*, and which is half an *aṅguli* broad. In the middle of the breadth of that hoop make a hole. Through this small hole made in the circumference allow a ray of the sun at noon to enter in an oblique direction. The degrees, intervening at the lower half of the circle between (the spot illumined by the ray and) the spot reached by a string hanging perpendicularly from the centre of the circle, represent the degrees of the zenith-distance of the midday sun.[1422]

Of course, a string cannot be suspended from the 'centre' of a ring, but a string let down from the topmost point of the ring will pass through the notional centre and represent the vertical.

1421 Cf. Shukla 1967, pp. 93, 98; see Ôhashi 1994, pp. 236-238.

1422 *The Pañcasiddhāntikā of Varāhamihira*, ed. tr. G. Thibaut and Sudhakara Dvivedi, Varanasi 1968, 2nd. ed., 14.21-22, p. 80; see Ôhashi 1994, pp. 238-239.

Rāmacandra Vājapeyin, In his *Yantraprakāśa* of 1427, describes three varieties of the ring dial, viz. *Valaya* (circle), *Cūḍā* (bracelet) and *Mudrikā* (finger- or signet-ring).[1423] All the three work on the same principle, but differ in size as their names suggest. Rāmacandra prescribes that the *Valaya-yantra* should measure a cubit in its diameter, the *Cūḍā-yantra* a span or less, and the *Mudrikā-yantra* much smaller. The inner concave surface is graduated in *ghaṭīs* for measuring time and the rim in 360 degrees for measuring altitudes.

Of the three sizes, the middle one, viz. *Cūḍā-yantra*, appears to have been more popular; it is represented in several Mughal miniatures, where it corresponds to this size.[1424] In these paintings, the astronomers/astrologers are depicted in majority of cases holding a small ring dial to measure the solar altitude, and not the astrolabe as one would have expected. Because of its frequent occurrence in paintings depicting the Mughal court, one is apt to think that it may have been of Islamic origin. But according to competent authorities on Islamic astronomical instruments whom I consulted, the ring dial was not known to the Islamic world.[1425]

In Europe, there is a similar instrument called ring dial or Bauernring in German. It is said to have been invented by George Peuerbach (1423-1461) and improved upon by his pupil Regiomontan (1436-1476). It was very popular until the nineteenth century, especially in Austria, but it is small in size like the signet ring.[1426] Since the ring dial was not known to the Islamic world, there does not seem to be any connection between the European ring dial and the Indian *Cūḍāyantra*.

The Yantra-prakāra of Sawai Jai Singh

The *Yantraprakāra*, which Sawai Jai Singh caused to be compiled before designing the huge masonry instruments for accurate observation, contains not only a detailed description of the *Cūḍā-yantra*, but also an elaborate set of tables to be used in conjunction with this instrument (*Cūḍāayantrasya Sāraṇī*). There are 19 separate tables,

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1423 Rāmacandra Vājapeyin, *Yantraprakāśa*, 6.9-13, Ms 975/1886-92 of the Bhandarkar Oriental Research Institute, Pune, ff. 61-62.

1424 Sarma 1992a.

1425 Professors E. S. Kennedy (Princeton) and David A. King (Frankfurt).

1426 Zinner 1979, pp. 120-122, Pl. 45.2; Price 1957, p. 598, fig. 351.

one for each decan of the zodiac, prepared for the latitude of Delhi (28; 39°).[1427] Here, the construction is explained thus:

> 'Now the method of constructing the instrument. Prepare a [cylindrical] ring of any diameter, the height [of the cylinder] being 4 *aṅgulas* or 5 *aṅgulas* or any other amount. With a tool, file the ring so that it becomes circular, even and smooth all around. Then at any point of the upper part, affix a crown (*kirīṭa*) with an aperture in it. Pass a plumb line through the aperture. By dropping the plumb line, draw a vertical line on the rim (*pāli*) of the ring. Also an east-west (horizontal) line. Then each quarter of the rim should be should be graduated in 90 degrees. Thus there will be 360 degrees on the rim of the instrument.
>
> 'Then on both sides of the crown, at any distance from it, draw the line of horizon, keeping, however, in mind that the distance from one horizon to the other should be slightly less than four times the maximum altitude [of the sun] at midday at that place. Then one horizon should be marked as southern *gola* and the other northern.
>
> 'Along the inner [concave] surface of the instrument, draw as many circum-parallel lines as the groups into which one wishes to classify the day-lengths (*abhīṣṭa-dinakhaṇḍa-saṃkhyāka*). Below the northern horizon, mark the southern half-days (*yāmya-dyudala*). Below the southern horizon, mark the half-days belonging to the northern *gola.* Calculate the degrees of altitude corresponding to each *ghaṭikā* after the sunrise (*uannata-ghaṭikā*), take double the degrees and mark these as 1, 2, etc., for each half-day in the corresponding circle. These then will be the marks of the desired *ghaṭikās* in the instrument.
>
> 'Next make an aperture in the line of horizon. Write down the name 'northern *gola*' both inside and outside above the half-days of the southern *gola,* near the aperture. Likewise write down the name 'southern *gola*' both inside and outside the northern *gola.*

[1427] Sarma 1986-87b, pp. 27-28 (text), 79-82 (translation), 105-114 (tables).

> ‘Hold the thread of the crown in the hand and so manipulate it so that, in whichever *gola* the sun is situated, the aperture belonging to that *gola* faces the sun. When this is done, the point where the sunlight, passing through the aperture, falls on the corresponding half-day circle indicates the time in *ghaṭikās* from the sunrise. Thus [ends] the construction of the ring/bracelet (*valaya*) instrument.’

Extant Specimens

Compared to horizontal and vertical sundials, the ring is more difficult to construct and also more difficult to use. It is probably for this reason, very few specimens are extant; in fact there exist just three. Two of these are preserved in Jai Singh’s observatory at Jaipur. These must have been made for Jai Singh himself in the first quarter of the eighteenth century at Jaipur. The third one, of an inferior make, is with the Museum of Indology at Jaipur.

O001⊙ CŪḌĀ-YANTRA, NOT SIGNED, NOT DATED

Early 18th century

Diameter 129 mm, height 88 mm

Jaipur, Jai Singh's Observatory



Figure O001.1 – Cūḍā-yantra (photo by S. R. Sarma)

This specimen appears to have been made for Jai Singh in the early eighteenth century. A square copper plaque is attached to it with a thin brass chain; on the plaque is engraved *cūḍā-yantra dinajñān ko* (*Cūḍā-yantra* for knowing the time of the day).

There are nine apertures in the breadth, with corresponding *ghaṭī* scales engraved on the inner surface. At the top of each scale is written the maximum duration of the daylight in *ghaṭīs* in a particular period, from 34 to 26 (see Figure O001.2). The columns show the *ghaṭīs* in a half-day, i.e. from sunrise to midday or from midday to sunset. In the first column the numbers are from 1 to 17, which means that the duration of the day is 34 *ghaṭīs*, or 13 hrs. 36 m. This is the duration of the longest day when the sun is at the first point of Cancer. The ninth and last column has numbers 1 to 13, implying that the shortest day, when the sun is at the first point of Capricorn, comprises 26 *ghaṭīs* or 10 hrs. 24 m.

A little away from the row of apertures is a single hole in the middle of the breadth, for a string to suspend the instrument vertically. (In the two figures, a white thread can be seen passing through this hole).



Figure O001.2 – Cūḍā-yantra, ghaṭī scales on the inner surface
(photo by S. R. Sarma)

On the outer surface of the ring is engraved a large table, probably of solar longitudes, in 17 columns and 13 rows, covering more than half of the surface area. The first column refers to signs, commencing with Aries (12) and the first row to *ghaṭīs* in a half day.

Table O001-1 Table engraved on the outer surface of the ring dial

↓ signs		→ *ghaṭīs* elapsed since sunrise (forenoon) / to elapse up to sunset (afternoon)														
:.:	:.:	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
12	00 00	00 07	00 14	22	00 29	36	00 44	51	58	01 06	01 13	01 20	01 28	01 35	01 42	01 50
1	03 41	03 49	03 57		04 14	04 22	04 28	04 9	16 7	04 58	05 24	05 12	05 27	05 29	05 38	05 46
2	07 54	08 04	08 14	08 24	08 34	08 44	08 54	09 04	09 15	09 25	09 35	09 45	09 55	10 05	10 15	10 25
3	12 58	13 09	13 21	13 23	13 44	13 55	14 06	14 10	14 29	14 40	14 51	15 03	15 14	15 26	15 32	15 48
4	18 90	18 51	18 2	19 14	19 26	19 37	19 49	20 00	20 12	20 13	20 35	20 48	20 58	21 8	21 21	21 32
5	24 25	23	24 41	25 58	25 09	25 20	25 32	25 43	25 24	26 5	25 18	26 20	26 28	25 50	27 01	27 12
6	30 00	30 11	3 22	0 22	30 44	30 55	31 7	31 18	35 28	31 40	31 52	32 3	32 14	31 25	32 5	32 48
7	25 35	25	35 58	35 9	36 21	36 32	36 44	36 55	37 07	37 18	37 30	37 45	37 53	38 04	38 16	38 21
8	41 20	41 30	41 42	41 51	42 05	42 12	42 28	42 39	42 51	43 02	43 13	43 25	43 26	43 47	43 59	44 10
9	41 2	41 12	47 22	41 32	50 42	4 52	48 03	48 13	48 23	48 3	48 43	48 54	49 04	48 14	49 24	49 34
10	52 6	2 14	52 22	52 31	52 39	52 47	52 56	53 05	53 13	53 21	53 39	53 38	53 47	53 5	54 03	54 12
11	56 19	56 26	56 33	5 4	56 68	56 55	57 03	57 10	57 17	57 15	57 ..	57 38	57 47	57 54	58 01	54 08
	→ longitudes of the sun ?															

BIBLIOGRAPHY

Garrett & Guleri 1902, p. 65.

O002⊙ CŪḌĀ-YANTRA, NOT SIGNED, NOT DATED

Early 18th century

Diameter 101 mm, height 49 mm

Jaipur, Jai Singh's Observatory



Figure O002.1 – Cūḍā-yantra (photo by S. R. Sarma)

This specimen is made exactly as prescribed in the *Yantraprakāra.* At the top of the ring, there is a crown-like projection with a small hole at its tip. The ring can be suspended by a string passing through the hole. On either side of the crown are the apertures to let the sunlight through; three in a row on each side. Above the holes on the left is engraved *dakṣiṇa-gole* ‖ (in the southern hemisphere) and above the holes on the right *uttara-gole* ‖ (in the northern hemisphere), indicating that when the sun in the southern hemisphere, his light falls through the apertures on the left and, when the sun is in the northern hemisphere, his light passes through the apertures on the right.

The upper edge of the ring is marked with a degree scale, with groups of 6° prominently marked.

Several *ghaṭī* scales are engraved on the inner surface. Under the row of holes labelled *uttara-gole,* there are ten columns of scales; at the top of scales are engraved what appear to be the half-durations of daylight in *ghaṭīs* and *palas*. These values are 12 [*ghaṭīs*];42 [*palas*] - 12;45,2 - 12;52,2 - 13;4 - 13;20 - 13;37 - 13;56 - 14;17 - 14;38 - 15;14.

Under the row of holes labelled *dakṣiṇa-gole,* there are nine columns of scales; the half durations engraved at the top of the columns are 15;22 - 15;43 - 16;4 - 16;13 - 16;40 - 16;58 - 17;8 - 17;15 - 17;17.

O003⊙ CŪḌĀ-YANTRA, NOT SIGNED, NOT DATED

19th century

Diameter 73 mm, height 16 mm

Jaipur, Museum of Indology



Figure O003.1 – Cūḍā-yantra (photo by S. R. Sarma)

There is a hole at the apex within a circular depression, probably for some arrangement for suspending the ring. Off the centre is another hole through which the sun's rays fall on the dial. The dial engraved on the inner surface consists of three bands. In the two outer bands there are 15 divisions each but labelled in contrary directions. That is to say, in the upper band, the divisions are marked from 1 to 15 in the left to right direction. In the lowermost band these divisions run from right to left. These must be *ghaṭīs* in half-a-day. In the middle band are 90 divisions; these represent 1/6th parts of the *ghaṭī*, i.e., 10 *palas*.

P. SANSKRIT COLUMN DIALS

INTRODUCTION

The column dial, also known as cylindrical sundial, consists of a straight wooden staff with a circular or prismatic cross-section; it is divided lengthwise into several columns or facets, each carrying a separate scale of *ghaṭīs* for measuring time in a particular season or solar month. The *ghaṭīs* are numbered serially from the top to the bottom according to the length of the half-day from sunrise to noon or noon-sunset in that particular season. In the upper part, just above the scale, there is a hole in each facet into which a horizontal gnomon is inserted which throws its shadow upon the scale below when the staff is set up vertically, either by suspending it or by pushing the lower end firmly in the ground. Suspension is preferable because then the staff will automatically assume a vertical position; when it is pushed into the ground, a plumb line becomes necessary to see that the staff is really in a vertical position.

For measuring time, the horizontal gnomon is inserted into the hole above the scale meant for the current solar month and the staff turned slowly towards the sun so that the gnomon throws its shadow exactly on the scale below.[1428] Where the end of the shadow touches the numbered scale, the number indicates in the forenoon the *ghaṭīs* that have elapsed since the sunrise, and in the afternoon, the number of *ghaṭīs* that are to elapse up to the sunset. Thus, if the shadow shows 5 on the scale of 13 in the afternoon, it means there are still 5 *ghaṭīs* left till sunset. To know how much time has elapsed since sunrise, 5 should be subtracted from the total length of the day. In a scale of 13 *ghaṭī,* the total length of the day will be twice 13, i.e., 26 *ghaṭīs*. Therefore, when the shadow indicates that there are still 5 *ghaṭīs* to go until sunrise on a day of 26 *ghaṭīs,* it means that (26 – 5 =) 21 *ghaṭīs* have elapsed since sunrise on that day.

The column dial is represented in India by several specimens, but its history in India is the most tangled one. In Sanskrit, it is called *Cābuka-yantra, Kaśā-yantra* or *Pratoda-yantra*. Of these names, *Cābuka* is a loan-word from Persian and denotes a

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[1428] It is important that the horizontal gnomon should be of a fixed length. When the length is changed, the dial is no more valid for the latitude for which it was prepared; cf. Winter 1964, p. 381.

horse-whip; the Sanskrit terms *Kaśā* and *Pratoda* have the same connotation and are clearly Sanskrit renderings of the Persian *Chābuk.* This fact suggests that the instrument was borrowed from the Islamic world, but the specimens in the Islamic world and those in India have hardly anything in common except the horizontal gnomon.

In certain museums in the UK, the specimens are labelled as 'Ashadar stick' or 'Tibetan Priest's Time-stick'; both these designations are based on questionable sources.

In the following pages, an attempt will be made to disentangle these strands by separating facts from uncritical assumptions. We begin with Sanskrit sources; these have been studied most thoroughly by Yukio Ôhashi in his paper entitled 'The Cylindrical Sundial in India,' which contains the relevant Sanskrit texts, critically edited from unpublished manuscripts, translated and commented by him.[1429]

1. Sanskrit Sources on the Column Dial

The column dial is mentioned in the following Sanskrit texts: (i) Rāmacandra Vājapeyin's *Yantra-prakāśa,* 1428, 1 verse; (ii) Hema's *Kaśā-yantra,* second half of the fifteenth century, 52 verses, (iii) Gaṇeśa Daivajña's *Pratoda-yantra,* sixteenth century, 13 verses; (iv) Nityānanda's *Siddhānta-rāja,* 1639, 2 verses; (v) Munīśvara's *Siddhānta-sārvabhauma,* 1646, 8 verses; (v) *Vṛddha-vasiṣṭha-siddhānta* of unknown authorship and unknown period, 2 verses. The treatment of the column dial in Rāmacandra Vājapeyin's *Yantra-prakāśa* and Nityānanda's *Siddhānta-rāja* is too brief to give a coherent idea of the instrument. The *Vṛddha-vasiṣṭha-siddhānta* devouts two verses to this instrument and repeats what is already known from the other texts. [1430]

1429 Ôhashi 1998.

1430 Ôhashi 1998, pp. S 198-200; Ôhashi would like to think that this *Vṛddha-vasiṣṭha-siddhānta* was composed before the contact with the Islamic knowledge systems; but there is no firm evidence for this; the first verse in this text describes the instrument briefly and the second verse provides the formula: 'The R-sine of the [sun's] altitude is multiplied by 12, and divided by the R-sine of the zenith distance. The result is [the length] of the shadow in reverse in terms of *aṅgulas.*' This formula occurs also in Hema (verse 24), Gaṇeśa (verse 8) and Munīśvara (verse 6).

1.1. The *Kaśā-yantra* of Hema

The *Kaśā-yantra* of Hema, composed in the second half of the fifteenth century in 52 verses, is the only complete treatment of the column dial.[1431] Hema lays down that the instrument be made of metal or of the timber of the *Śiṃśapa* tree (commonly known as Shisham, *Dalbergia Latifolia* Roxb.), that the gnomon of the instrument (*śaṅku*) must be 12 *aṅgulas* long and the staff (*yaṣṭhi*) should be twenty-two times the length of the gnomon, and that the staff be endowed with seven columns or facets that run lengthwise (*saptāsraka*). At the top is tied a silk thread for suspending the instrument in a vertical position.

Three of the columns are to be marked with scales for the solar months when the sun is in the northern hemisphere and three for the months when the sun is in the southern hemisphere. On this Ôhashi remarks as follows: 'Since the sun's declination ia symmetrical before and after the solstice, one column can be used in two corresponding solar months except for the solstitial month. So, three column are used for five solar months.' But then, there would remain just one column for the month of winter solstice and for the month of summer solstice. Hema does not say how to arrange the scales foe two month, nor does Ôhashi make a comment on this. Presumably, these have to be accommodated by dividing the seventh column vertically in two halves. Then why not have eight complete columns, as is done in several of the extant specimens (P008 to P022)?

On these columns *ghaṭī* scales are marked according to the length of the reverse shadows (*utkramacchāyā*). Above the scales, holes are bored for inserting the gnomon. Below the hole are written the length of the day in terms of *ghaṭīs* in that particular month. When the sun is in the east, i.e., in the forenoon, the dial shows the *ghaṭīs* elapsed since sunrise; in the afternoon it shows the *ghaṭīs* to elapse up to sunset.

Hema teaches how to calculate the reverse shadow from the length of the day as taught by Padmanābha in his manual on the southern astrolabe (verses 21-26) and how to calculate the R-sine (*trijyā*) at intervals of 6 (27-34).

[1431] Ôhashi 1998, pp. S 149-174: complete text based on a single manuscript, translation and commentary.

Interestingly Hema envisages the use of this sundial for telling time at night also, on the basis of oblique ascensions when one of the 27 *nakṣatras* (lunar mansions) is on the meridian. Thus he states (37-38):

> 'With this instrument of seven columns, the time can easily be known at night from [the star] on the meridian and from the degree of *lagna* that have been told in the verses. A small slit should be made above the cavity, through which the object on the meridian is observed. Then with the top of this instrument, the star on the meridian should be observed following the instruction of the preceptor.'[1432]

For this purpose, Hema provides oblique ascensions of all the 27 *nakṣatras* (34-35). This is followed by the enumeration of the right ascensional differences of *nakṣatras* in terms of *palas* (*antara-palāni*) (39-41) and the calculation of solar longitude from the time measured on the *Kaśā-yantra* (42-47).

The notion of using the column dial for telling time at night is no doubt ingenious, but it does not seem to be quite practical. The position of the hole at the top to view the star is not clearly defined, but wherever the hole is at the top of the staff, suspending the large staff by a silk thread with one hand and viewing the star through a hole would not have been an easy task. No other writer recommends this procedure.

1.2. The *Pratoda-yantra* of Gaṇeśa Daivajña

Gaṇeśa Daivajña's work consists of 13 verses.[1433] He recommends that the shaft should have 16 vertical columns (*paṭṭikā, paṭṭī*), three of which are marked with the degrees of altitude (*unnata-bhāga*) , shadows of the vertical gnomon (*śaṅkucchāyā*) and a man's shadow in feet (*caraṇacchāyā*), but does not elaborate how these are to be marked. No extant specimen carries this feature. The other thirteen columns carry *ghaṭī* scales; Ôhashi is of the view that these are adequate to mark *ghaṭī* scales for each half-solar month from the winter solstice to the summer solstice.

[1432] Ôhashi 1998, pp. S 155, 167-168.

[1433] Ôhashi 1998, pp. S 174-186, containing a critical edition of the text on the basis of 8 manuscripts, an English translation and commentary.

The work contains rules for calculating the sun's altitude from the time measured on the column dial; for calculating from the solar altitude the length of the shadow on the instrument as well as the length of a man's shadow in terms of feet; for calculating the shadow lengths of the vertical gnomon from the shadow lengths of the horizontal gnomon and so on.

1.3. Pratoda-yantra in the *Siddhānta-sārvabhauma* of Munīśvara[1434]

In the *Yantrādhyāya* chapter of his *Siddhānta-sārvabhauma* of 1646, Munīśvara describes the column dial in eight verses. He begins by saying that he is offering a summary of what Gaṇeśa said about an instrument with which time can be measured without much effort (*gaṇeśoditaṃ yantram etat pratodam anāyāsa-kālāvabodhaṃ pravacmi*).[1435] But his design for the instrument is different from that of Gaṇeśa and is quite pragmatic. He says that the instrument should have as many sides as there are *ghaṭīs* in the difference between the longest day and the shortest day at a given latitude. This addresses quite well the requirements for the north Indian localities. The difference in northern India is generally about eight *ghaṭīs* and therefore the column dials usually have eight *ghaṭī* scales.

In the monthly general meeting of the Asiatic Society of Bengal, held on 7 November 1860 at Calcutta, a *Pratoda-yantra* made by Lehna Singh Majithia (P023) was the main subject of discussion. [1436] In this connection, Pandit Bapu Deva Sastri communicated an 'extract from an old Hindoo work astronomy'. This communication was in fact a literal translation of the first seven verses of Munīśvara's description. Because this translation has not been noticed in literature and because of its historical importance, it is reproduced below in full:

> '1. I am explaining the instrument called *Pratoda* (a goad) invented by Ganesa, by which the hour of the day can be easily known. Take a straight stick of moderate thickness of the tree called Dalbergia Sisu, of any length.

1434 Ôhashi 1998, pp. S 188-192.

1435 There are some manuscripts containing just these eight verses, sometimes with a commentary. Some modern scholars thought erroneously that this the work was composed by Gaṇeśa; thus Sharma 1982.

1436 *Journal of the Asiatic Society of Bengal,* 23 (1860) 424-427.

‘2. Make it in the form of a right prism whose ends should be regular polygons having as many angles as the number of *ghatikas* contained in the excess of the longest day above the shortest (at the given place) ; and for the convenience of holding it join a chain (or a string) at the top ; (and mark the number of *ghatikas* from that of the *ghatikas* of the shortest day to that of those of the longest on the upper parts of the sides of the prism successively.)

‘3. Below its support, in order to place a gnomon, make holes in each side of the prism at the beginning of its length in such a manner that they may not touch each other in the middle (of the prism).

‘4. In order the conceal the gnomon (in this instrument) make *another* hole near the support (of the prism) at its top in the middle. Let the length of the gnomon be such as after placing it in the hole (made in each side) the length of its external part be nearly equal to the sixth part (of the length of the prism).

‘5. A twelfth part of the length of the external portion of the gnomon should be considered an *Angula* (a digit) in this *Pratoda* instrument. And find the sines of the (sun’s) zenith distance and altitude at the end of each of the given *ghatikas* (from the sun-rise of every day, the number of the length of which is marked on the instrument) by the rule mentioned by the former astronomers.

‘6. The sine of the (sun’s) altitude (found at the end of the given *ghatikas* from sun-rise) multiplied by 12 divided by the sine of the zenith distance (of the sun found at the same time) gives the number of digits belonging to the given *ghatikās.*

‘This find the digits belonging to the given *ghatikas* one, two, &c., from sun-rise (of every day, the length of which is marked on the instrument) and mark these digits on the respective (sides of the prism) from the hole.

‘7. (When you want to know the time after sun-rise at the given day) place the gnomon in the hole of that side (of the prism) on which the number of the *ghatikas* contained in the length of the given day are marked, and hang the instrument by holding it in the chain in such a manner that the shadow of the gnomon falls on the side. And reckon the *ghatikas* (on the side) from the

hole to the end of the shadow. These *ghatikas* are after sun-rise (when you observe the shadow) before noon, (but when you observe it) after noon they are the *ghatikas* remaining (to complete the whole day.) (This holds then when the end of the shadow falls exactly on the mark of the *ghatikas*) but when it falls between two marks, there will be required a proportion.'

1.4. King and the Column Dial

Perhaps to justify the allusion to the horse-whip in the name of the instrument, the Sanskrit texts emphasize that this instrument is particularly suitable for the king to know time while riding a horse. Thus Hema declares:[1437] 'The king, […] astride a horse, swift like the wind, can find all on his own, and with much interest, [the time in] *nāḍikās* and their fractions, by holding in his hands this skillfully designed instrument (*catura-racita-yantra*) named *Kaṣā,* made of metal or of wood.'

Gaṇeśa also speaks in the same vein at the beginning and end of his small tract:[1438]

> 'I shall describe the *pratoda-yantra,* which amazes the kings and pleases the best of astronomers. Even if a man is riding a horse, he can obtain the full knowledge of the time, the gnomon-shadow and so on, merely by holding [this instrument in his hands]. Therefore, this cleverly designed [instrument] (*yuktyā yukta*) should always be carried by the members of the king's entourage, by mature astronomers, and even by wise kings, [as if] for controlling [the horse].'

[1437] Hema, *Kaśā-yantra,* verse 19; cf. Ôhashi 1998, p. S 152:
pavana-java-turaṅgādhiṣṭhito bhūmipālaḥ
kalayanti kutukād vāpy ātmanā nāḍikādyam |
kara-vidhṛta-kaṣākhye dhātuje dāruje vā
catura-racita-yantre mālinī-vṛtta-vettā ‖

[1438] Gaṇeśa, *Pratoda-yantra,* verses 1 *cd* -2; cf. Ôhashi 1998, p. S 178:
pratoda-yantraṃ gaṇakāgra-tuṣṭyai
vakṣye camatkārakaraṃ nṛpāṇām ‖
hayādyārūḍhenāpi ca vidhṛtamātre 'tra sa nare
ghaṭī-śaṅkucchāyādika-sakala-bodhaḥ prabhavti |
ato yuktyā yuktaṃ nṛpa-sahacraiḥ pauḍha-gaṇakaiḥ
sadā dhāryaṃ bhūpair api sumatibhis tarjanavaśāt ‖

Again at the end of the work he repeats that this instrument produces amazement in the kings (*camatkṛti-karaṃ bhūpādikānāṃ*).[1439]

This is indeed very strange and very intriguing. It is not clear why this simple device should produce amazement in kings; such a statement is not made in connection with any other instrument. Moreover, even if the king had a great urge to know the precise time, it would be impossible while riding a swift horse to suspend the staff in a vertical position and to read the time from the shadow length.

1.5. Column Dial in the Islamic world

It has been mentioned that the names *Cābuka, Kaśā and Pratoda* suggest that the instrument was borrowed from the Islamic world.

One of the earliest column dials in the Islamic world is a Syrian sundial made for Sulṭān Nūr al-Dīn who ruled Aleppo from 1146-1173; it was made by Abu'l Farāz ᶜĪsā, in 554 AH (AD 1159-60) for determining the hours at the latitude of 36°, which is the latitude of Aleppo, and also at the latitude 33°, the latitude of Damascus.[1440] It has twelve columns and the hours on these are divided by continuous curves.[1441]

In the thirteenth century, Abu'l Ḥasan ᶜAlī, generally known as al-Marrākusī, composed a treatise *Jamiᶜ al-mabādi' wa-l-ghāyāt fi ᶜilm al-mīqāt* (Comprehensive Collection of the Principles and Objectives in the Science of Timekeeping), where he discusses the column dial among several other types of sundials. He too envisages that the staff be divided into twelve columns, one for each of the zodiac signs, and that the hours in these columns are divided by continuous curves.[1442]

But neither source contains any reference to a horse-whip which is called *sawṭ* in Arabic. A faint trace is found in an Arabic manuscript of unidentified authorship which speaks of the 'construction of the *mukḥula* for the hours (*sc.,* as a sundial), which is suitable for the column, the whip (*sawṭ*) and the stick.' [1443] The passage that follows

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1439 Gaṇeśa, verse 13; cf. Ôhashi 1998, p. S 182.

1440 Cf. Casanova 1923.

1441 See the illustrations in Casanova 1923, Pl. XLV.

1442 Sédillot 1834, vol. 2, book 2, chapter 3, pp. 433-437; plate 71; the plate is reproduced in Ôhashi 1998, p. S 196.

1443 Charette & Schmidl 2004, p. 159.

describes a portable vertical sundial which has the shape of a conical container for collyrium, and makes no other reference to the horsewhip.

But it is possible that there may be other so-far unexplored Arabic sources where the column dial is associated with the horse-whip. Some such source may have reached India and transmitted the notion of the horsewhip.

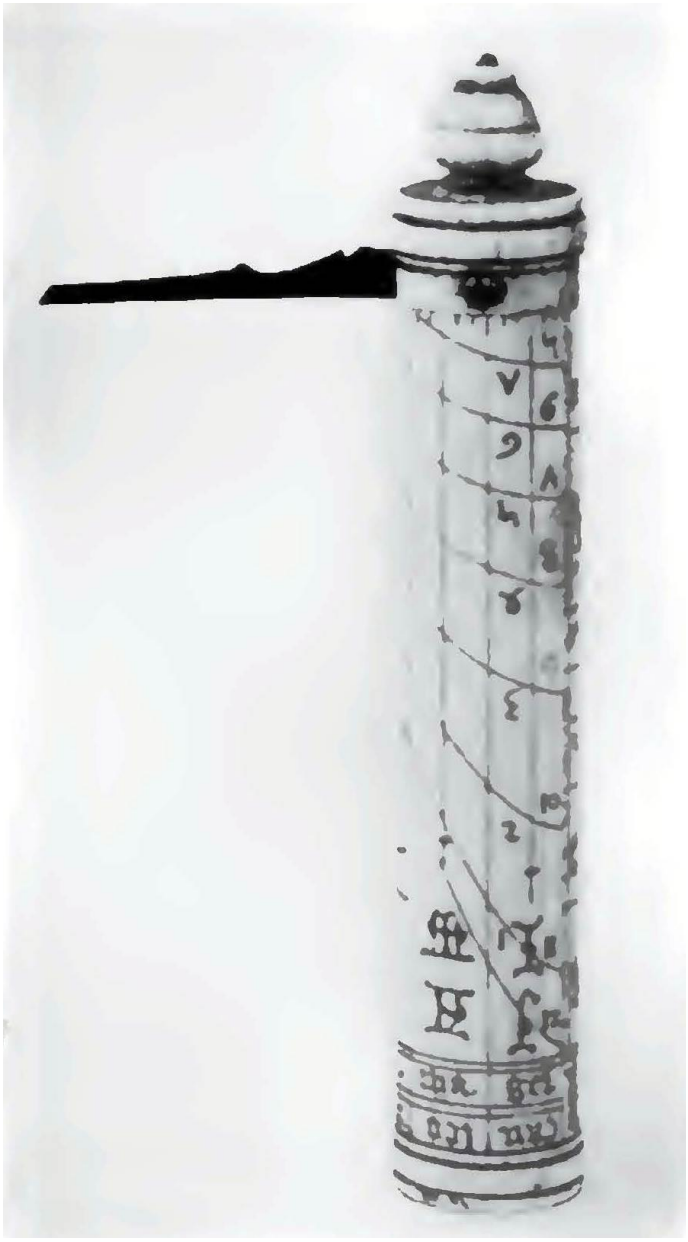


Figure P1 – Ivory Sundial dated 1455.[1444]

[1444] From Bassermann-Jordan 1922, figure 31 on p. 38.

1.6. Column Dial in Europe

The column dial is known in Europe since the eleventh century. Hermann of Reichenau, also known as Hermannus Contractus, (1013-1054) composed a small work on the column dial to be used at latitude 48° (roughly Vienna). In the subsequent centuries, several works appeared on this instrument, generally known as *horologium viatorum*.[1445]

The earliest extant specimen in Europe is made of ivory is dated 1455; it is preserved in the National Museum at Munich.[1446] Here the columns are assigned to the twelve zodiac signs and the hours in the scales are marked by continuous curves. This specimen is interesting also from another point of view. The numerals engraved on this object show close similarity to Devanagari numerals, especially 3, 4 and 5, and thus illustrate an important stage in the development of the modern international numerals (popularly, but erroneously, known as 'Arabic' numerals).

Similar sundials were used till recently by shepherds in the Pyrenees mountains between France and Spain, lying approximately on latitude 42°. Therefore, this type is also called Shepherds' Time Stick. There are several specimens of these in museums in Europe.

Of the specimens produced in the Islamic world, there do not seem to have survived many specimens; a well preserved Ottoman specimen of the eighteenth century is in the Institut du Monde Arabe at Paris.[1447]

However, both the Islamic and the European specimens are somewhat different in construction. They are much smaller, with lengths about 200 mm. The scales on their facets are divided by continuous curves which flow from one facet to another. The top with the gnomon can be rotated so that the gnomon rests on the desired month.

Compared to these, the Indian versions are much longer, ranging between 1100 to 1550 mm. The scales are separate for each month and the gnomon has to be inserted into a separate hole for each month. The scales are not divided by continuous curves;

1445 Zinner 1979, pp. 50-51.

1446 Zinner 1930.

1447 Naffrah 1989. Another column dial made for the latitude of Istanbul at 41;5° is with the Adler Planetarium, Chicago; cf. Pingree 2009, p. 222.

the divisions are marked by straight lines unconnected with those on the adjacent facet. In other words, these are cruder imitations of those produced in the Islamic world and in Europe. Obviously the theory of horizontal gnomon came from the Islamic world (we cannot identify the exact process of transmission), but the Sanskrit authors merely borrowed the name, but not the principle feature, namely the style of marking the hours on the difference scales by continuous curves.

2. Names given to Column Dials

2.1. 'Ashadar Stick'

In certain museums in the UK, the specimens are labelled as 'Ashadar stick' or 'Tibetan Priest's Time-stick'. These names have their origin in an unusual event. Of the 23 extant specimens, a large majority of 15 are made of carved wood. A carved wooden column dial was exhibited for the first time in 1898 in a horological exhibition at the Urania Palace in Berlin by a certain Professor Reuleaux. The *Deutsche Uhrmacherzeitung* reported about this exhibition and gave detailed descriptions of some exhibits in several instalments in 1898 and 1899.[1448] The carved wooden column dial was the very first instrument to be described in the issue of October 1898, because Professor Reuleaux claimed that it was about two thousand years' old. The *Horological Journal* carried the description of the wooden stick under the title 'Pilgrim's Staff with Sun-dial,' in its issue of 1899, with an exact English rendering of the account from the *Deutsche Uhrmacherzeitung* along with the two illustrations. It is necessary to quote the entire long passage, in order to clear up the various misconceptions that arose from this report. The account in the *Horological Journal* reads as follows:

> 'It was an East Indian[1449] pilgrim's staff, 160 centimeters long, and at the widest places about four centimeters thick, and so arranged that it could by means of the divisions cut into its eight lateral surfaces, perform the services of a sun-dial. In a vertical hole bored into the top end of the staff, a little stick is lodged, fitting in the cross holes closely, above the beginning of the scales.

1448 Anon 1898.

1449 The original has 'Indian'; the English version made it 'East Indian' so that the English reader may not mix it up with 'West Indian, or 'Red Indian' !

If this little rod is, as far as a certain mark, introduced into one of the holes, allowing the pilgrim's staff to hang down perpendicularly and directing the point of the small rod toward the sun, the shadow of the latter will fall on the division (see the dotted line in illustration) and thus denote the time of the day.

'The explanation given by Prof. Reuleaux, the exhibitor, regarding this highly interesting piece, is as follows:

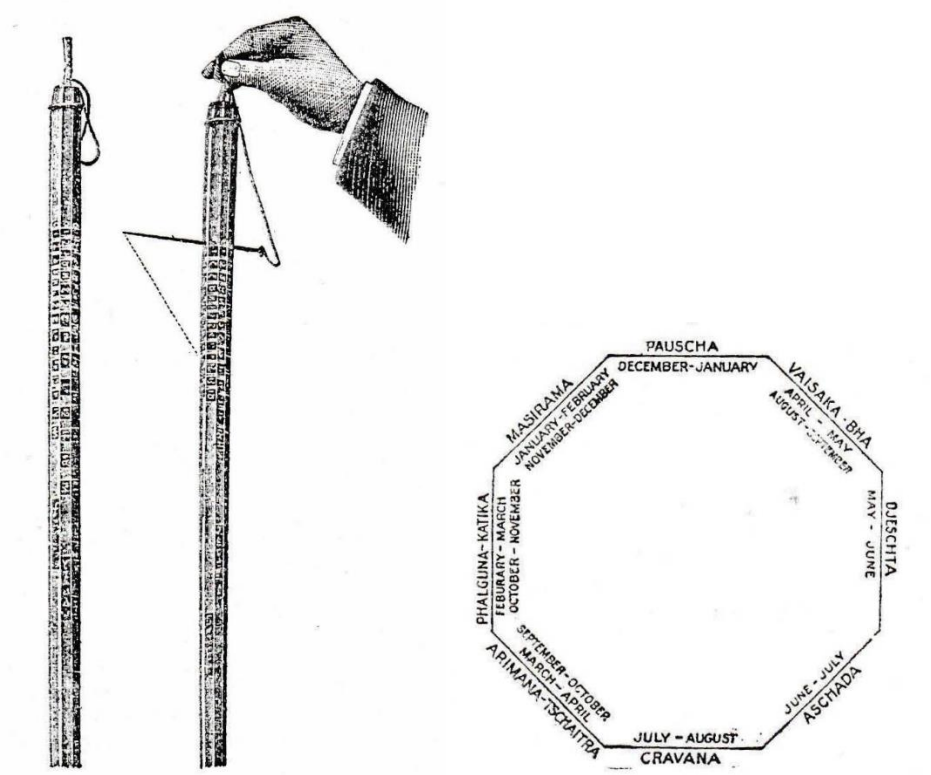


Figure P2 – The staff with the *ghaṭī* scales (left); cross-section with the Sanskrit months and their modern equivalents (right)[1450]

'The name of such a staff is Ashadah, after the month of the same name - from middle of June to middle of July - during which the pilgrimages to Benares are chiefly commenced. The staffs of the East Indian pilgrims are made from the wood of the Palaca tree; this doubtless holds good for the staff exhibited, which was purchased from a pilgrim on the road leading through the Himalayas to Benares. The shadow of the little stick when inserted in the staff (ordinarily it is carried inside the latter) shows upon the divisions

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[1450] From *The Horological Journal,* January 1899, p. 70.

carved into the surface of the staff, the number of half-hours which have elapsed since sunrise; if it in the afternoon, it indicates the number of half-hours counted till sundown.

'According to the month, or very strictly speaking, to the day on which the observation is made, a certain division must be employed. For points of time in equal distances from the solstices, the division can be the same. This has enabled the maker to have the eight surfaces of the staff suffice for the twelve months.

'It is very noteworthy that the engraved names of the months are in the language and characters of Sanscrit (with a few orthographic errors). This speaks for the great age of the article; if it were of more recent origin the Hindoostanee characters and Hindoostanee names, greatly different from the Sanscrit names, would have been used.

'In the following figure will be found, on the outside, the names engraved in the staff-surfaces, including the orthographical errors, with our corresponding English denominations inside the octagon.

'The deviation of "Arimana" instead of "Aacvinah" (wind month in the fall), wherein the name of the old-Persian evil spirit occurs (Ahriman), indicates that the old Persian-Indian influences have been expressed in the text.

'The age of this peculiar and exceedingly well preserved sun-dial is estimated about two thousand years.'

Franz Reuleaux (1829-1905) was a distinguished scholar who is said to have raised the profession of engineering to a rigorous academic discipline. He was a lecturer at the Berlin Royal Technical Academy and rose to become the President of the Academy. He was often called the father of kinematics. But a smattering of Sanskrit philology caused him to make several grave errors.

About the source of the column dial, Reuleaux merely says that it 'was purchased from a pilgrim on the road leading through the Himalayas to Benares'; he does not say whether he bought it himself in India or acquired it in Germany from a dealer in antiques. Most probably the latter must have been the case. We do not know whether the dealer told Reuleaux (i) that the time-stick was bought from a pilgrim on his way to Benares, (ii) that the stick is called *Āṣāḍha,* (iii) that *Āṣāḍha* is the month in which

pilgrimages to Benares are undertaken and (iv) that the staffs of the Indian pilgrims are made from the timber of the Palāśa tree.

This dealer may have acquired it in Darjeeling (in the Himalayas); but all others are either tales told by the dealer or assumptions made by the German professor. Assumptions iii and iv can easily be dismissed; there is no specific time as such for pilgrimages to Benares; but it is a matter of commonsense that pilgrimages covering long distances were undertaken in autumn, when the rains have ceased and the temperature is rather moderate, and certainly not in the month of *Āṣāḍha* (June-July) when summer is at its severest in the Gangetic plains.

I do not know where Reuleaux got the notion that these time sticks are made of the timber of Palāśa tree; he may have learnt from dictionaries that the Palāśa tree is also called Āṣāḍha in Sanskrit and therefore concluded that the Āṣāḍha time-sticks were made from the timber of Āṣāḍha tree, also called Palāśa. But the timber of Palāśa, commonly known as the 'Flame of the Forest' (*Butea Monosperma* Taub.), is hardly suitable for the time-sticks; Pradip Krishen says that 'the timber is not durable except under water and used for well-curbs and scoops.'[1451] On the other hand, we have seen that Hema and Gaṇeśa recommend the timber of *śiṃśupa* (Shisham, *Dalbergia Latifolia* Roxb.) for making the column dials. G. Watt remarks: 'The timber is one of the most valuable in India, is strong, very hard, close-grained, and of a purple black colour. It takes a beautiful polish, is reckoned the best furniture wood.'[1452]

Reuleaux's conclusion that instead of the month name *Āśvinaḥ* the carving on the stick reads 'Arimana' which goes back to Ahriman of old Persian is patently absurd. Because of the hardness of the wood, the carved letters look slightly different from printed or hand written letters; because of the similarity between *Āśvina* (आश्विन) and *Arimana* (अरिमन), and Reuleaux misread *Āśvina* (आश्विन) as *Arimana* (अरिमन) and jumped to the absurd conclusion that the time-stick emanates from the times of old-

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1451 Cf. Pradip Krishen, *Trees of Delhi: A Field Guide,* Dorling Kindersley, Delhi 2006, p. 201.

1452 Cf. G. Watt, *Dictionary of Economic Products of India,* 1890, vol. 3, p. 9, cited in H. Santapau, *Common Trees,* National Book Trust, New Delhi, 3rd impression, 1981, p. 33.

Persian. But even in those days of old-Persian, Ahriman never denoted or symbolized the month of *Āśvina*.

Finally, his view that 'in recent times' in the Gangetic plains 'Hindustani characters and Hindustani names, greatly differing from the Sanskrit names, would have been used' is also wrong. I suppose by Hindusthani, he means Urdu written in Persian script; but in the Gangetic plains various dialects of Hindi, with a large vocabulary of words derived from Sanskrit and written in Devanagari script prevailed in nineteenth century as also at present, side by side with Urdu.

Modern writers do not accept any more Reuleaux's notion that the time-stick is more than 2000 years' old, but follow his designation as *Āṣāḍha* stick and apply this not only to the carved wooden varieties, but also to the other kinds of column dials. Aside from Reuleaux's statement, there is no other evidence that this time-stick was ever called *Āṣāḍha*. But modern writers justify the name with the reasoning that it is called *Āṣāḍha* stick because the scale for this month is the longest. In British pronunciation, the name became 'Ashadar' and the instrument is labelled as 'Ashadar Stick' in museums in the UK.

2.2. 'Tibetan Priest's Time-Stick'

It difficult to say how this carved wooden column dial came to be associated with Tibetan pilgrims. Reuleaux himself does not state this. Somebody in the UK must have thought that the 'pilgrim on the road leading through the Himalayas to Benares' who sold the stick must be a Tibetan pilgrim.[1453] But Tibetans, being Buddhists, do not make pilgrimages to Benares, which is famous for its temple of Śiva. The Tibetan Buddhists could make a pilgrimage to Sarnath, which is close to Benares, where Buddha received enlightenment. But Sarnath was forgotten and lay in ruins for long time until archaeological excavations in the nineteenth century began to unravel its significance for the history of Buddhism; however it did not develop into a centre of Buddhist pilgrimage until the twentieth century. Even if it is assumed that the Tibetan Buddhists

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[1453] For example, in Ward 1958, II, p. 9, no. 57, a column dial at the Science Museum, London, is designated as 'Tibetan Priest's Time Stick'.

have heard of the archaeological excavations and began visiting Sarnath around 1898, why would they from their colder regions travel to Sarnath in the hottest of all seasons?

H. J. J. Winter, the noted historian of science, published a valuable study of the column dial preserved in the Gershom Parkington Collection of time-measuring instruments at Bury St. Edmunds (P009).[1454] In this study, Winter compared the numerals carved on this stick with those inlaid on the damascened steel specimen at the Museum of the History of Science at Oxford (P001) and the Tibetan numerals from J. A. Jäschke's *Tibetan Grammar* and came to the conclusion 'that whilst the Nepali figures are essentially Nāgarī, the ones on our specimen seem to exhibit in addition very slight Tibetan influence.'[1455] However, what he added in a footnote 'Or perhaps the difference could be accounted for by the fact that the carving of the figures is in hard wood,' hits the mark. They are Devanagari numerals alright, but the curves in them became somewhat straight when carved on a hard timber.

3. Extant Specimens

The extant specimens can be classified into three groups. In the first group are those which are not made of wood.

3.1. Metal or Ivory Dials from Rajasthan

There are just two specimens in this category and these two form exceptional cases. One (P001) is an exquisitely crafted steel column dial where all the lines on the scales, the numbers and decorative patterns are inlaid with gold. It is topped with an ornate finial and the other end terminates in a sharply polished blade. This must have been created for some noble man in Rajasthan.

The other one made of ivory (P002) is also of excellent workmanship, with a beautifully carved finial at the top and an ornate end at the bottom.

3.2. Painted wooden Column Dials from Rajasthan

In the second category are wooden column dials on which the scales and numbers are painted. In Jai Singh's Observatory at Jaipur, there is one with twelve columns, one

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1454 Winter 1964.

1455 Winter 1964, pp. 378-379.

for each solar month (P003). The wooden surface is given a coat of white paint on which the scales and numbers are written in black. However, much of this writing is effaced now and cannot be read anymore. But it appears that on this and the other specimens in this category, the length of the daylight in *ghaṭīs* is mentioned at the top of the scales, as is done in P001.

3.3. Carved wooden Column Dials from the Darjeeling Region

A majority of wooden column dials (from P008 to P022) belong to this type, where the numbers and letters are carved in relief. These are said to have been made in the Himalayan foothills in the region of Darjeeling (27;3 N, 88;16 E) and Kalimpong (27;3,36 N, 88;28,12 E).

The Museum of the History of Science, Oxford, has a display sheet for 0 which says: 'A staff-dial of this type is said to have been invented and made by Kalu Jaisi at Chuybu Busti, District of Kalimpong, Darjeeling, in 1898-99.' Probably the second word should read 'Josī' (astrologer / astronomer) and 'Jaisi'. The place Chuybu Busti, according to Winter, is in the Himalayan Foothills at latitude 27;5° N and altitude 3500 ft. above sea level. [1456] This Kalu Josī could not have been the inventor, nor the person who introduced the style in this region, for there exist sticks made earlier to this date, in 1869 (0) and 1884 (P013). The second one even carries the name of maker Jemaṃgala (or Jaya-maṅgala).

These column dials appear to have been for the latitude of about 27°; their length varies from 1034 mm (0) to 1541 (P020). All the extant specimens are in museums and private collections outside India. No Indian museum owns a single specimen. Apparently, these were acquired by British colonial officers in the late nineteenth or early twentieth century and brought directly to England and Europe. The column dial 0 at thePitt Rivers Museum was presented by Lady Westland; she may have acquired it at Darjeeling. Some may even have been made on order; for example, in P010 at Edinburgh, the maker left much space above each scale so that the man who ordered it could write down the names in Roman transliteration.

[1456] Winter 1964, p. 283.

These are all octagonal. On each column, instead of the maximum day-length in *ghaṭīs,* the names of the solar months are engraved; on four columns are engraved the names of two months in which the maximum day-length is the same. Usually, the distribution of the 12 solar months on the 8 facets of the column is as follows: 1. *Āṣāḍha*; 2. *Jyeṣṭha*; 3. *Pauṣa*; 4. *Śrāvaṇa*; 5. *Caitra* & *Āśvina;* 6. *Vaisākha* & *Bhādrapada*; 7. *Phālguna* & *Kārtika*; and 8. *Māgha* & *Mārgaśira*. These Sanskrit names undergo slight phonetic changes in Napali language; particularly remarkable is Sanskrit *Mārgaśira* becomes *Māṃsir* in Nepali.

On some column dials, the month names are carved at the top of the scales (P008, P010, P012, P014, P016, P019, P020) and in some others (P011, P013, P015, P018, P021, P022) they are below the scales. In P015, the boundaries between the complete *ghaṭīs* are marked by dots enclosed by small circles.

Nearly all the column dials are equipped with an iron spear-head at the bottom. This iron spear-head has to be dug into in the ground so that the column stands upright and the scale for the current month faces the sun. A plumb line is needed to ensure that the staff is in vertical position, which is not necessary when the staff is suspended by means of a rope or chain.

Finally, the last specimen of the column dials (P023) was produced by Lehna Singh Majthia, a general in the army of the Sikh ruler Maharaja Ranjit Singh. Lehna Singh is said to have combined the column dial with a gun, but further details are lacking.

4. Correct Designation of the Column Dial

In the light of the above discussion, the correct designation of this time-measuring device should be ‘Indian Column Dial’ or ‘Indian Cylindrical Sundial’; it can also be called ‘Sanskrit Column Dial’ or ‘Sanskrit Cylindrical Sundial’. Although ‘Ashadar’ has some justification, the manner in which it is spelt may not immediately suggest the solar month ‘*Āṣāḍha*’ when the days reach the maximum length and consequently that *ghaṭī* scale pertaining to this month is the longest.

This device is latitude-specific and can be used only at the latitude for which it is designed. There is no question of pilgrims using it as a walking stick and time-measurer in their long journeys which cross many latitudes. Therefore, any association with pilgrims, whether Tibetan or otherwise, is unwarranted.

As for the place of manufacture, the carved dials were produced in the Darjeeling region in the Himalayan foothills. The main population in this region are of Nepali origin and speak Nepali language, but the region itself is in India, and not in the Kingdom of Nepal. I have not come across any evidence that such column are used either in Nepal proper or in Tibet. Therefore the geographical attribution to either Nepal or to Tibet would not be correct. Other types of columns, made of metals or painted wood, were not produced in Darjeeling region, but in Rajasthan; therefore, they should not be confused with the carved wooden specimens.

P001 ⦿ COLUMN DIAL OF DAMASCENED STEEL, NOT SIGNED, NOT DATED

19th century ?

Length 956 mm, thickness 21 mm

Oxford, Museum of History of Science (# 50041)



Figure P001.1 – Column dial (photo by S. R. Sarma)

This octagonal steel column dial is exquisitely crafted with numbers and decorative lines inlaid in gold. At the top is a spherical finial, beautifully worked out with an elegant design with gold inlay; it contains a hollow cavity for depositing the gnomon and holes at the sides for the suspension rope to pass through. At the bottom is a very sharp and shining blade. The gnomon is missing.

At the head of each facet is mentioned the day length in *ghaṭīs* in the solar month concerned. Below it is the hole for inserting the gnomon and below that is engraved the *ghaṭī* scale for that month. The eighth facet is halved by a vertical line so that the two halves carry two scales. The numbers in each scale are separated by horizontal lines.

The Museum sheet calls this device “North-Indian or Nepali Ashadar Stick”. The metalwork and the shape the numbers show clearly that it was produced in Rajasthan and not in Nepal, or Nepal-Darjeeling region as the carved wooden sticks were.

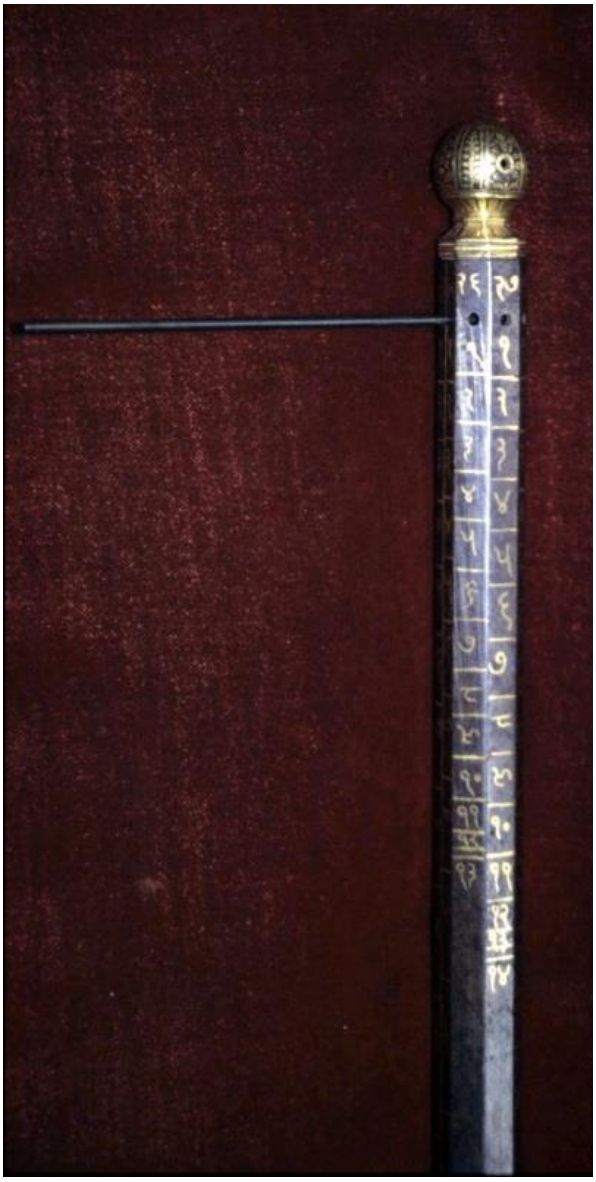


Figure P001.2 – Upper part of the column dial
(photo by S. R. Sarma)



Figure P001.3 – Blade at the lower end
(photo by S. R. Sarma)

Table P001-1 *Ghaṭī* Scales

Day Length in *ghaṭīs*	Number of *ghaṭīs* (sunrise to noon)
26	1---13
27	1---13/14
28	1---14
29	1---14/15
30	1---15
31	1---15/16
32	1---16
33	1---16/17
34	1---17

BIBLIOGRAPHY

Anderson 1982, no. 136, p. 36.

Turner 1990, no. 97, pp. 76-77

P002 ⊙ IVORY COLUMN DIAL, NOT SIGNED, NOT DATED

18th century

Length 510 mm, thickness 18 mm

PLU, ex-Rockford: Time Museum (#1299)

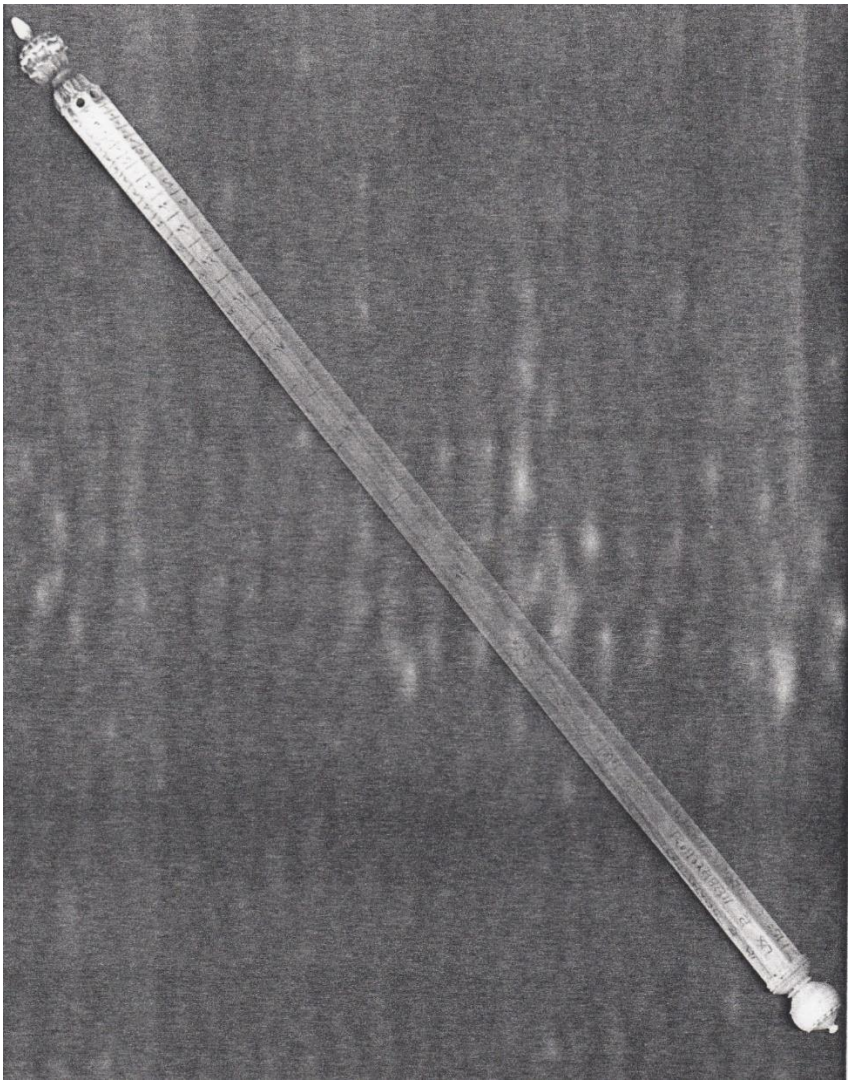


Figure P002.1 – Ivory column dial (photo courtesy Time Museum)

This is a rare ivory column dial, with decoration in red and green colours and inscriptions inlaid with gold. There is an exquisitely carved finial at the top, formed like two lotus flowers joined base to base. There is a hollow cavity in the finial for depositing the gnomon when not in use. The lower end is given an ornate spherical form; it is made separately and joined to the main body.

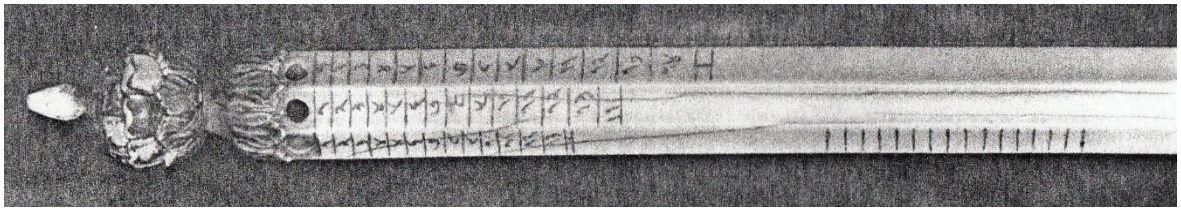


Figure P002.2 – Ivory column dial, upper part (photo courtesy Time Museum)

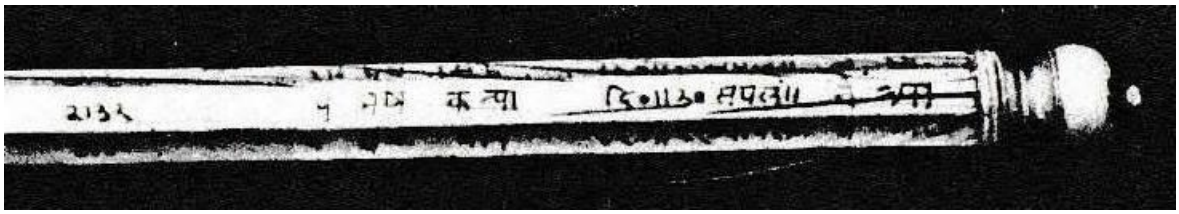


Figure P002.3 – Ivory column dial, lower part (photo courtesy Time Museum)

At the head of each column, there are holes for inserting the gnomon, followed by the *ghaṭī* scales. The *ghaṭīs* are numbered from 1 downwards. Some columns end with full *ghaṭīs.* Some others end with half-*ghaṭīs*; for example, the half-*ghaṭī* following the complete 13th *ghaṭī* is marked as '13-13'.

In the lower part of each column, there is much engraved data with abbreviated words. For instance, in the first column is written the following:

madhyachāyā 7|30 vṛścika dhana di○‖26 sapalaṃ‖ bhā pau

The first unit '*madhyachāyā 7*|30' indicates the length of the noon shadow of the gnomon of 12 digits (*aṅgula*) expressed as 7;30 digits. The second unit '*vṛścika dhana*' contains the names of two zodiac signs when the noon shadow of the gnomon has a length of 5;30 digits.

Likewise, the fourth unit '*bhā pau'* carries the names of the two solar months corresponding to the two zodiac signs in the third unit and the noon shadow length of 5;30 in the first unit. Finally '*di○‖26 sapalaṃ‖*' refers to the maximum day-length (*dina-māna*) expressed in *ghaṭīs,* corresponding to the other three units; '*sapalaṃ*' implies that this day-length is rounded up 26 *ghaṭīs,* but there are some additional some *palas,* which are not expressly mentioned.

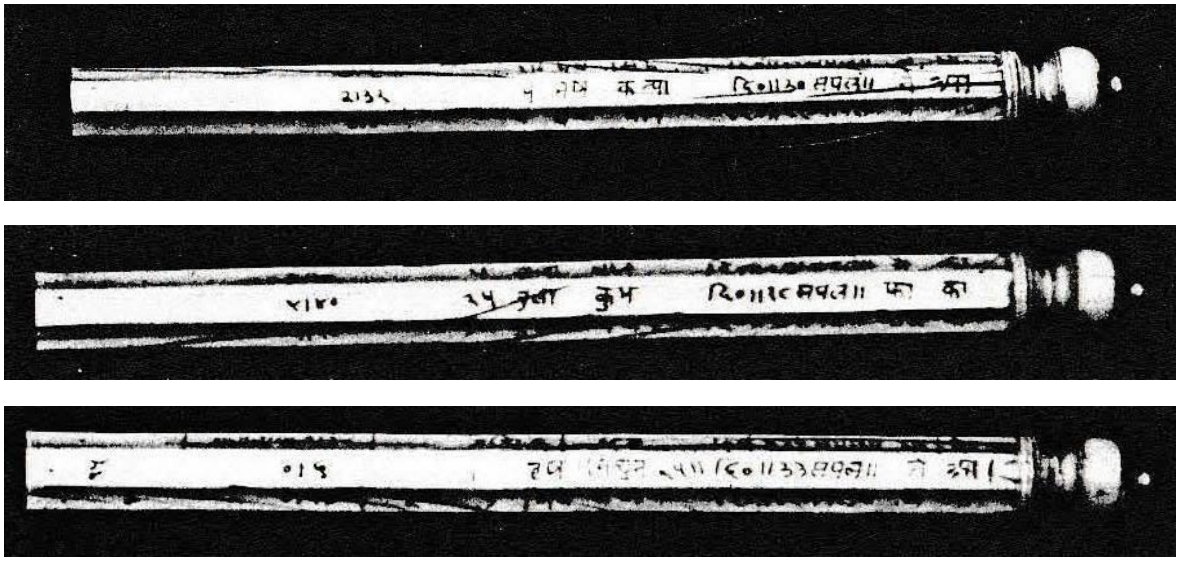


Figure P002.4 – Details of engraved data (photos courtesy Time Museum)

The data engraved on the eight columns is shown in the following table; *sapalaṃ* is represented by the + sign after the number of *ghaṭīs.*

Table P002-1 *Ghaṭī* scales, gnomon shadows, maximum day-lengths

***ghaṭī* scale**	**Shadow length at noon**	**Zodiac signs**	**Maximum day lengthin *ghaṭīs***	**Solar months**
1 - 13	7;30	Scorpio & Sagittarius	26 +	*Bhā*[*drapada*] & *Pau*[*ṣa*]
1 - 13 ½	5;50,30	Libra & Capricorn	27 +	*Māgha* & *P*[*h*]*ā*[*lguna*]
1 - 14	4;40,25	Libra & Aquarius	28 +	*Phā*[*lguna*] & *Kā*[*rtika*]
1 - 14 ½	3;40,5	Libra & Pisces	29 +	*Cai*[*tra*] & *Kā*[*rtika*]
1 - 15	2;32,5	Aries & Virgo	30 +	*Cai*[*tra*] & *Ā*[*śvina*] ?
1 - 15 ½	1;45,25	Aries & Leo	31 +	*Vai*[*śākha*] & *Bhā*[*drapada*]
1 - 16	0;43,30	Aries & Cancer	32 +	*Vai*[*śākha*] & *Śrā*[*vaṇa*]
1 - 17(?)	0;05	Taurus & Gemini	34 +	*J*[*y*]*e*[*ṣṭha*] & *Ā*[*ṣāḍha*]

***ghaṭī* scale**	**Shadow length at noon**	**Zodiac signs**	**Maximum day lengthin *ghaṭīs***	**Solar months**

This mode of pairing the signs and the solar months is quite intriguing, because in many cases the two members of the pair do not belong together. In the first row, for example, the month *Pauṣa* has the minimum day length, but not the month *Bhādrapada.* Compare this, with the tables of *ghaṭī* scales in P008, P010, P013 and so on. The day-length reaches the maximum limit when the sun is at the first point of Cancer; in the table Cancer is paired with Aries. Libra, on the other hand, is paired with three different signs.

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P003 ⊙ PAINTED WOODEN COLUMN DIAL, NOT SIGNED, NOT DATED

18th century

Length 870 mm, diameter 50 mm

Jaipur, Jai Singh's Observatory

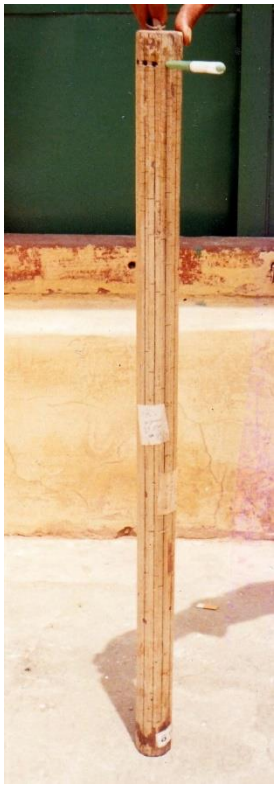


Figure P003.1 – Column dial
(photo by S. R. Sarma)

Wood painted white on which the graduations are marked in black but not numbered. The column is divided into 12 facets, each bearing a scale for a particular solar month. At the top of each facet, there is a hole for inserting the gnomon. Above each hole, there are some numbers, but these are not legible any more. These probably indicate the length of the daytime in that solar month, expressed in *ghaṭīs*. There is a ring at the top for suspension and a hallow cavity for depositing the gnomon when not in use. However, the gnomon is now missing.

This column dial may have been made during the reign of Sawai Madho Singh.

P004 ⦿ PAINTED WOODEN COLUMN DIAL, NOT SIGNED, NOT DATED

19th century

Length 620 mm

Jaipur, Shri Sanjay Sharma Museum & Research Institute

The octagonal column dial is made of reddish timber on which numbers are painted in white and varnished. At many places the varnish turned dark and it is difficult to read the numbers. At the top of each facet, there is a hole, below which is a *ghaṭī* scale. Above the holes are written the maximum number of *ghaṭīs* of day length in different months: 27, 28, 29, 30, 31, 32, 33, 34. The gnomon is missing.

P005 ⊙ PAINTED WOODEN COLUMN DIAL, NOT SIGNED, NOT DATED

19th century

Length, ca. 900

Jaipur, Shri Sanjay Sharma Museum & Research Institute

This column dial is much larger than the previous specimen (P004), with a length of about 900 mm. There is much writing on it, painted in white letters. But, unfortunately, it could not be taken out of the display case for closer examination.

P006 PAINTED WOODEN COLUMN DIAL, NOT SIGNED, NOT DATED[1457]

19th century

Length 577 mm, thickness 40 mm

Hastings-on-Hudson, NY, Tesseract

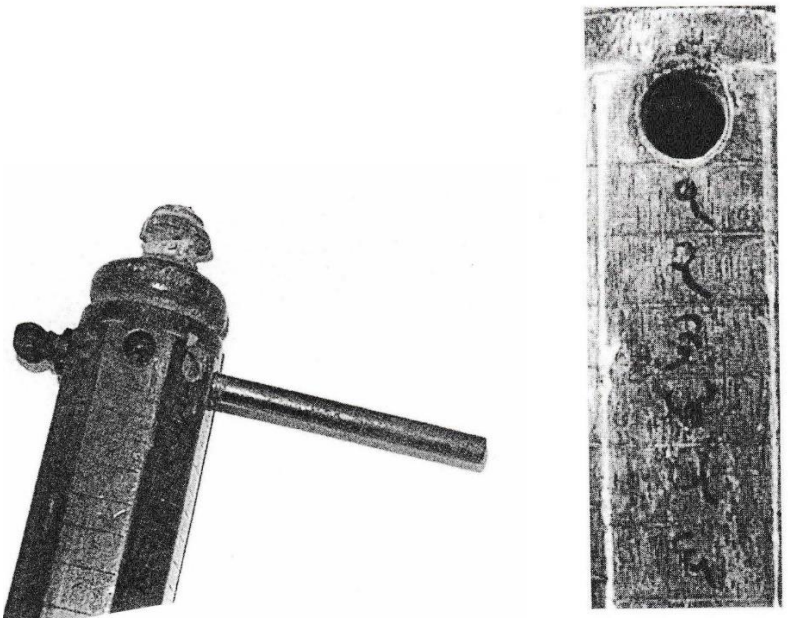


Figure P006.1 – Column dial, details (from Tesseract catalogue 75)

Octagonal staff with nicely shaped ends. It is coated with a reddish varnish on which Devanagari numerals are painted in black. There are said to be nine *ghaṭī* scales; presumably two scales are painted on one of the columns. At the top of each scale is written the maximum day-length in *ghaṭīs,* ranging from 26 to 34. There is an iron gnomon, 135 mm long, with a decorative handgrip.

PROVENANCE

Formerly in the private collection on Leonard Linton, Point Lookout, NY.

[1457] Entry based on Tesseract catalogue 75, lot 16.

P007 WOODEN COLUMN DIAL, NOT SIGNED, NOT DATED[1458]

19th century

Length 610 mm

Jodhpur, PC

This wooden column dial, designed for the latitude of Jodhpur, carries nine *ghaṭī* scales. Probably the names and numerals are written in ink or lightly incised in the wood. At the top are written the maximum number of *ghaṭīs* in the corresponding month/s, followed by month names and the *ghaṭī* scales, as shown in the following table.

Table P007-1 *Ghaṭī* Scales

Day Length in *ghaṭīs*	**Solar Month Names**	**Number of *ghaṭīs* (sunrise to noon)**
30	*Caitra Kārtika*	1 --- 15
32	*Vaiśākha Bhādrapada*	1 --- 16
33	Jyeṣṭha Śrāvaṇa	1 --- 16
34	*Āṣāḍha*	1 --- 17
31	*Āśvina*	1 --- 16
28	*Mārgaśīrṣa*	1 --- 14
27	*Māgha*	1 --- 14
27	*Pauṣa*	1 --- 13
29	*Phālguna*	1 --- 14

[1458] Entry based on Sharma 1982, pp. 12-13.

The dial is said to carry the following additional information:

Latitude: 26;18°

Maximum Declination: 23;27°

Maximum zenith distance at transit: 26;18° + 23;27° = 49;45°

Paramocca (apogee on *Āṣāḍha* = 1 July) 34 *ghaṭīs*

Paramanīca (perigee on *Pauṣa* = 31 December) 27 *ghaṭīs*

Paramakrānti uttara (maximum north declination) 21 June

Paramakrānti dakṣiṇa (maximum south declination) 21 December.

Bibliography

Sharma 1982.

P008 ⊙ CARVED WOODEN COLUMN DIAL, NOT SIGNED, NOT DATED

19th century

Length 1275 mm, thickness 30 to 31 mm

Brussels, PC



Figure P008.1 – Column dial (photo by S. R. Sarma)



Figure P008.2 – Lower part of the column dial, note the varying lengths of the *ghaṭī* scales (photo by S. R. Sarma)

Octagonal column dial made of light reddish timber. Near the upper edge, there are eight holes, one in each facet, for winding the suspension rope. Below these are carved the names of the solar months. Below the names, there are again eight holes, one on each facet, for inserting the gnomon, which is now missing. Below these holes are *ghaṭī* scales, the longest being for the month of Āṣāḍha. The column tapers towards the lower end, but there is no iron spearhead at the bottom.

Table P008-1 *Ghaṭī* Scales

Month Names	Number of *ghaṭīs* (sunrise to noon)	Maximum Shadow Length at Noon in mm
Caitra Aseja	1---16	438
Vaisāka Bhādā	1---17	480
Jyāṣṭā	1---18	545

Month Names	**Number of *ghaṭīs* (sunrise to noon)**	**Maximum Shadow Length at Noon in mm**
Āṣāḍā	1---19	616
Sāvana	1---16	436
Kātika Phāguna	1---15	234
Masira Māgha	1---14	175
Pauṣa	1---14	160

P009 CARVED WOODEN COLUMN DIAL, NOT SIGNED, NOT DATED[1459]

19th century

Length 1499 mm

Bury St. Edmunds, Suffolk, UK, John Gershom Parkington Memorial Collection

Octagonal column with an iron spearhead at the bottom and a 165 mm long wooden gnomon. The *ghaṭī* scales on the eight facets are marked for 14, 14, 15, 15, 18, 18, 17, 15 *ghaṭīs* respectively.

BIBLIOGRAPHY

Winter 1964.

[1459] Entry based on Winter 1964.

P010 ⊙ CARVED WOODEN COLUMN DIAL, NOT SIGNED, NOT DATED

19th century

Length 1360 mm

Edinburgh, Royal Scottish Museum (# 1956.97)



Figure P010.1 – Column dial (courtesy Royal Scottish Museum, Edinburgh)

This octagonal column dial of light timber was probably made on order for a Briton who added the month names in Roman script. There is a hollow cavity at the top for depositing the gnomon when not in use. Close to the upper edge holes are bored in alternate facets; the suspension rope is wound through these holes and taken out at the top through the hollow cavity. The names of the solar months are incised lightly on each facet. Above these month names in Devanagari script are written the names of the corresponding English months in ink; below the Devanagari names are added their Roman transliteration in ink.

Below these month names are the holes on each facet for inserting the gnomon, and these are followed by the *ghaṭī* scales. On the scales, the *ghaṭī* numbers are so carved that the numbers stand out in low relief. The numbers are separated by two horizontal lines. The boundaries between two complete *ghaṭīs* are indicated by small circles. At the bottom of the column is an iron spearhed by means of which the stick is dug into the ground and made to stand straight for measuring time.

Table P010-1 *Ghaṭī* Scales

English month names in ink	**Sanskrit Month names carved**	**Roman transliteration added in ink**	**Number of *ghaṭīs* (sunrise to noon)**
September & March	*Aśvina Caitra*	*Aswin Chaitra*	1---17
August & April	*Bhādra Vaisāṣa*	*Bhadra Baishak*	1---18
May	*Jyaṣṭa*	*Jyeshtha*	1---18
June	*Aṣaḍa*	*Ashadh*	1---17

English month names in ink	**Sanskrit Month names carved**	**Roman transliteration added in ink**	**Number of *ghaṭīs* (sunrise to noon)**
July	*Śrāvana*	*Sravana*	1---17
October & February	*Kātika Phāguna*	*Katik Phagun*	1---15
November & January	*Maṃsira Māgha*	*Mansir Magh*	1---14
December	*Pauṣa*	*Paush*	1---13

In the scale for *Bhādra Vaiṣāṣa,* the number 12 is missing.

P011 ⊙ CARVED WOODEN COLUMN DIAL, NOT SIGNED, NOT DATED

19th century

Length ca. 600 (the stick is broken just below the longest scale)

Edinburgh, Royal Scottish Museum (on permanent loan from the Royal Observatory)

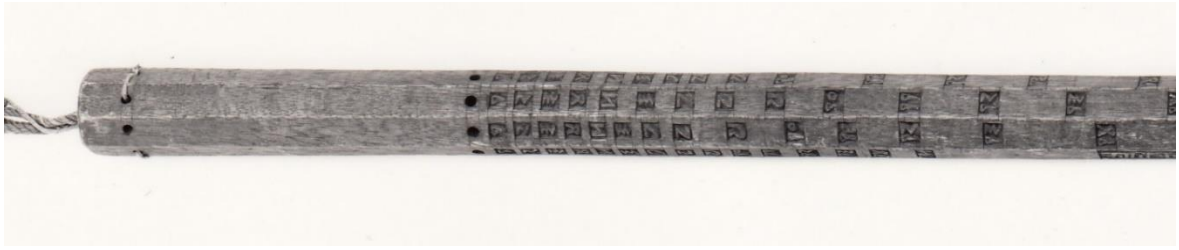


Figure P011.1 – Upper part of the column dial (courtesy Royal Scottish Museum, Edinburgh)

At the top, there is a hole through which the suspension rope issues out after being wound through holes on each facet close to the edge. Much below, there are holes in each facet for the insertion of the gnomon. Below the holes are the *ghaṭī* scales. The names of the solar months are carved below the *ghaṭī* scales.

Table P011-1 *Ghaṭī* Scales

Month name	**Number of *ghaṭīs* (sunrise to noon)**
Caitra Asoja	1---15
Vaisāka Bhādrā	1---17
Jyāsṭa	1---18
Aṣarā	1---18
Savana	1---15
Kātika Phāguna	1---15
Maṃsira Māgha	1---14
Pauṣa	1---14

P012 CARVED WOODEN COLUMN DIAL, NOT SIGNED, NOT DATED

19th century

Length 1360 mm

Hastings-on-Hudson, NY, Tesseract



Figure P012.1 – *Ghaṭī* scale on the column dial (photo courtesy Dr David Coffeen)

This octagonal column dial is incomplete. It appears that the artisan first pierced holes on all the eight facets for inserting the gnomon, carved the *ghaṭī* scales below the holes, and then began adding the month names below the scales. While doing so, he carved five pairs of names on five facets and one each on the sixth and the seventh facet. Then he realized that there was no month name left for the eight facet. Therefore, he discontinued the work. He did not create a hollow cavity at the top for depositing the gnomon, he did not bore holes near the upper edge for the suspension rope, and he did not add a metal spearhead at the bottom. He merely added iron bands on both ends.

The eight *ghaṭī* scales are numbered thus: 1 to 14; 1-14; 1-14; 1-16; 1-19; 1-18; 1-17; 1-16; 1-15. The month names engraved on the seven facets are reproduced below with correct orthography in parentheses.

1	*Kātika* (*Kārtika*)	*Ceta* (*Caitra*)
2	*Naiṣāsa* (*Vaiśākha*)	*Bhāda* (*Bhādrapada*)
3	*Sāvana* (*Śrāvaṇa*)	*Phāgana* (*Phālguṇa*)
4	*Māgha*	*Mārga* (*Mārgaśira*)
5	*Asāra* (*Āṣāḍha*)	*Asaja* (*Āśvayuja*)
6	*Jeṭha* (*Jyeṣṭha*)	
7	*Pauṣa*	
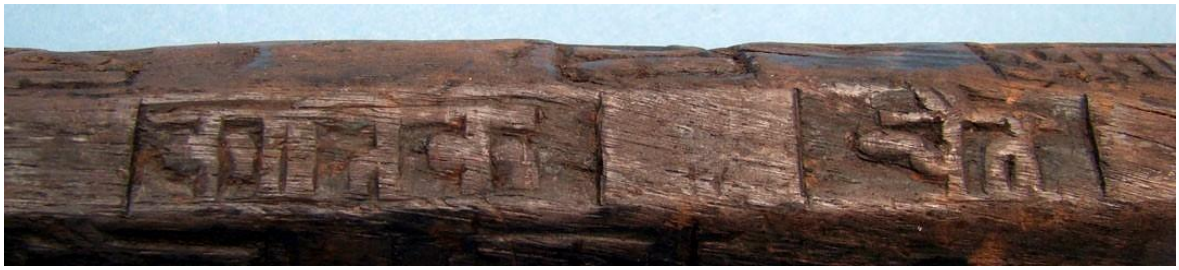


Figure P012.2 – Month names *Kātika* (*Kārtika*) & *Ceta* (*Caitra*) (photo courtesy Dr David Coffeen)
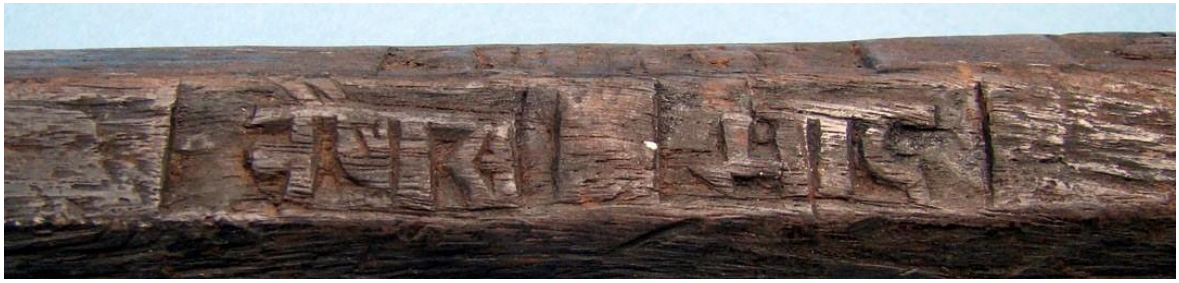


Figure P012.3 – Month names *Naiṣāsa* (*Vaiśākha*) & *Bhāda* (*Bhādrapada*) (photo courtesy Dr David Coffeen)



Figure P012.4 – *Sāvana (Śrāvaṇa)* & *Phāgana (Phālguṇa)* (photo courtesy Dr David Coffeen)



Figure P012.5 – Month names *Māgha & Mārga (Mārgaśira)* (photo courtesy Dr David Coffeen)



Figure P012.6 – Month names *Asāra* (*Āṣāḍha*) & *Asaja* (*Āśvayuja*) (photo courtesy Dr David Coffeen)



Figure P012.7 – Month name *Jeṭha (Jeṣṭha)* (photo courtesy Dr David Coffeen)



Figure P012.8 – Month name *Pauṣa* (photo courtesy Dr David Coffeen)

P013 ⊙ CARVED WOODEN COLUMN DIAL BY JEMANGALA, 1941 VS (AD 1884)

Length 1166 mm, thickness 28 mm

London, Horniman Museum (# 21.2 52/5)



Figure P013.1 – Column dial, detail with the name of the maker (photo by S. R. Sarma)



Figure P013.2 – Column dial, detail with the date of manufacture (photo by S. R. Sarma)

This is the only signed and dated specimen which is extant. It is an octagonal stick, with sharply defined edges, terminating in a simple iron spearhead. This spearhead is 130 mm long with a square cross-section. The handle at the upper end is carved with an ornamental pattern. At the top there a ring for suspension and a hollow cavity for depositing the gnomon, which is now rusted inside and became jammed, causing a crack in the handle. There is another crack below the scales and one more towards the iron spearhead.

Table P013-1 *Ghaṭī* Scales

Month Names	**Number of *ghaṭīs* (sunrise to noon)**
Aśvīna Caitra	1---15
Vaisāṣa Bhādra	1---17
Jyeṣṭa	1---17
Āṣāḍa	1---18

Month Names	**Number of *ghaṭīs* (sunrise to noon)**
Śrāvaṇa	1---17
Phāguna Kārtika	1---15
Maṃsira Māgha	1---14
Pauṣa	1---14

INSCRIPTION

The scales of *Pauṣa* and *Maṃsira-Māgha* are not of equal length. On these two scales is carved an inscription:

> *jemaṃgala dvija hasta jeṣṭi (?) liṣitama*
> *śrī samvat 1941 sāla miti pauṣa śudi 6 roja śubhama*
> 'Jemaṃgala (= Jayamaṅgala), the Brahmin (*dvija*), hand (*hasta*) was written (*liṣitama = likhitam*)
> [in] the auspicious Saṃvat year measured by 1941, in the bright half of [the month] Pauṣa, on the sixth day (*roja*). [Let it be] auspicious (*śubhama = śubham*).'

The first line may be interpreted as 'carved by the hands of Jayamaṅgala, the brahmin'. The date corresponds to Tuesday, 23 December 1884.

PROVENANCE

Gifted by the Wellcome Institute for the History of Medicine, London, on 21 February 1952.

P014 ⦿ CARVED WOODEN COLUMN DIAL, NOT SIGNED, NOT DATED

19th century

Length 1355 mm, thickness 27 mm

London, Horniman Museum (# 972.810)

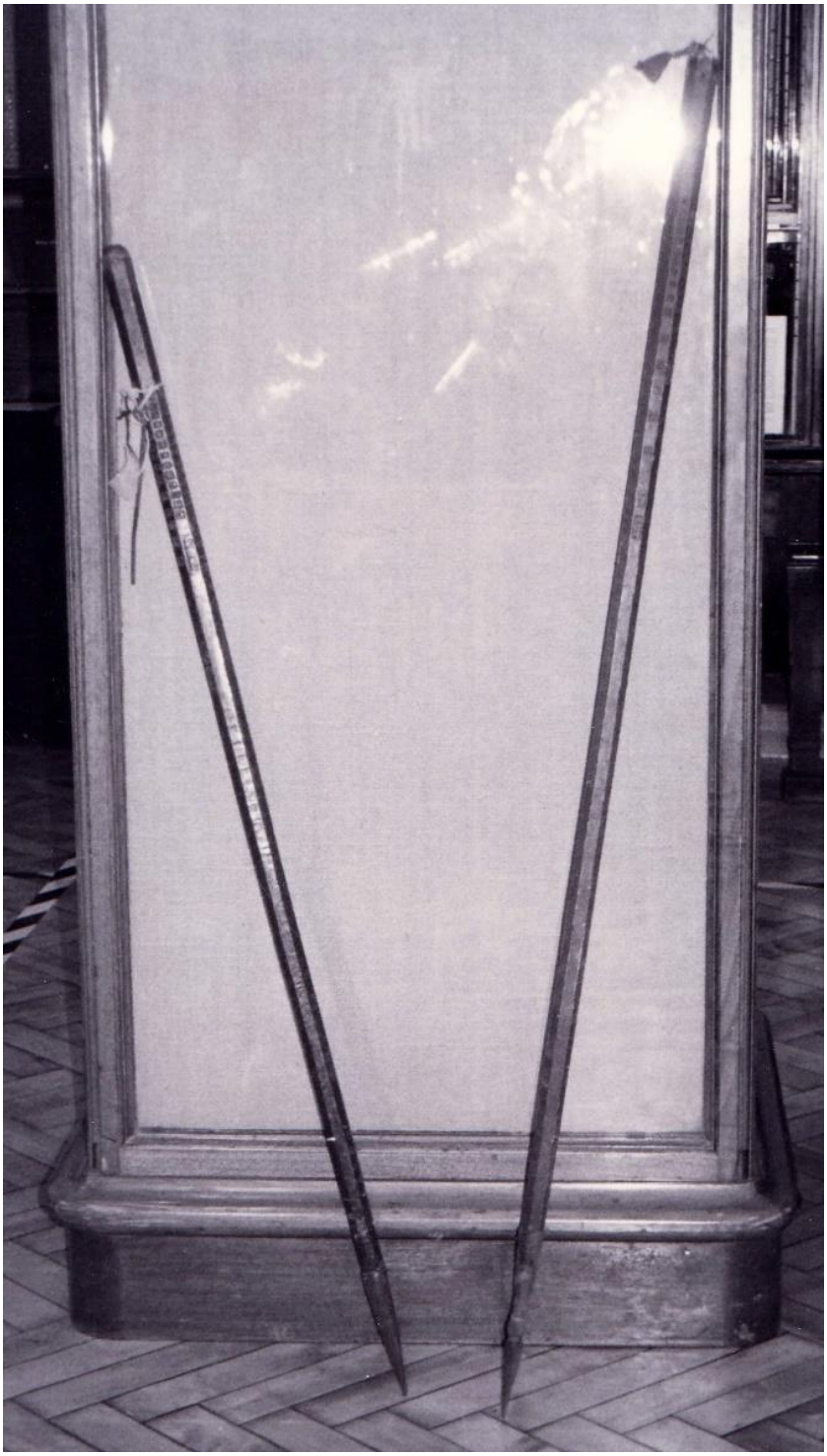


Figure P014.1 – Two column dials; on the left P013 and on the right P014 (photo by S. R. Sarma)

Wooden octagonal stick terminating in a simple iron spear point, which is 210 long with square cross-section. At the top there is a hollow cavity for depositing the gnomon when not in use, but the gnomon is missing now. Near the upper edge there are four holes on alternate faces, through which the suspension thread runs. Below these are holes on each facet for inserting the gnomon, followed by the month names and the *ghaṭī* scales.

The numerals and month names are carved in relief inside rectangular boxes. The boundaries of complete *ghaṭīs* are marked with dots enclosed in circles.

Table P014-1 *Ghaṭī* Scales

Month Names	**Number of *ghaṭīs* (sunrise to noon)**
Asviṇa Caitra	1---15
Bhādra Vaisāka	1---16
Jyaṣṭa	1---17
Āṣāḍa	1---18
Śrāvaṇa	1---17
Phalaguṇa Kārtika	1---15
Masira Māgha	1---14
Pauṣa	1---13

P015 ⊙ CARVED WOODEN COLUMN DIAL, NOT SIGNED, NOT DATED

19th century

Length 1034 mm

London, Science Museum (# 1952-442)



Figure P015.1 – Column dial, detail showing month names *Asviṇa Paitra* (sic! *Caitra*) (photo by S. R. Sarma)



Figure P015.2 – Column dial, detail (photo by S. R. Sarma)

This is a finely carved piece. At the top, there is a hollow cavity for depositing the gnomon when not in use. But the original gnomon is missing; it is replaced by an iron wire with a circular loop at one end. At the upper edge four holes are bored in alternate facets for the suspension ring, below which there are holes, one on each facet for the insertion of the gnomon. Below these holes are the *ghaṭī* scales, and below them the names of the solar months carved in relief. In the *ghaṭī* scales, the numbers are separated by horizontal lines; boundaries between complete *ghaṭīs* are marked with dots enclosed in circles. There must have been a metal spearhead at the bottom, but it is now missing.

Table P015-1 *Ghaṭī* Scales

Month Names	**Number of *ghaṭīs* (from sunrise to noon)**
Asviṇa Caitra	1---15
Bhādra Vaisāka	1---16

Month Names	Number of *ghaṭīs* (from sunrise to noon)
Jyāṣṭa	1---17
Āṣāḍa	1---18
śrāvaṇa	1---17
Phāguna Kārtika	1---15
Māsira Māgha	1---14
Pauṣa	1---13

P016 ⊙ CARVED WOODEN COLUMN DIAL, NOT SIGNED, NOT DATED

19th century

Length 1330 mm

London, Science Museum, ex-Wellcome Collection

The top of this octagonal column dial is carved as a hemisphere, in which there is a hollow cavity for depositing the gnomon when not in use. The metal gnomon has a double loop at one end. The column terminates below in a metal spearhead.

At the top of the column, there are four holes on alternate facets for the suspension rope. At some distance below these are holes in each facet for the insertion of the gnomon. The month names are carved below these holes and the *ghaṭī* scales thereafter.

Table P016-1 *Ghaṭī* Scales

Month Names	**Number of *ghaṭīs* (sunrise to noon)**
Āśvina Caitra	1---15
Vaïśagha Bhādra	1---16
Jyaṣṭa	1---19
Āṣāḍa	1---18
Śrāvaṇa	1---17
Phāguna Kātika	1---14
Maṃsira Māgha	1---13
Pauṣa	1---12

P017 ⊙ CARVED WOODEN COLUMN DIAL, NOT SIGNED, NOT DATED

19th century

Length 1508 mm

London, Science Museum, ex-Wellcome Collection.

This octagonal column dial terminates in a long ornately shaped iron spearhead. At the top of the column, there is a hollow cavity for depositing the gnomon; but the gnomon is now missing. There are four holes at the upper edge for the suspension rope and somewhat below these, holes in each facet for inserting the gnomon. The numbers and month names are carved in relief in box-like depressions. Interestingly, whenever names of two months are written side by side, these are carved in two separate boxes and not in one as in other column dials.

Table P017-1 *Ghaṭī* Scales

Month Name	**Number of *ghaṭīs* (sunrise to noon)**
Caitra Asoja	1---15
Vaisāka Bhādrā	1---17
Jesṭā	1---18
Aṣaḍā	1---18
Sāvana	1---17
Kātika Phāguna	1---15
Maṃsira Māgha	1---14
Pauṣa	1---14

P018 ⊙ CARVED WOODEN COLUMN DIAL, NOT SIGNED, NOT DATED

19th century

Length 1277 mm, diameter 30 mm

Oxford, Museum of the History of Science (# 52782)



Figure P018.1 – Column dial (photo by S. R. Sarma)

The dial is made of a very light timber. At the top, there are four holes, in alternate facets, for the suspension rope, which is now missing. At a distance 150 mm from the top are the holes for inserting the gnomon on each facet, followed immediately by the *ghaṭī* scales, where the numbers are very neatly carved in relief. The names of the solar months are carved below the *ghaṭī* scales. Originally there must have been a metal spearhead at the bottom, which is now missing.

Table P018-1 *Ghaṭī* Scales

Month Names	**Number of *ghaṭīs* (sunrise to noon)**	**Maximum Shadow Length at noon (in mm)**
Āsviṇa Caitra	1 --- 15	278
Bhādra Vaisāṣa	1 --- 17	353
Jyāṣṭa	1 --- 18	530
Āṣāḍa	1 --- 18	552
Śrāvaṇa	1 --- 14	530
Phālaguṇa Kārtika	1 --- 15	214
Maṃsira Māgha	1 --- 14	148
Pauṣa	1 --- 14	138

BIBLIOGRAPHY

Anderson 1982, no. 137, p. 36.

P019 ⊙ CARVED WOODEN COLUMN DIAL, NOT SIGNED, 1926 VS (AD 1869)

Length 1318 mm, thickness 28 mm

Oxford, Pitt Rivers Museum of Ethnology (# 1925.49-1)

This is the earliest extant dated column dial of this genre. However, the maker's name is not mentioned. The octagonal column is made of a heavy shining red timber; the metal spearhead at the bottom has a silvery shine. At the top there are four holes bored diagonally into the shaft for the suspension the rope to pass through. A 181 mm long bamboo gnomon is tied to the rope. The names of the months are carved in relief within small rectangular boxes in the handle, i.e. the part above the holes made in each facet for inserting the gnomon. Below these holes are the *ghaṭī* scales.

Table P019-1 *Ghaṭī* Scales

Month Names	**Number of *ghaṭīs* (sunrise to noon)**
Caitra Asauja	1---15
Vaisāṣa Bhādra	1---17
Jyeṣṭha	1---18
Āṣāḍha	1---18
Śrāvaṇa	1---17
Phāguna Kātika	1---15
Pauṣa	1---13

INSCRIPTION

On the facet for the month of Pauṣa, the *ghaṭī* scale is followed by the inscription:

sāke 1791 saṃvat 1926 sāla miti kātika vadi 1 roja* subh[a]m.*

'In the year measured by Śaka 1791 and Saṃvat 1926, in the dark half of Kārtika [month], on the day 1*. [Let it be] auspicious.'

The second digit of the date is illegible; it can be any number between 10 and 15; therefore the date corresponds to any day between 30 October and 4 November 1869.

PROVENANCE

The accession card of the museum carries the following notation: ‘Sundial Staff, Darjeeling, N. India, presented by Lady Westland 1925.’

P020 ⦿ CARVED WOODEN COLUMN DIAL, NOT SIGNED, NOT DATED

19th century

Length 1541 mm, thickness 33 mm

Oxford, Pitt Rivers Museum of Ethnology (# 1892.41.56)

Octagonal column; the 208 mm long iron spearhead became loose and is completely detached from the shaft. At the top, there are four holes in alternate facets through which the suspensory rope can pass; but the rope is now missing. Below these holes, the names of the months are lightly incised and not carved. Below the names are the eight holes for inserting the gnomon, followed by the *ghaṭī* scales. In these scales, the numbers are carved in relief and the boundaries of complete *ghaṭīs* are indicated by dots enclosed in circles. The day-lengths in some of the months vary from the same in other column dials.

Table P020-1 *Ghaṭī* Scales

Month names	**Number of *ghaṭīs* (from sunrise to noon)**
Asoja Caitra	1---16
Bhāda Vaisāṣa	1---17
Jyaṣṭha	1---18
Aṣāḍa	1---19
Śrāvana	1---17
Kātika Phāguna	1---15
Masira Māgha	1---14
Pauṣa	1---13

PROVENANCE

The accession card of the museum carries the following notation: ‘Sundial and calendar staff (for 1889 or 1890) Nepalese, Darjeeling, presented by Major R. C. Temple 1892.’ It is a misconception to call this a ‘calendar for 1889 or 1890’. There is no calendrical element here. The sundial can show time in any year, and not only in 1889 and 1890, provided it is employed at the same terrestrial latitude.

P021 ⊙ CARVED WOODEN COLUMN DIAL, NOT SIGNED, NOT DATED

19th century

Length 1124 mm, length of the iron spearhead 145 mm

Paris, PC

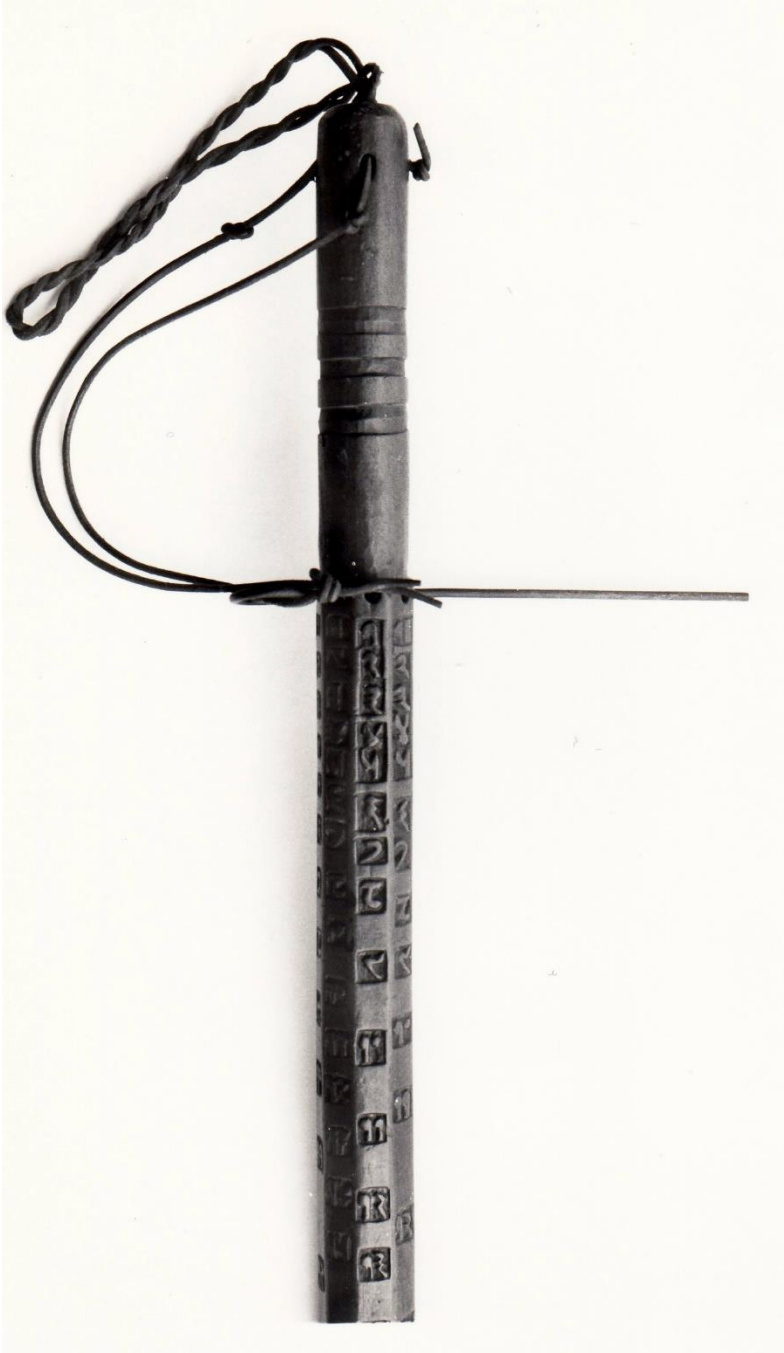


Figure P021.1 – Column dial, upper part
(photo courtesy Professor G. L 'E. Turner)

A nicely carved dial made of some light, shining timber, with leather thongs for suspension. A hollow cavity at the top for depositing the gnomon, four holes at the upper

edge for the suspension rope to pass through and holes on all eight faces for the insertion of the gnomon. The names of the months are carved below the *ghaṭī* scales.



Figure P021.2 – Column dial, detail (photo courtesy Professor G. L 'E. Turner)

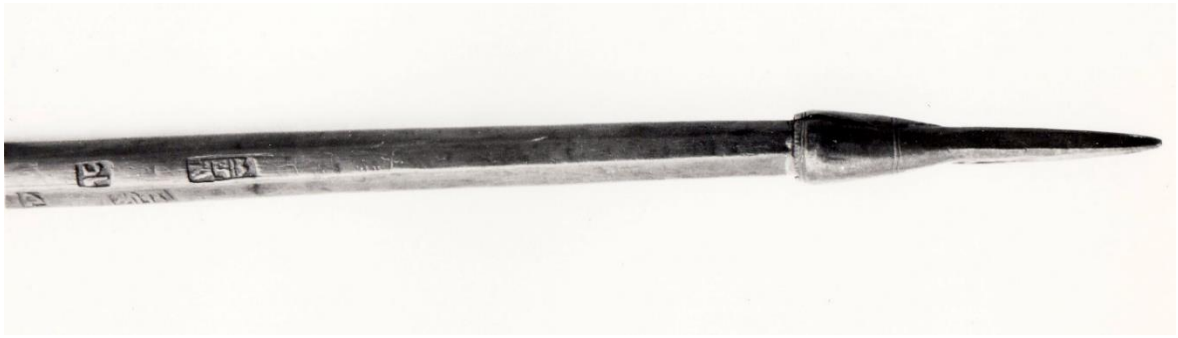


Figure P021.3 – Column dial, iron spearhead (photo courtesy Professor G. L 'E. Turner)

Table P021-1 *Ghaṭī* Scales

Month Names	**Number of *ghaṭīs* (sunsise to noon)**	**Maximum Shadow Length at noon (in mm)**
Asauja Caitra	1---15	277
Vaiśāṣa Bhādra	1---17	394
Jeṣṭa	1---17	516
Aṣāḍa	1---18	549
Śrāvaṇa	1---17	521
Kātika Phāguṇa	1---15	213
Māgha Māsara	1---14	160
Pauṣa	1---14	143

PROVENANCE

Formerly of the Time Museum, Rockford, Illinois; after the closure of the museum, this column dial, along with many other instruments of this museum, were auctioned by Christie's, South Kensington, London, on 14 April 1988; and was acquired by the present owner.

BIBLIOGRAPHY

Christie's, London, *Time Measuring Instruments from the Time Museum,* auction catalogue of 14 April 1988, lot no. 133, p. 76.

P022 CARVED WOODEN COLUMN DIAL, NOT SIGNED, NOT DATED[1460]

19th century

Length 1500 mm

Prague, Náprstek Museum of Asian, African and American Cultures (# 56 396)

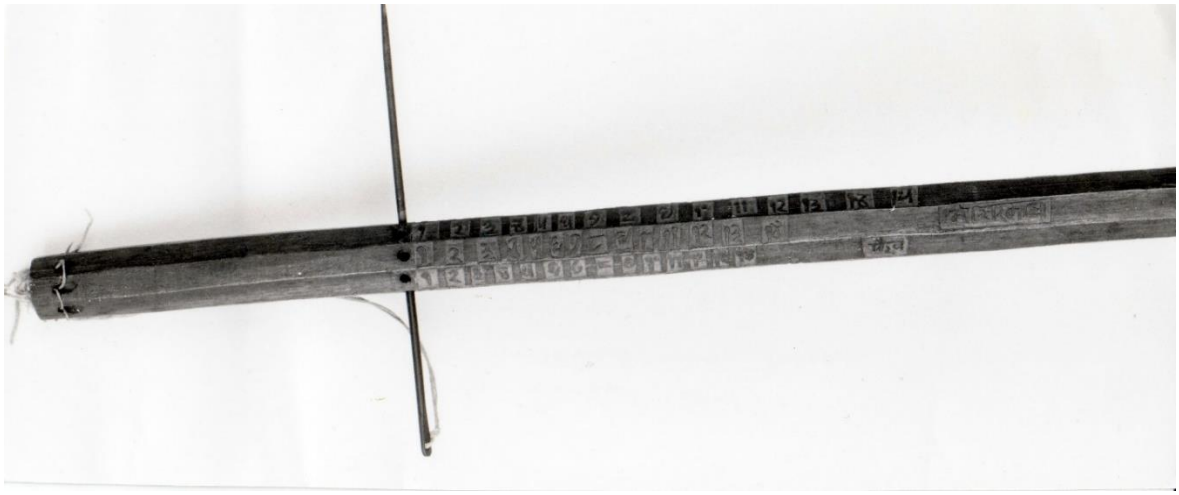


Figure P022.1 – Column dial (photo courtesy Dr Dagmar Pospisilova, Náprstek Museum)

Near the upper edge, there are holes in each facet; the suspension rope is wound through these holes and taken out the through the hollow cavity at the top. Some distance away from these upper holes is another set of holes in each facet for inserting the gnomon. Beneath these holes are the *ghaṭī* scales, followed by the names of the solar months.

This column dial displays close similarity with the column dial P011 at the Royal Scottish Museum of Edinburgh. However, the numbers in the *ghaṭī* scales are perpendicular to the length of the column, a feature not found in any other column dial.

A long needle with an eye-hole is substituted for the original gnomon.

PROVENANCE

The Náprstek Museum received this column dial from the regional museum at Louny, a small city in the Czech Republic, in 1953.

[1460] Entry based on the information and photo kindly provided by Dr Dagmar Pospisilova, Náprstek Museum, Prague.

P023 IRON COLUMN DIAL BY LEHNA SINGH MAJITHIA FOR LORD HARDINGE

Ca. 1850

Length ?

Kolkata, Asiatic Society ?

Besides the *Palabhā-yantra* described under N003, Lehna Singh Majithia also produced an iron column dial. Interestingly, this column dial was the main topic of discussion in the monthly general meeting of the Asiatic Society of Bengal, held on 7 November 1860 at Calcutta. [1461] First, on behalf of Professor Griffith, Mr. Halsey presented 'a singular iron sun-dial called *Pratoda* or *Pratola* (serving also for an hour-glass [,] gun and a spear) believed to have been made by Sirdar Lena Singh for Lord Hardinge.'[1462]

Then, Pandit Bapu Deva Sastri explained 'the instrument called *Pratoda* (a goad) invented by Ganesa [Gaṇeśa Daivajña], by which the hour of the day can be easily known'.[1463]

Thereafter, Archdeacon J. H. Pratt, who chaired the meeting, 'gave the following account of its character and uses.'

> 'The instrument appears to be roughly graduated and to be in a rickety condition. It has nine sides. If these are *exactly* suited to the latitude, the place for which it was made was in latitude 27° 56′ or thereabouts. If the latitude of the place did not accord with an *exact* number of sides, then it must have been between 26° 40′
> and 29° 12′ [,] that is, corresponding to 8 ½ and 9 ½ sides. Delhi lies between these last two latitudes. The instrument may, therefore, have been made for that city.

1461 *Journal of the Asiatic Society of Bengal,* 23 (1860) 424-427; I am highly obliged to Dr V. V. Bedekar for drawing my attention to this.

1462 Governor General of India from 1844 to 1848.

1463 For Bapu Deva Sastri's explanation, see the introduction to this section.

> ‘The manner of using the instrument appears to be this. Suppose the day that you use it is one which the length is 50 minutes longer than the shortest day: then as 50 = 2 x 24 + 2 and 24 minutes make a *ghatika,* you must screw the gnomon into the hole in the third side, in which the figures run down to the third shortest length. Then hang up the instrument and turn it round, thus hanging, so that the shadow of the gnomon may fall on the length of the instrument; the extremity of the shadow will point out the hour of the day in *ghatikas* from sunrise or sunset as it is before or after noon.’
>
> ‘The instrument is certainly curious, though of no particular scientific value.’
>
> Finally, ‘Colonel Baird Smith communicated to the meeting the following interesting particulars respecting the constructor of the dial.’
>
> ‘Lena Singh Majeteeah, the constructor of the *Pratoda* Dial, was the representative of a well known distinguished Sikh family. He did not take any very prominent part in the Sikh campaign, but his brother Runjoor Singh commanded the Khasla army at the battle of Aliwal where, as all know, he was signally overthrown by the force under Sir Harry Smith. On that occasion an exquisitely beautiful battery of six field guns, the property of Lena Singh, and the produce, probably, of the same workshop which produced the *Pratoda* Dial was captured. Nothing could surpass the whole design and details of these guns, and while they were ornamented with great taste, they were at the same time good working guns, and had been vigorously used during the day.
>
> ‘Lena Singh had very considerable mechanical capacity. He enjoyed greatly hearing of all forms of mechanical invention. The long range and explosion shells for guns were favorite subjects of experiment and discussion with him …’

Unfortunately, the instrument itself is not clearly described in these proceedings, except that it serves ‘also for an hour-glass [,] gun and a spear.’ Here the word ‘ hour-glass’ needs to be understood in a general sense of a time-measuring device and not as the glass instrument where sand flows from one half to another. The fact that it serves also as a spear shows that the iron rod is equipped with a spearhead at the bottom so that it can be dug into the ground and made to stand in a vertical position.

But, the statement that it also serves as a gun is intriguing. It is indeed true that Lehna Singh was an expert in making guns. Colonel Biard Smith who extolled his expertise in gun making, did not say a word about the gun in this sundial. It is not explained Lehna Singh combined the column sundial with a gun? A gun barrel could not have been attached parallel to the column dial, for this would have interfered with the use of the column dial for measuring time. Most likely, the iron column was made hollow throughout so that it could serve as the barrel of the gun. The outer surface then was shaped into nine facets and each was engraved with a different *ghaṭī* scale. The holes above the *ghaṭī* scales were not made too deep to run into the hollow gun barrel. These must have been quite short with a screw thread so that the gnomon could be screwed into them. Then the gun would require a handle, a trigger and some arrangement for inserting gun powder.

In other words, Lehna Singh must have made first a gun with a long barrel, then added nine *ghaṭī* scales on the outer surface of the barrel and attached a spearhead below the gun handle so that when the device is set up vertically for measuring time, the opening of the barrel will be upwards. Then it can be certainly called a ‘singular iron sun-dial’.

It is therefore a great pity that we have no information about the present whereabouts of the column dial. It is not known whether it is with the Asiatic Society at Kolkata.

Q. INDO-PERSIAN HORIZONTAL SUNDIALS IN MOSQUES AND MUSEUMS

INTRODUCTION[1464]

SUNDIALS IN THE ISLAMIC WORLD

It is obligatory for Muslims to offer five prayers in a day, a day which commences at the sunset. These prayers are *maghrib*, *ʿishā'*, *fajr, ẓuhr* and *ʿaṣr*. The times for these prayers were standardized in the eighth century. The prayers are offered within certain intervals or time brackets which are astronomically defined. The interval for the *maghrib* prayer begins when the disc of the sun has set over the horizon; the intervals for the *ʿishā'* and *fajr* prayers commence at daybreak and nightfall respectively. Thus the times of these night prayers are determined in terms of horizon and twilight phenomena.

The times of the two daytime prayers, on the other hand, are defined in terms of shadow lengths, usually the lengths of the shadows cast by a gnomon of standard length, of either 7 feet or 12 digits. Accordingly, the interval for the *ẓuhr* begins at midday when the sun has crossed the meridian, i.e., when the length of gnomon's shadow is at its minimum (say n). The interval for the *ʿaṣr* begins when the shadow length equals the midday shadow (n) plus the length of the gnomon (g) and ends when it equals the midday shadow plus twice the length of the gnomon ($n + 2g$). These times are variable according to the declination of the sun, and have to be computed for each day and for each latitude.

As Islam spread in areas which were formerly under the Greco-Roman domain and the Muslim astronomers came into contact with Greco-Roman sundials, they realized that these sundials could be effectively used to regulate their prayers and began to modify them by adding lines to indicate the times of the midday (*ẓuḥr*) and afternoon (*ʿaṣr*) prayers.

[1464] This section owes its existence largely to the invaluable help rendered by Debasish Das and Mubashir Ul-Haq Abbasi. Das took several photos of the sundial in Delhi and arranged through his friends the photography of the sundials at Hyderabad (Subbarao, K.), Jaipur (Sanjay Parmar), Mysore (Ejaz Ahmed) and Pulicat (Premnath, M. S.); he also collected several interesting references to these sundials. Abbasi, who designs sundials himself, deciphered and translated the Persian inscriptions and legends; more important; he analyzed the projected lines and provided detailed technical explanations. It is a pleasure to thank Das, his network of friends, and Abbasi.

To facilitate the construction of such dials, Muslim astronomers, with their well-known penchant for preparing detailed mathematical tables, began compiling special tables from the ninth century onwards. In early ninth century, al-Khwārizmī compiled at Baghdad a set of tables of coordinates for the construction of horizontal dials. About this work, David King notes:

> 'With values of solar altitude and azimuth (*h, a*), computed for the required ranges of solar longitude and time intervals, the radial coordinates of the points of intersection of the hour lines with the shadow traces are simply (*n* cot *h, a*) where *n* is the length of the gnomon. Each of al-Khwārizmī's sub-tables for a specific latitude display for both of the solstices the solar altitude, the shadow of a standard gnomon (12 units) and the solar azimuth, i.e., triplets (*h, s, a*) for each seasonal hour of the day.'[1465]

Ḥabash al-Ḥāsib, who worked at Baghdad during the ninth and tenth centuries, prepared tables for the construction of horizontal dials with vertical gnomons, where he recorded the height of the sun over the horizon and the length and direction of the gnomon's shadow for each of ten latitudes, and for each seasonal hour on both of the solstices.

Towards the end of ninth century, Thābit ibn Qurra, also at Baghdad, wrote a comprehensive work on the theory of the sundial, where he discussed the transformation of coordinates between the planes of horizon, celestial equator and the sundial, with the possibility that the plane of the sundial can be of many kinds.

Most prominent of all is Abu'l Ḥasan ᶜAlī al-Marrākushī, who composed the magnum opus *Jamiᶜ al-mabādi' wa-l-ghāyāt fi ᶜilm al-mīqāt* (Comprehensive Collection of the Principles and Objectives in the Science of Timekeeping) at Cairo at about 1280.[1466] It contains an extensive treatment on a vide variety of sundials, horizontal, vertical, inclined, cylindrical and conical, with tables and diagrams. He also discussed portable dials in plane, cylindrical or conical formats.

[1465] King 1996c, pp. 170-171; see also King 2004, Part II: A survey of tables for regulating the times of prayer, pp. 191-456.

[1466] For a French translation, see Sédillot 1834.

Thousands of sundials are believed to have been constructed in the Islamic world between the ninth and nineteenth centuries, but those that have survived are very few and no full inventory of has been made of these so far.[1467] Most of these carry markings for *ẓuhr* and *ᶜaṣr* prayers in seasonal or equal hours; some are engraved with the direction of the *Qibla*.

The earliest surviving dial was made by Ibn al-Ṣaffār about 1000 at Cordoba. Only one half of it is extant which displays lines for seasonal hours and for the *ẓuhr* prayer; presumably lines for the *ᶜaṣr* prayer were engraved on the missing half. The vertical gnomon is missing, but its length is indicated by the radius of the circle described around the point where the gnomon was originally affixed.[1468]

The most spectacular sundial was constructed by Ibn al-Shāṭir in 1371/72 for the great Umayyad Mosque in Damascus. It is a horizontal sundial engraved on a rectangular marble plate measuring 2 x 1 m. The gnomon is inclined to the horizon at an angle of 33;30°, which is the medieval value for the latitude of Damascus, and thus points to the celestial north pole. This is indeed the origin of the triangular gnomon associated with the *Palabhā-yantra* in India and with the most common form of the sundials in Europe. But the dial itself is highly complex; in fact, it consists of three separate dials.

> ‘The small northern sundial with its gnomon has markings for the seasonal hours and the *ᶜaṣr* prayer. The small southern sundial has markings for equatorial hours before midday and after midday, as well as after sunrise and before sunset. Its gnomon, parallel to the celestial axis, is ingeniously aligned with the larger gnomon of the third and main sundial. The latter bears markings for each twenty minutes before midday and after midday, as well as for each twenty equatorial minutes after sunrise up to midday and for each twenty minutes before sunset starting at midday. There are also curves for each twenty minutes up to the *ᶜaṣr* prayer starting two hours before the prayer, as well as curves for the times three and four hours after daybreak.

1467 On the extant Islamic sundials see King 1987a, XV-XVIII; King 1996c; Berggren 2001; King 2005, ch. 7 (Sundials), pp. 81-91.

1468 Cf. King 1996c, plate 4.11; Berggren 2001, p. 10, Fig. 1.

> Finally, there is a curve for the time 13 ½ hours before daybreak the next day.'
>
> '… It measures time relative to the *ẓuhr* and *maghrib* prayers, and the *ʿaṣr* curves enable measurement of time relative to the *ʿaṣr* prayer as well. The curves associated with night fall and daybreak are for measuring time with respect to the *ʿishā'* and *fajr* prayers.'[1469]

This sundial was set up on a platform on the southern side of the main minaret of the mosque, but was damaged towards the end of the nineteenth century. The fragments are on display in the garden of the National Museum in Damascus. An exact replica of the original sundial made by al-Ṭanṭāwī in 1890 can be seen on the minaret.

Sundials in India

As in the Middle East, in the Indian subcontinent also very few sundials exist in the mosques with projections to indicate the prayer times.

Agra, Moti Masjid

J. T. Boileau, of the Bengal Engineers, was the first to describe a sundial set up in a mosque in India. In 1833, he published a short description of a sundial in the Moti Masjid inside the Red Fort at Agra along with a sketch:

> '… a dial-plate of white marble, with lines inlaid on its surface of a black slate … The style, which appears to have been an upright round pin, is gone, and the inlaying has been pulled out; but the configuration of the lines is still perfect, being marked by channels wherein inlaying fitted. The breadth of these channels is about 3/8 of an inch.'
>
> 'The dial-plate is set up in the court of the *Moti Masjid,* a building which was constructed in the latter end of the reign of Aurangzib, about the year 1673, and it is probable that this dial was put up about the same time; but whether in its present site or position, or elsewhere, I have not been able to ascertain.'

[1469] King 1996c, pp. 166-167, plate 4.13.

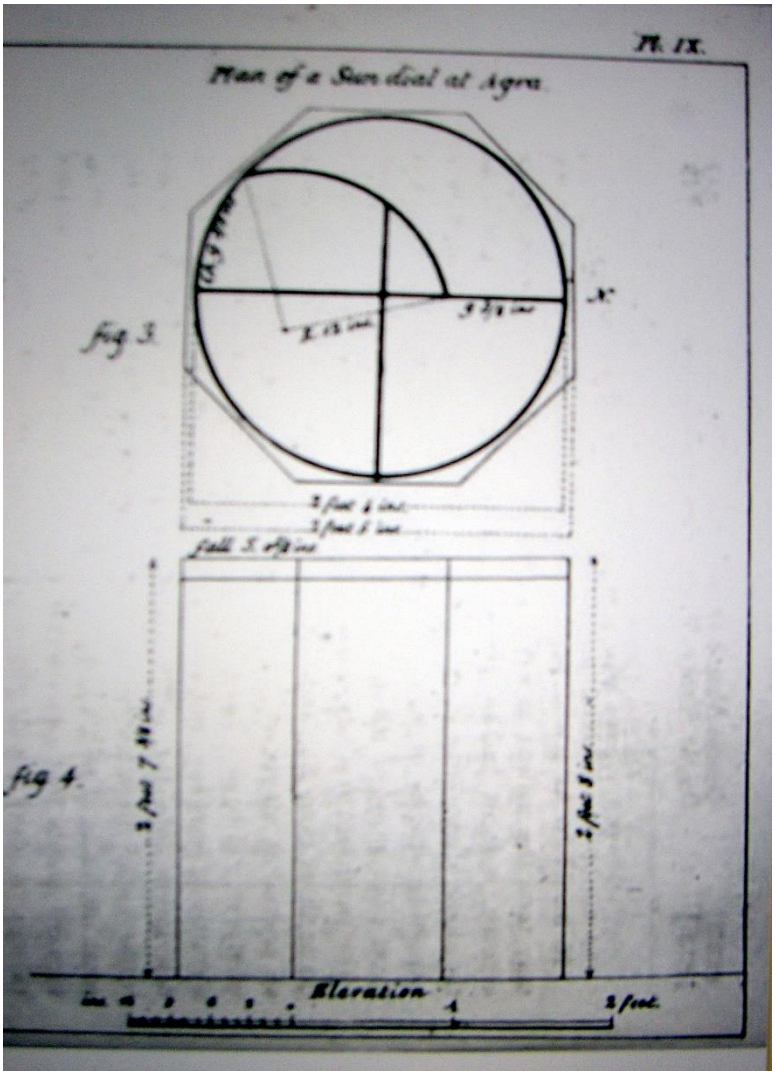


Figure Q1 – Sketch of the sundial and its pedestal (from Boileau 1833)

‘The absence of hour lines, excepting XII and VI A. M. and P. M. would lead to the supposition, that the object for which the dial was constructed had reference only to the times of Mussulman prayer ; but the object of the circular arc, which subtends an angle of about 95 degrees, has never been explained, although many celebrated *Moulvis* have visited the *Masjid* and examined the dial as it stands.’

‘The surface of the dial inclines south about 3/8^{ths} of an inch, which leads me to believe , that it has been removed from the place where it was originally fixed.’

> 'It is not possible … that the circular arc, which is inclined about 29° to the present meridian line, could under any circumstances mark the shadow of a style placed as the style of this was, in a vertical position.'[1470]

Boileau is not quite right in stating that the Moti Masjid in the Red Fort at Agra was constructed under Aurangzeb in 1673; it was in fact constructed by Shāh Jahān. The noted historian of Indian architecture, James Fergusson, states that '… the Moti Masjid or Pearl Mosque, which Shah Jahan erected in the Fort of Agra, 1646-1653, is one of purest and most elegant buildings of its class to be found anywhere.'[1471] But the sundial may not have been set up at the same time.

Already in 1833, when Boileau examined the sundial, he thought that the sundial must been moved from its original position. Moreover, his description gives the impression that the dial may not have been engraved completely. Whether it is still there now or not cannot be ascertained because the Moti Masjid is now closed to the public.

Leaving this one aside, we know at present of six sundials in mosques which carry lines to indicate prayer times.[1472] The earliest of these was set up in 1694 in the Mecca Masjid at Hyderabad. It is the only sundial in India which shows close affinities with the sundials in the Middle East (Q001). Three others (Q002, Q003, Q004) are designed like the *Palabhā-yantra* with a horizontal dial engraved with a semi-circular time-scale and a triangular gnomon; but the curves to display the two time limits of the *ʿaṣr* prayer are drawn differently in each of them. The last two (Q005 and Q006) carry an identical design of concentric circles. Detailed individual descriptions of these six sundials will follow this introduction. Here will be given brief descriptions of the mosques where these sundials are set up.

1. Hyderabad, Mecca Masjid

The construction of this mosque was commenced by Muḥammad Qulī Quṭb Shāh in 1616, but was completed much later in 1694 under the Mughal emperor Aurangzeb

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1470 Boileau 1833.

1471 Fergusson 1910, II, p. 317.

1472 To explore all the mosques in the Indian subcontinent for sundials is far beyond the scope of this project. But it is worthwhile doing so, for there may be some interesting sundials, hitherto unnoticed.

who annexed the kingdom of Hyderabad into the Mughal empire in 1687. Muḥammad Qulī Quṭb Shāh is said to have begun its construction with bricks made of the sacred soil brought from Mecca; therefore, the mosque came to be called Mecca Masjid. It is very large mosque that can accommodate about ten thousand people. The sundial was set up at the time of completion of the mosque under the orders of Aurangzeb in his 36th regnal year in 1694. The dial is made of a polished black stone with a diameter of 635 mm; it is set up upon a 1219 mm high pillar.

When I saw the sundial and photographed it in 1991, the gnomon was missing and the dial face began to deteriorate. Now in the year 2017 the pedestal is much damaged, plaster is peeling off the pedestal and the dial plate rests precariously on the pedestal. The sundial is in urgent need of conservation and preservation. This is the only sundial which shows some affinity to the sundials of the Middle East, with the solstices represented as hyperbolas and with a line showing the direction of the *qibla* (Q001).



Figure Q2 – Sundial in 1991 (photo by S. R. Sarma)



Figure Q3 – Two views of the sundial in 2017 (photos by Subbarao K., courtesy Debasish Das)

2. Delhi, Jama Masjid

The *Masjid-i Jahān-Numā* (World-reflecting Mosque), commonly known as the **Jama Masjid,** was built by the Mughal emperor Shāh Jahān between 1644 and 1656. It is a large and ornately built mosque; its forecourt can accommodate about five thousand devotees at the time of congregational prayers.



Figure Q4 – Jama Masjid with the world map in the foreground (photo by Debasish Das)

In the centre of the forecourt is a large water tank, lined with marble, for ablutions before the prayers. It is not known whether any sundial was set up at the time of its construction, but there exists now a sundial that was erected much later in 1829-30. In fact, there exist now three small structures. In the south-east corner of the forecourt, there are two pedestals, one circular and the other rectangular. The former may have carried a circular dial on its top, but it is now missing. The rectangular pedestal (470 mm high and the upper surface measures 1190 x 460 mm) was designed to carry two square dial plates side by side, but only one is extant and the other is missing. The surviving dial plate (460 x 450 mm) is engraved with a sundial and another dial for the determination of the times of the beginning and end of the interval for the *ʿaṣr* prayer in all seasons. It was made by Ḥāfiẓ Anwar ʿAlī Siddiqī of Rohtak under the supervision of Saiyid Aḥmad, the Imām of the congregational mosque at Ajmer, in 1245 AH (= AD 1829-30) (Q002).

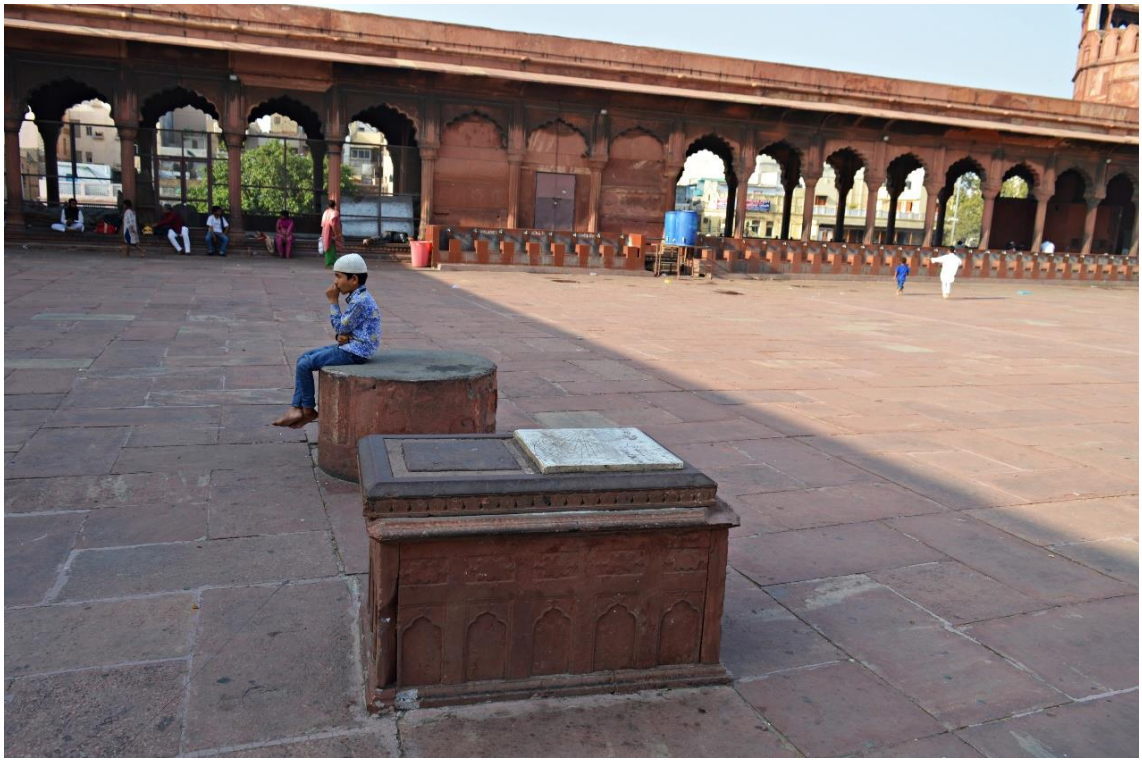


Figure Q5 – Sundial and an empty circular pedestal in the forecourt ;
in the background is the southern arcade (photo by Debasish Das)

The third pedestal is in the north-east corner of the forecourt. It is 1120 mm high and covered on the top by marble plaque measuring 580 x 550 mm. The plaque is engraved, most unusually, by a world map drawn inside a circle in what is technically known as ‘Lambert azimuthal equal-area projection’. On it the circles of latitude and

those of longitude are drawn for every 10°, with the prime meridian passing a little to the proper right of the peninsular India. The outline of the Indian peninsula is not well defined. Australia is labelled as *naw wilz janub,* 'New South Wales', which was the original name of the first British colony in Australia. It must obviously have been copied from an English atlas, but why it was set up in a mosque remains an enigma. At the centre, where 0° latitude and longitude intersect, is a large hole. There may have been some kind of a pole erected in it, but for what purpose is not known.



Figure Q6 – World Map in the North-East corner of the forecourt
(photo by Debasish Das)

The inscription engraved at the bottom of the plaque in three lines reads as follows: [1473]

ṣūrat arḍ wa aqālīn janūbī wa shamālī khaṭṭ istiwā bā khaṭūṭ darjāt ṭūl wa ᶜarḍ bilād

dar ᶜahd ḥaḍrat muḥammad akbar shāh pādshāh ghāzī sanah 1247 hijrī bāmar (?) shāhzādah ᶜalījāh muḥammad salīm bahādur shāh qāḍī shujāᶜ al-dīn ᶜalīkhān ghāzī (?) hū … (?) darsat kardah yādgār guzāsht

'The figure of the earth and the southern and northern climates [with respect to] the equator with the lines of longitude and latitude of the cities

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[1473] I am grateful to Professor Mohammad Baqeri and Mubashir Ul-Haq Abbasi for deciphering and translating the inscription.

‘in the reign of His Majesty Muḥammad Akbar Shāh Bādshāh Ghāzī, [in the] year 1247 AH (1831-32), by order of the prince ᶜĀlījāh Muḥammad Salīm Bahādur Shāh, Qāḍī Shujaᶜ al-Dīn

ᶜAlī-Khān Ghāzī ... built and left as a memorial.’

The following labels are engraved on the map (from north to south): *quṭb shamāl* (North Pole); ? (England); *frāns* (France); *āsīyā* (Asia); *īrān* (Iran); *fars* (Persia); *hindūstān* (India); *ᶜarabistān* (Arabia); *afrīqā* (Africa); *bahr ᶜarab* (Arabian Sea); *khalīj bangālah* (Bay of Bengal); *bahr hind* (Indian Ocean); *naw wīlz* (?) *janūb* (New South Wales, original name of the British Colony in Australia); *bahr janūb* (southern ocean); *bahr quṭb* (polar sea, Antarctic ocean); *quṭb janūb* (South Pole).

Muḥammad Akbar Shāh Bādshāh Ghāzī, generally known as Akbar Shah II, was the penultimate Mughal king (r. 1806-1837) of Delhi. Prince Mīrzā Muḥammad Salīm Bahādur Shāh (1799-1836) was his son. He was younger than Bahādur Shāh Zafar who succeeded Akbar Shah II as the last Mughal ruler (r. 1837-1857). Qāḍī Shujaᶜ al-Dīn ᶜAlī-Khān Ghāzī must be the person who set up the world-map. No other information is available about him. The inscription states that the world map was set as a memorial (*yādgār*). It is not known which event it is supposed to commemorate.

Sir Syed Ahmad Khan, the founder of the Aligarh University, wrote a valuable book on the historical monuments of Delhi, entitled *Asār ul-Sanādīd* in 1854. There he mentions an addition made in the Jama Masjid by prince Mīrzā Salīm:

> ‘Thanks to God’s blessings, the mosque is able to accommodate such a large number of worshippers that they resemble ants and many cannot hear the voice of the *imam.* Hence, Prince Mirza Salim, son of King Mo’inuddin Muhammad Akbar Shah, had a magnificent raised platform of stone constructed in the middle of the central arch in 1245 AH (1829 AD), so that a *mukabbir* could stand upon it and deliver the call to prayer and other sections recited aloud so that they would resound in the ears of all present.’[1474]

[1474] Sir Syed Ahmad Khan, *Asār ul-Sanadīd,* edition 1904, Book III, p. 66; translation of the passage by Quraishi 2012, p. 14.

The pavilion is still extant. Interestingly it was constructed in the same year when the sundial by Ḥāfiẓ Anwar ᶜAlī Siddiqī was set up in the south-eastern corner of the forecourt. Therefore, it is entirely possible that the sundial was also set up at the instance of this prince; the missing plaque next to the sundial may have carried some reference to the prince. It is also possible that he caused the setting up of some other sundial on the round pedestal next to it about the same time. While the sundials in a mosque are appropriate, if not essential, the world map in the mosque deserves an explanation.

Obviously it was influenced, in some way or other, by the British administration of Delhi. For, Akbar Shah II was just a nominal king, and the actual administration was in the hands of the British Resident, who represented the Governor-General of the British East India company. Therefore any repairs which become necessary at the Jama Masjid were done by British engineers on behalf of the Resident. For example, when the northern minaret was struck by lightning and fell down and the flooring of the forecourt suffered damage, the English had rebuilt the minaret and repaired the flooring in 1817.

However, the sundial and world map find hardly any mention in the nineteenth century accounts. Sir Syed merely states that there is a sundial (*dā'ira'-i hindī*) opposite the southern and eastern arcades,[1475] but does not mention the world map. Consequently, Stephen Carr Stephen is the only one to mention both:

> 'In the year 1829, Mirzá Salim, son of Akbar II, put up a sand-stone pulpit under the central entrance of the mosque, the congregation being at times too large to take part in the prayers offered by the Imám inside the mosque.'
>
> 'In the north-eastern corner of the court of the mosque is a plain sphere cut upon marble, giving a map of the world, according to the common projection of the sphere. …
>
> 'In the south-western corner of the court-yard, is a marble sun-dial, corresponding to the plain-sphere on the opposite side.'[1476]

1475 Sir Syed Ahmad Khan, *Asār ul-Sanadīd,* edition 1904, Book III, p. 67 (as explained by Muabashir Ul-Haq Abbasi).

1476 Stephen 1876, p. 253.

Both Sir Syed and Stephen Carr mention only one sundial; if the circular pedestal also carried a sundial, they would have mentioned the 'sundials' in plural; it means either the dial on the circular pedestal was removed by at least 1854 or the circular pedestal was meant for another purpose which is not known. As regards, the rectangular pedestal, from their statement it is not clear whether the two marble plaques were still in tact or not at the time of their writing.

3. Pulicat, al-Masjid al-Musharraf

The next sundial is found in the far south, at Pulicat (13;25° N; 80;19° E), which lies on the coast of Bay of Bengal on the southern border of Tamilnadu. It was an important port of the Vijayanagara empire in the fourteenth and fifteenth centuries. In 1502 the Portuguese established a trading post and built a fort there. The Dutch occupied the port in 1609 and held it until 1825 when the British East India Company seized it.

There has been a large Muslim population in Pulicat throughout its history. Two of the important mosques today are the Peria Jamia Pallivasal which is the large congregational mosque and the Chinna Pallivasal. The sundial is set up in the Chinna Pallivasal. The mosque was constructed in 1708, but the sundial was added only in 1334 AH (AD 1915-16).[1477] This is the only sundial where the gnomon is intact.

4. Patna, Khanqah Emadia

In Patna, there is a Ṣūfī seminary named Khanqah Emadia. Sometime in the second half of the twentieth century, the head of the Khanqah, Shah Faridul Haque Emadi, designed an elegant sundial and had it set up on the roof of the mosque. The dial was engraved with hour lines and two long curves to indicate the times of the midday prayer *ẓuhr* and the after-noon prayer *aṣr*. I saw it and photographed it in 1991. In course of repairs, subsequently, the sundial was removed and discarded in a store room; I understand that the dial plate is still intact, but the gnomon is lost.

[1477] Cf. *Pulicat & Sadras : Confluence of History, Culture & Environment,* Anameka Architects & Designers, Chennai 2010, pp. 70-71.

5. Srirangapatna, Tipu Sultan's Sundials

Tipu Sultan (1750-1799) built at Srirangapatna (Lat. 12;26 N; Long. 76;35 E), near Mysore, a mausoleum for his father, which is popularly known as the Gumbaz (dome), and a mosque named Jamia Masjid or Masjid-i Aʿlā in about 1782 and set up sundials of identical design at both places (Q005 and Q006). The dial faces are badly eroded; all that can be seen are a series of nineteen concentric circles upon which eight diameters are drawn indicating the cardinal and intermediate directions.

Other Extant Indo-Persian Sundials

Besides these sundials in the mosques, there exist three other specimens which show just the hours of the day (Q008, Q009 and Q010) and resemble the *Palabhā-yantras* in their design. Finally, there are two portable dials which were designed after European models (Q011 and Q012).

Q001⊙ SUNDIAL BY MĪR QĀSIM, 36TH REGNAL YEAR OF MUHY AL-DĪN MUḤAMMAD ᶜĀLAMGĪR (AD 1694)

Dimeter of the dial 635 mm; height of the pedestal 1219 mm

Hyderabad, Mecca Masjid



Figure Q001.1 – Sundial with the pedestal (photo by S. R. Sarma)

This sundial set up in the Mecca Masjid at Hyderabad on the orders of the Mughal emperor Aurangzeb in his 36th regnal year (AD 1694), after the construction of the mosque has been completed under his aegis. It is of a polished black stone with a diameter of 635 mm; it rests on a 1219 mm high pedestal, which is shaped like a pillar with fluted columns.

The design of the sundial resembles to a large extent the general design of the sundials in the Middle East. David King published a photograph of this sundial along with the remark: ‘We see in addition to the hour-lines the markings for the daylight

prayers and the qibla at Hyderabad (all Islamic) and a family of circular arcs around the gnomon to serve as a scale for measuring the length of the shadow (Indian).'[1478]

The following description of this sundial is based on the technical explanation of the projected lines and the decipherment of the inscriptions kindly provided by Mubashir Ul-Haq Abbasi.

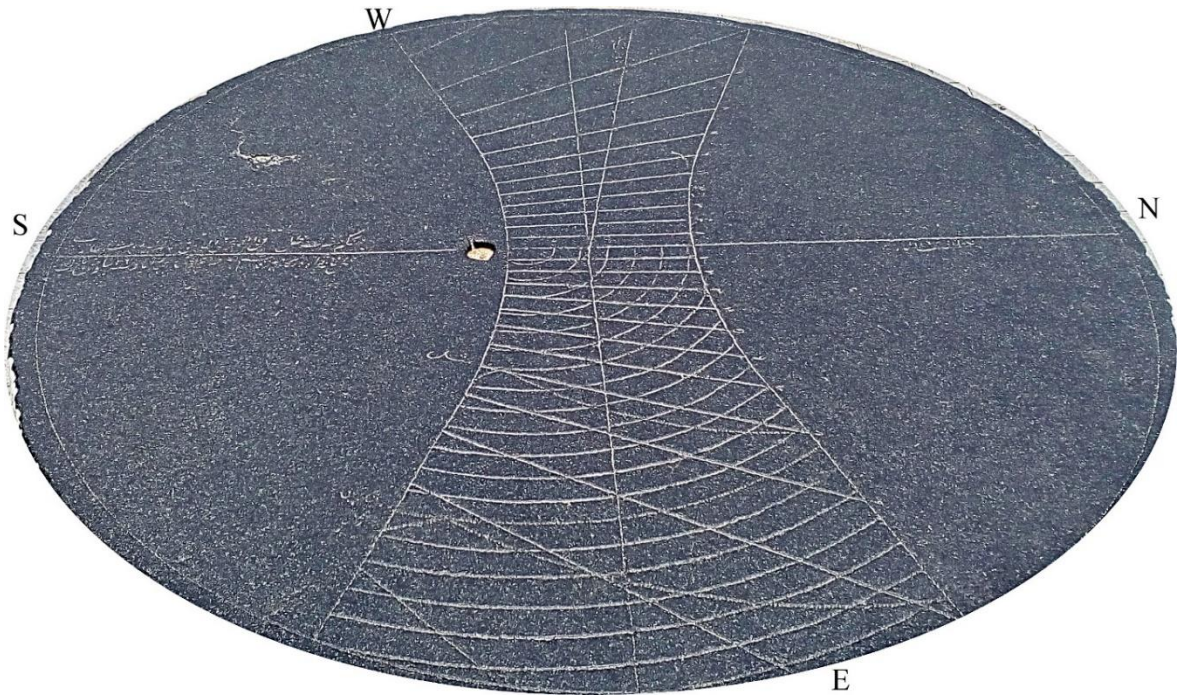


Figure Q001.2 – Sundial (photo by Subbarao K., courtesy Debasish Das)

The dial plate is divided by the north-south diameter (to be seen in the photo as the horizontal diameter running from the left to the right) and the east-west diameter. The north-south diameter, or the meridian line, is labelled on the right hand side as *niṣf al-nahār* (midday). On the left hand side an inscription is engraved in two lines, one above and the other below the midday line.

As in the sundials in the Middle East, two hyperbolas are drawn on the either side of the east-west line; the one on the left represents the summer solstice and that on the right the winter solstice, while the east-west line represents the equinoxes. The two solstices constitute the two extremities of the sun's declination; and hence the two hyperbolas on the sundial represent the two limits of the projections. A series of 20 concentric quarter circles are drawn in the east to measure the lengths of the gnomon

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[1478] King 2005, p. 810.

shadow in the afternoon. The gnomon is missing now; it must have been a triangular type with the hypotenuse subtending an angle equal to the local latitude and thus pointing to the celestial north pole, and vertical side arising from the point which is the centre of the concentric circles.

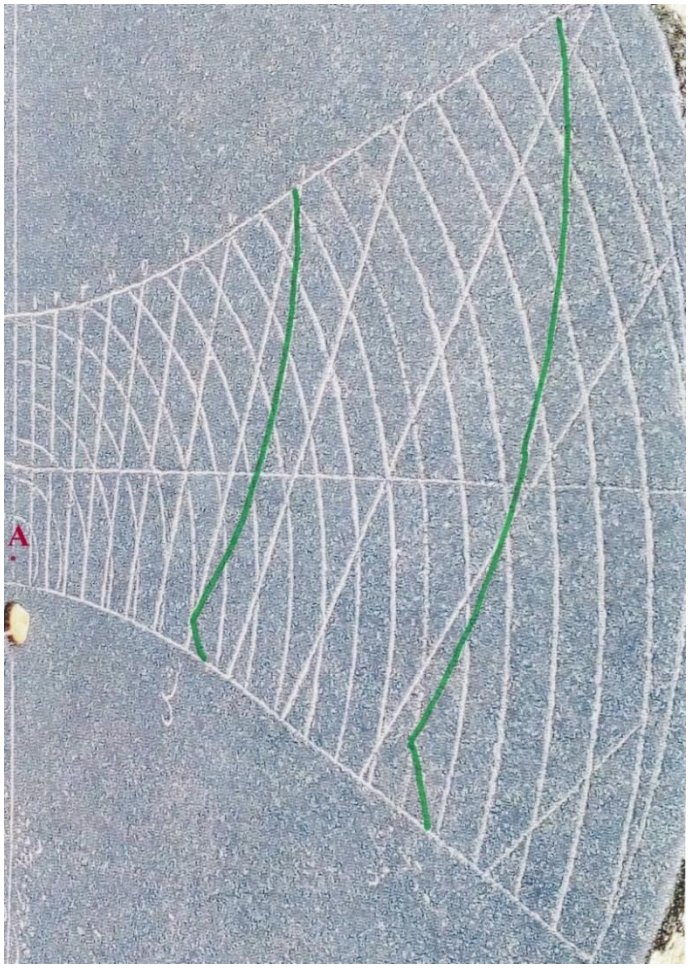


Figure Q001.3 – Ghaṭī lines and ᶜAṣr curves (detail of Figure Q001.2)

Ghaṭī Lines

A set of ten lines is drawn on either side of the midday line and numbered from 1 to 10 starting from the midday line. These cannot be the hour lines; they are most likely the lines of *ghaṭīs* (24 minutes). The sundial then represents a range of four hours before midday (8;00 a.m.) to 4 hours after midday (16;00 p.m.). This range does not represent the entire duration of daylight at the latitude of Hyderabad at 17.39°, but is adequate to show the two limits of the interval for performing the *ᶜaṣr* prayer. That is say, the sundial was not designed to show time in regular intervals from sunrise to sunset, but only to indicate the times of the *ᶜaṣr* prayer, that too in the traditional Indian units of *ghaṭīs*. These are converted into hours in the following table.

Table Q001-1 Ghaṭīs and the equivalent hours

ghaṭīs	hours; minutes	
	forenoon	afternoon
1	11;36	12;24 ↓
2	11;12	12;48
3	10;48	13;12
4	10;24	13;36
5	10;00	14;00
6	9;36	14;24
7	9;12	14;48
8	8;48	15;12
9	8;24	15;36
10	8;00 ↑	16;00

[C]Aṣr Curves

The interval for the performance of the afternoon prayer *ᶜaṣr* commences, by definition, when the length of the gnomon's shadow at midday (n) increases by the length of the gnomon (g), i.e. when the shadow attains a length of ($n + g$); the interval concludes when the shadow reaches a length of ($n + 2g$). The times when the gnomon's shadow assumes the length of ($n + g$) and ($n + 2g$) vary as the sun's declination varies from solstice to solstice. The two variable intervals from the winter solstice to the summer solstice are represented by dotted curves on the right hand side of the dial (highlighted in green in Figure Q001.3), the first labelled as *mithl* and the second as *mithlayn.* Here the term *mithl* denotes the increase in the shadow of an amount 'equal' to the length of the gnomon (g), and the term *mithlayn* (two *mithls*) the increase of an amount of two lengths ($2g$).[1479]

[1479] Cf. Steingass 1892, s.v.: 'alike, equal …'.

The upper tips of the two curves pertain to the winter solstice and the lower tips to the summer solstice. There is a sharp bend in the lower parts of the curves; the points where the bends occur indicate the two days when the declination of the sun at midday equals the local latitude; then the sun will be overhead (zenith) at midday and the gnomon's shadow will be nil.[1480]

At Hyderabad with the latitude of 17.39°, *ᶜaṣr awwal* is at 15;10 hours at the winter solstice when the sun's declination is -23.5°; 15;22 hours at the equinoxes when the sun's declination is 0° and 15;24 hours at the summer solstice when the sun's declination is +23.5°. Likewise, at Hyderabad *ᶜaṣr thānī* is at 15;57 hours at the winter solstice when the sun's declination is -23.5°, 16;22 hours at equinoxes when the sun's declination is 0° and 16;37 hours at the summer solstice when the sun's declination is +23.5° (see Table Q001-2)

Qibla Direction

On the dial, from the point of intersection of the north-south and east-west diameters, a line is drawn in the north-westerly direction, subtending an angle of 77.27° with the midday line; it is the *qibla* line, indicating the direction of Mecca. The angle is derived as follows:

Longitude Hyderabad	$\lambda = 78.491$
Latitude of Hyderabad	$\varphi = 17.39$
Longitude of Mecca	$\lambda = 39.823$
Latitude of Mecca	$\varphi_M = 21.423$

: $\Delta\lambda = 38.668$ (difference of latitude between Mecca and Hyderabad)

Al-Bīrūni's formula for the direction of *qibla*:

$\text{Sin}(a) = \text{Cos}(\varphi)\ \text{Sin}(\Delta\lambda)$

$\text{Sin}(\varphi_1) = \text{Sin}(\varphi) / \text{Cos}(a)$

[1480] This occurs only at places where the local latitude is less than the obliquity of the ecliptic (which is roughly placed at 23;30°). Thus these bends can be seen in the sundial at Pulicat (Q003) which lies on latitude 13;25° and in the sundial at Srirangapatna (Q006) on the latitude of 12;26°. At Mecca this happens on 16 July and 28 May every year, when the sun's declination equals the latitude of Mecca and the gnomon casts zero-length shadow; this helps in finding direction of *qibla* from most parts of the world.

$f = (\varphi_1) - \varphi_M$

Cos (d) = Cos (f) Cos(a)

Sin (q) = Cos(φ_M) Sin ($\Delta\lambda$) / Sin (d)

"a"= 36.6017

"d"= 36.6039

"Sin (q)"= 0.9754

Angle with respect to north-south Line = q = 77.27°

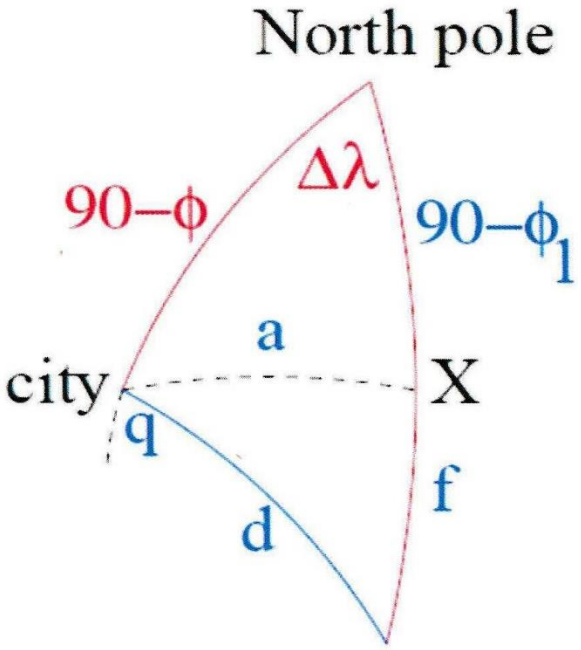


Figure Q001.4 – Computation of the qibla
(drawing by Mubashir Ul-Haq Abbasi)

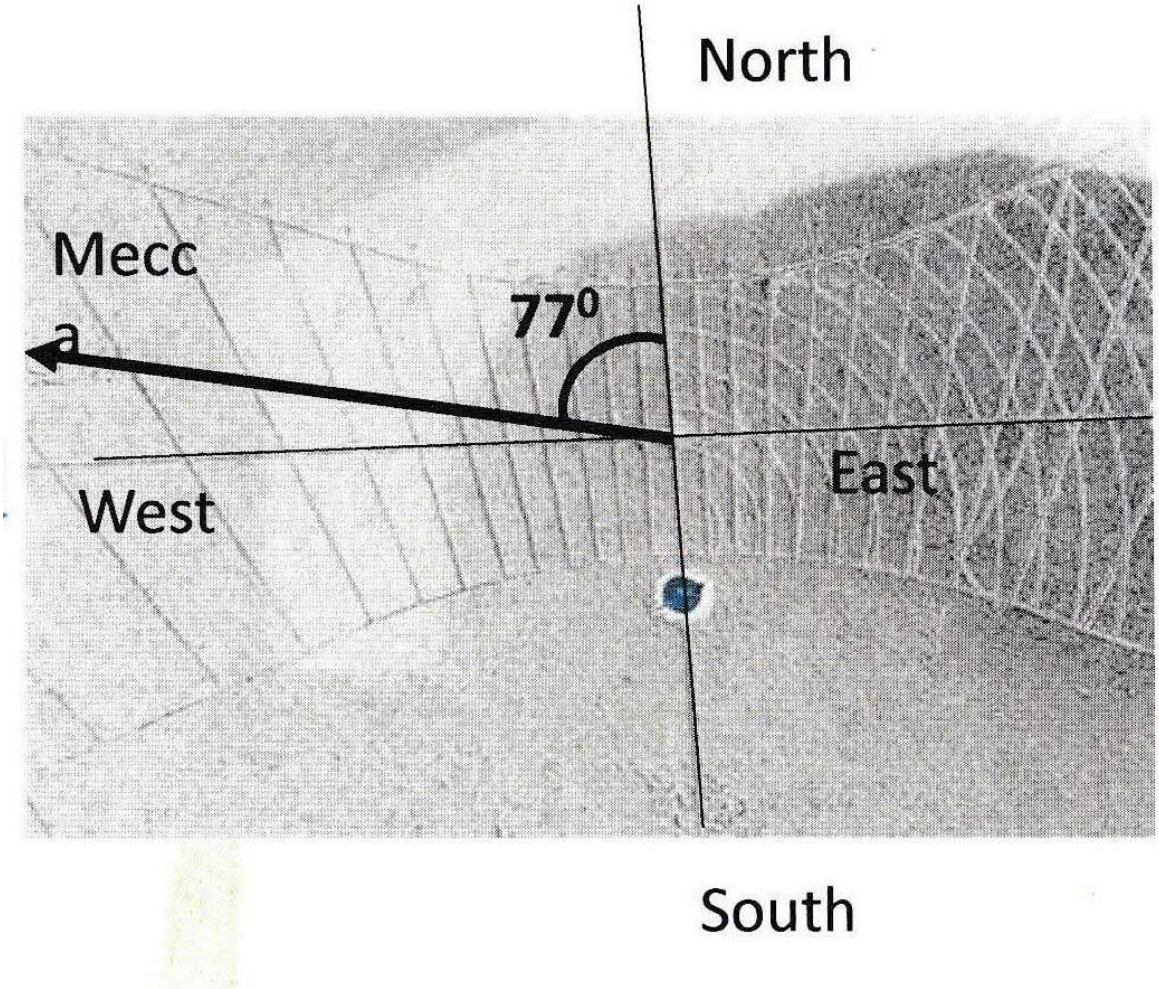


Figure Q001.5 – Qibla direction marked on the dial (detail of Figure Q001.2)

INSCRIPTION

On the southern half of the midday line, an inscription is engraved in two lines, one above the line and the other below it. Due to the erosion of the surface of the dial, the inscription is difficult to decipher completely. It reads, in parts, as follows:

ba-ḥukm haḍrat ẓill allāh (?) abū al-muzaffar mohy al-dīn muḥammad ᶜālamgīr

bādshāh …

ᶜamal khane qara (?) mīr qāsim al-ᶜarḍ balad haidarābād .. sanah 36 julūs mubārak

‘By the order of His Majesty … Abū al-Muzaffar Muhy al-Dīn Muḥammad ᶜĀlamgīr Bādshāh

Made by … Mīr Qāsim for the latitude of the city of Hyderabad in the blessed regnal year 36 …’

Table Q001-2 Length of the gnomon's shadow at midday, at *ᶜAṣr awwal* and *ᶜAṣr thānī*. (latitude 17.39° - gnomon height 7 units)

Midday			***ᶜAṣr awwal***			***ᶜAṣr thānī***		
Sun's Declination	Sun's Altitude	Gnomon Shadow (n)	Gnomon Shadow (n +7)	Sun's altitude	Time	Gnomon Shadow (n + 14)	Sun's Altitude	Time
-23.5	49.11	**6.1**	**13.1**	28.19	15:10	**20.1**	19.24	15:57
-18.5	54.11	**5.1**	**12.1**	30.12	15:15	**19.1**	20.16	16:04
-13.5	59.11	**4.2**	**11.2**	32.03	15:19	**18.2**	21.05	16:10
-8.5	64.11	**3.4**	**10.4**	33.95	15:21	**17.4**	21.92	16:15
-3.5	69.11	**2.7**	**9.7**	35.90	15:22	**16.7**	22.78	16:19
0	72.61	**2.2**	**9.2**	37.29	15:22	**16.2**	23.38	16:22
3.5	76.11	**1.7**	**8.7**	38.72	15:22	**15.7**	23.99	16:24
8.5	81.11	**1.1**	**8.1**	40.85	15:19	**15.1**	24.88	16:26
13.5	86.11	**0.5**	**7.5**	43.12	15:14	**14.5**	25.81	16:27
18.5	88.89	**0.1**	**7.1**	44.45	15:12	**14.1**	26.34	16:29
23.5	83.89	**0.7**	**7.7**	42.09	15:24	**14.7**	25.39	16:37

Q002 SUNDIAL & ᶜAṢR INDICATOR BY ḤĀFIẒ ANWAR ᶜALĪ SIDDIQĪ RUHTAKĪ, 1245 AH (AD 1829-30)

Dimensions 460 x 450 mm

Delhi, Jama Masjid, forecourt

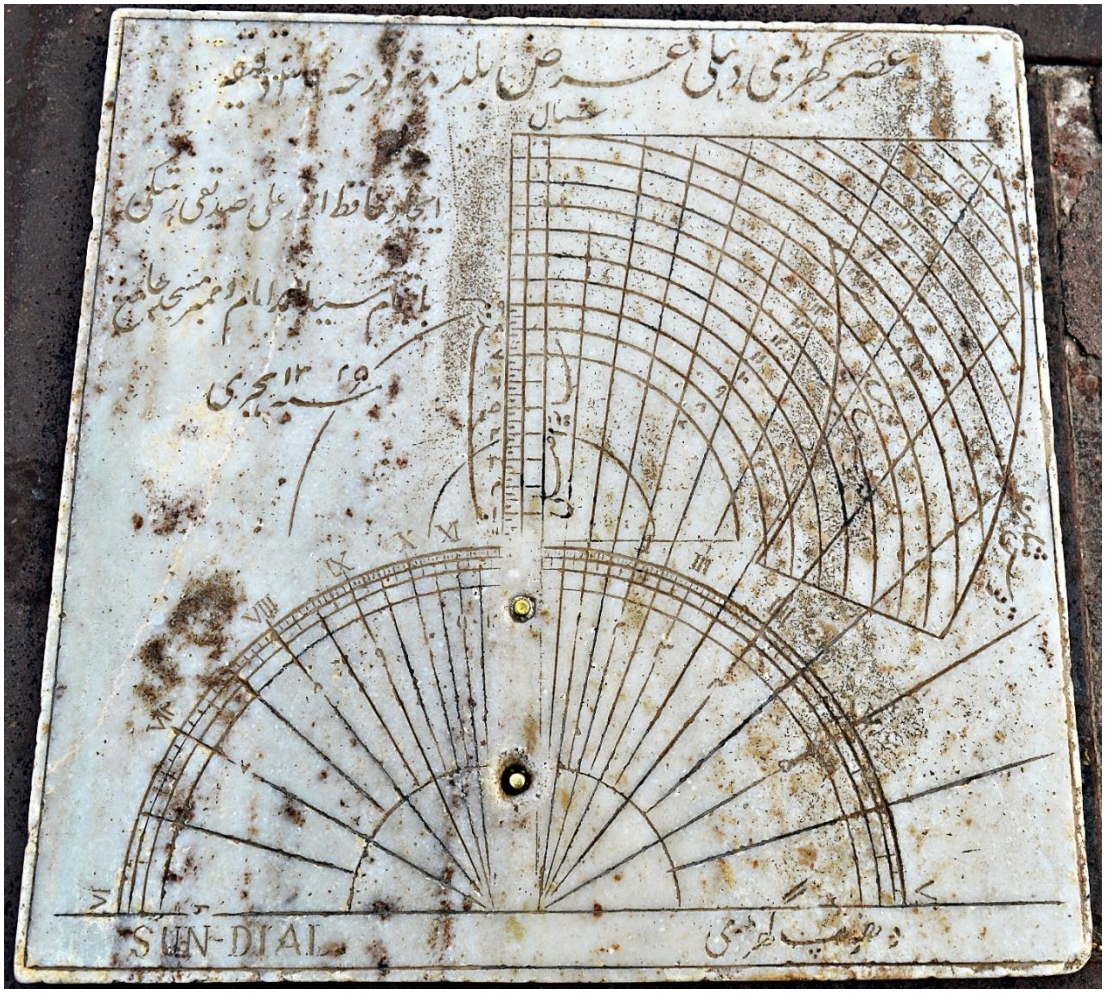


Figure Q002.1 – Sundial (photo by Debasish Das)

This sundial is located in the south-east corner of the forecourt of the Jama Masjid at Delhi. It can be seen on the left hand side as one enters the mosque through the man eastern gate. The inscription states that it was made by Ḥāfiẓ Anwar ᶜAlī Siddiqī of Rohtak under the supervision of Saiyid Aḥmad, the Imām of the congregational mosque at Ajmer in 1245 AH (= AD 1829-30). As mentioned in the introduction to this section, it may have been set up at the instance of Prince Mīrzā Salīm.

The following description of this sundial rests on the technical explanation of the projected lines and the decipherment of the inscriptions kindly provided by Mubashir Ul-Haq Abbasi; these are reproduced here with slight rearrangement of the material and minor changes in wording.



Figure Q002.2 – Sundial with the pedestal (photo by Debasish Das)

PEDESTAL

The sundial engraved on a marble slab is set up on the right hand side upon a pedestal made of red sand-stone. The pedestal is 470 mm high and the upper surface measures 1190 x 460 mm. There must have been another marble sundial of the same size on the left as well, but it is missing now and its place is empty. It is not known what type of dial was engraved on it. The red sand-stone covering the pedestal is decorated on all four sides with a row of arches below and cartouches above, both carved in low relief.

PLAQUE

At the bottom of the marble plaque, the name of the dial is given in English as 'SUN-DIAL' and in Urdu as *Dhūp-Ghaḍī.* The name engraved at the top reads *ᶜAṣr Ghaḍī Dihlī ᶜarḍ balad 28 darjah 39 daqīqah,* 'ᶜAṣr Clock for the city of Delhi at the latitude of 28 degrees and 39 minutes.' The use of the terms *ghaḍī,* derived from the Sanskrit *ghaṭī,* in the sense of 'clock' and *dhūp* in the sense of 'sunlight' indicate that the language of the inscriptions on this sundial should be regarded as Urdu rather than Persian. It is interesting that the latitude of Delhi is given as 28;39°; this is the same

value assigned by Malayendu Sūri in his commentary on Mahendra Sūri's *Yantrarāja* which was composed in 1370.[1481]

As stated in the captions at the bottom and at the top, the dial consists of two parts; in the lower half is a sundial to measure time from sunrise to sunset in equal hours and in the upper right a diagram to indicate the beginning and end of the interval for the *ᶜaṣr* prayer.

DHŪP GHAḌĪ

The *Dhūp Ghaḍī* (sundial) in the lower half is drawn in the form of a semicircle with a radius of 160 mm. It is marked with hour lines from 6 a.m. to 6 p.m., arranged clockwise and numbered in Roman and common Arabic/Persian numerals. The scale is marked for ½ hours and for 5 minutes. The missing gnomon presumably had the form of a right triangle, with a base of 160 mm, equal to the radius of the semicircle, and the vertical side of about 86 mm, the hypotenuse pointing to the north pole.

Procedure of drawing the hour lines

The angles between the hour lines are obtained by the formula $\tan \alpha = \sin \varphi \cdot \tan \beta$, where α is the angle between the hour line and the line of the midday and β stands for time units expressed as arc degrees.

a. Time t = 1, 2, 3, 4, 5 hours before and after midday

b. Time units expressed as arc degrees: 1 hr = 15°, 2 hrs = 30°, … 5 hrs = 75°.

c. By substituting the latitude value of 28;39° (= 28.65°) and the angles 15° etc., successively, we obtain the angles between the hour lines as 7.3°, 15.4°, 25.4°, 39.5°, 60.6°.

d. The vertical line at the centre is the hour line for 12;00 hrs (midday). The other hour lines are drawn from this line at angles listed in c.

[1481] Cf. Malayendu Sūri, pp. 16-18, 23, et passim; see also Apx.D1. The same value is given also in the *Yantraprakāra* which was compiled between 1716 and 1724 at the court of Sawai Jai Singh of Jaipur; cf. Sarma 1986-87b, pp. 76-77, 115; see also the introduction to N. Palabhā-yantra.

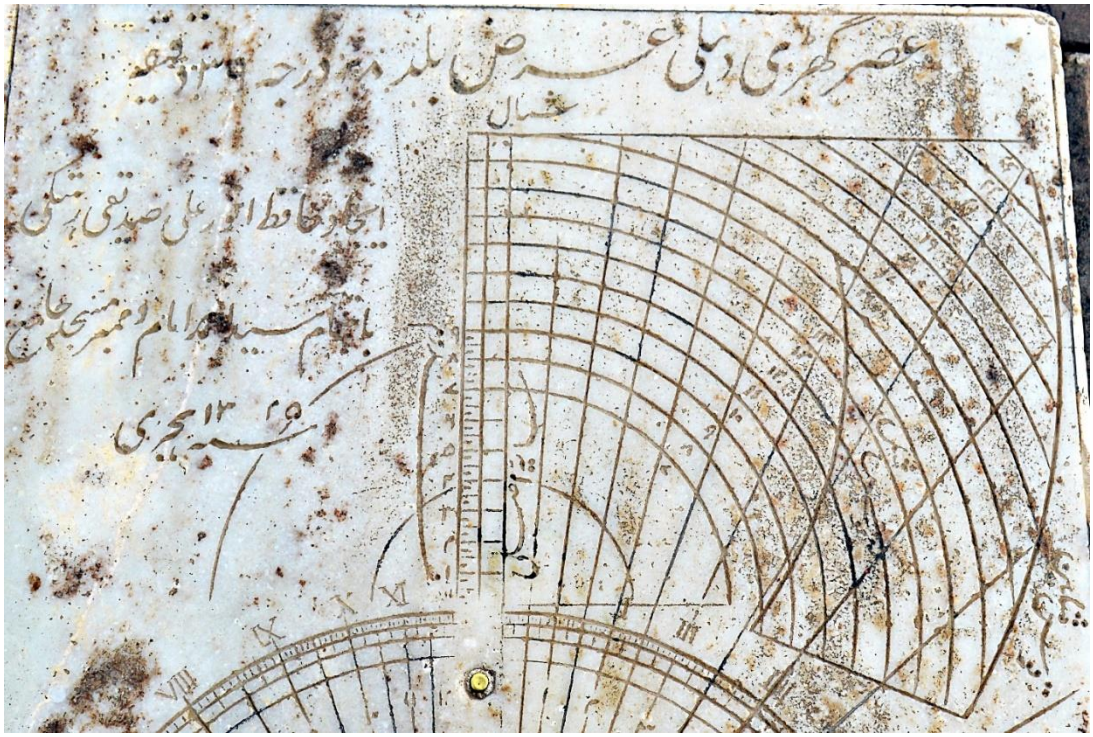


Figure Q002.3 – ᶜAṣr Dial (detail of Figure Q002.1)

ᶜAṢR GHAḌĪ

The interval for the *ᶜaṣr* prayer commences when the length of the gnomon shadow equals the length of the gnomon shadow at midday plus the length of the gnomon ($n + g$); it ends when the length of the gnomon shadow equals the length of the gnomon shadow at midday plus double the length of gnomon ($n + 2g$). These times are variable according to the declination of the sun.

The *ᶜAṣr Ghaḍī* consists of concentric arcs drawn with their centre at the point on the semi-circle of the sundial at which the line for 12;00 hours clock terminates. From this centre rises a vertical scale, in continuation of the hour line for middayin the sundial; it is divided into 16 units, each unit representing one foot of the 'vertical' gnomon of seven feet. The lower part of this scale is numbered from 1 to 9, and each unit is divided in ½ s and ¼ s. On the left is written *qadūm* (feet). The nine units represent the maximum length of the gnomon shadow when the sun is at the zenith at the latitude of Delhi. On the right is written *sāyah aṣlī* (real shadow or original shadow) indicating 9 units on the scale which is the length of the gnomon shadow at midday.

In order to draw these lines, the length of the gnomon shadow when the sun is at the zenith is obtained as follows. First, the sun's altitude is calculated by the formula

sun's altitude = 90 – latitude + declination of the sun

The latitude of Delhi is 28.65° and the declination of the sun varies from -23.5° to 0° and + 23.5°. For these three values, the solar altitudes at midday will be

sun's altitude (winter solstice) = 90 - 28.65 + (-23.5) = 90 - 28.65 - 23.5 = 37.85°

sun's altitude (equinox) = 90 - 28.65 + (0) = 90 - 28.65 = 61.35°

sun's altitude (summer solstice) = 90 - 28.65 + (+23.5) = 90 - 28.65 + 23.5 = 84.85°

If the sun's altitude is known, the length of the shadow of the gnomon of 7 feet or units is

S = 7 ÷ tan (altitude)

Therefore, the shadow lengths for the three values of the solar altitude calculated above are

S1 = 7 ÷ [tan (37.85)] = 9.00 units

S2 = 7 ÷ [tan (61.35)] = 3.8 units

S3 = 7 ÷ [tan (84.85)] = 0.6 units

S1 and S2 are represented by semicircles on the dial. S1 indicates the length of the shadow of the 7 unit gnomon at the winter solstice when the declination is - 23.5° and the shadow at midday is the longest; on the scale it is shown as 9 units. S2 indicates the length of the shadow at the equinoxes when the declination is zero and the shadow is the shortest; on the scale it is shown as 3.8 units.

Commencement of the Interval for the ᶜAṣr Prayer (*ᶜaṣr awwal*)

As stated above, the interval for the *ᶜaṣr* prayer commences when the length of the gnomon shadow equals $n + g$. Therefore,

a. when the sun's declination is - 23.5°, the shadow length will be 9 + 7 = 16 units on the scale.) : S1 + 7 = 9 + 7 = 16 units;

b. when the sun's declination is 0°, the shadow length will be 3.8 + 7 = 10.8 units;

c. when the sun's declination is + 23.5°, the shadow length will be 0.6 + 7 = 7.6 units.

Arc to indicate the Commencement of the Interval for the ᶜAṣr Prayer

On the upper right of the dial, quarter circles are drawn at 3.8 units when the gnomon shadow will be at the lowest, at 7 which represents the height of the gnomon, then at each unit up to 23 units when the shadow length will be maximum and these are numbered from 7 to 23.

The commencement of the interval for the *ʿaṣr* prayer in different seasons is represented by the arc entitled *qaws mithl* ([midday shadow length + length] equal [to the height of the gnomon][1482]). It commences at a point on the quarter circle for 16 units, corresponding to the time of 14;51 hours on the sundial.

The reason why this particular point on the quarter circle for 16 units corresponding to 14;51 hours on the sundial is chosen as the initial point is as follows: the sun moves between -23.5° and +23.5°. These two extreme values of declination mark the two extreme points.

a. When the declination of sun is - 23.5, then a 7-unit gnomon will cast a shadow of 9 units at local midday

b. The *ʿaṣr* prayer commences when the shadow has a length of 16 units (= 7 + 9 = length of gnomon + its shadow at midday).

c. Therefore, one has to find the time when the shadow will have a length of 16 units and also the sun's altitude at this point of time.

d. In a right triangle with a vertical side of 7 units and a base of 16 units, the tangent of the angle of elevation will be 7 ÷ 16; from this is obtained the angle of 23.6°. This is the altitude of the sun at this time.

e. Now the sun's altitude is 23.6°, the declination is - 23.5, and the local latitude 28.65°. By applying the cosine formula of spherical trigonometry, these values will lead us to the time of 09;09 hours before midday and 14;51 hours afternoon; since the *ʿaṣr* is offered only in the afternoon, the time of 09;09 hours in the forenoon should be ignored.

In the same manner, it can be determined that when the sun's declination is + 23.5°, the corresponding time is 15;32 hours. A point corresponding to 15;32 hours in the quarter circle of 16 units is the end point of the arc *qaws mithil.* This means that at the latitude of Delhi, the commencement of the *ʿaṣr* prayer varies from 14;51 to 15;32 hours according to the season (see Table Q002-1).

[1482] Cf. Steingass 1892, s.v.: 'alike, equal …'.

Conclusion of the Interval for the ᶜAṣr Prayer (*ᶜaṣr thānī*)

The intervals for the *ᶜaṣr* prayer ends when the length of the gnomon shadow equals the length of the gnomon shadow at midday plus twice the height of the gnomon which is 7 feet or units.

a. When the sun's declination is - 23.5°, the length of the shadow will be 9 + 14 = 23 units on the scale. By using the similar procedure we find the altitude of sun (= 16.92°) when a 7 unit gnomon casts a shadow equal to 23 units. We use cosine formula to find the time when the sun will be at the altitude of 16.92° by using the latitude of Delhi and declination of sun (-23.5°)

b. When the sun's declination is 0°, the shadow length will be 3.8 + 14 = 17.8 units and hence altitude of Sun = 21.44°. By applying the altitude, latitude and declination values in the cosine formula, we find the time to be 16;22 hours.

c. When the sun's declination is + 23.5°, the shadow length will be 0.6 + 14 = 14.6 units and the altitude of sun 25.568°. By applying the altitude, latitude and declination values in the cosine formula, we find the time to be 16;50 hours.

Arc to indicate the Conclusion of the Interval for the ᶜAṣr Prayer

The conclusion of the interval for the *ᶜaṣr* prayer in different seasons is represented by the arc entitled *qaws mithlayn* (equal [to the midday shadow plus] twice [the height of the gnomon]) on the dial, which is engraved on the right of the arc *qaws mithl*. It commences at a point on the quarter circle for 23 units, corresponding to the time of 15;33 hours on the sundial and ends below the quarter circle for 15 units (representing shadow of 14.6 units), corresponding to 16;50 hours. This means that at the latitude of Delhi, the last time for offering the *ᶜaṣr* prayer varies from 15;33 to 16;50 hours according to the season (see Table Q002-1). There is a point-to-point link between the two arcs, because *ᶜaṣr* prayer has a time bracket which varies from minimum ~40 minutes to ~78 minutes according to the seasons.

Therefore, for knowing the times for the *ᶜaṣr* prayer, one has to notice first the shadow length at midday on a given day. Supposing it is 8 units on the given day, the interval for the *ᶜaṣr* commences at the point where the quarter circle for 15 units (8 + 7) intersects the arc of commencement and looks at the corresponding time on the scale of the sundial; it will be exactly 15;00 hours on this day; likewise the *ᶜaṣr* prayer should preferably be offered on this day before 16;30 hours.

INSCRIPTIONS

1. Inscription at the top of the plate:

ᶜaṣr ghaḍī dihlī ᶜarḍ balad 28 darjah 39 daqīqah
'ᶜAṣr Clock for the city of Delhi at the latitude of 28 degrees and 39 minutes'

2. Inscription in the upper right:

ījād ḥāfiẓ anwar ᶜalī siddiqī ruhtakī
ba-ihtamam saiyid aḥmad imām ajmīr masjid jāmiᶜ
sanah 1245 hijrī
'the creation of Ḥāfiẓ Anwar ᶜAlī Siddiqī of Rohtak
under the supervision of Saiyid Aḥmad, the Imām of the congregational mosque at
Ajmer,
[in the] year 1245 Hijrī (= AD 1829-30).'

3. Inscription at the bottom:

SUN-DIAL *dhūp ghaḍī*
'Sundial (in English and Urdu)'

Table Q002-1 Length of the gnomon's shadow at midday, at *ᶜAṣr awwal* and at *ᶜAṣr thānī* (latitude 28;39° - gnomon height 7 units)

Midday			***ᶜAṣr awwal***			***ᶜAṣr thānī***		
Sun's Declination	Sun's altitude	Gnomon Shadow (n)	Gnomon Shadow (n +7)	Sun's altitude	Time	Gnomon Shadow (n + 14)	Sun's Altitude	Time
-23.5	37.85	**9.0**	**16.0**	23.62	14:51	**23.0**	16.92	15:33
-18.5	42.85	**7.5**	**14.5**	25.70	15:1	**21.5**	18.00	15:45
-13.5	47.85	**6.3**	**13.3**	27.69	15:10	**20.3**	18.99	15:57
-8.5	52.85	**5.3**	**12.3**	29.64	15:17	**19.3**	19.93	16:7
-3.5	57.85	**4.4**	**11.4**	31.55	15:24	**18.4**	20.83	16:16
0	61.35	**3.8**	**10.8**	32.89	15:27	**17.8**	21.44	16:22
3.5	64.85	**3.3**	**10.3**	34.24	15:30	**17.3**	22.05	16:27
8.5	69.85	**2.6**	**9.6**	36.19	15:33	**16.6**	22.90	16:34
13.5	74.85	**1.9**	**8.9**	38.20	15:34	**15.9**	23.77	16:40
18.5	79.85	**1.3**	**8.3**	40.30	15:34	**15.3**	24.65	16:46
23.5	84.85	**0.6**	**7.6**	42.53	15:32	**14.6**	25.57	16:50

Q003 SUNDIAL BY MUḤAMMAD ᶜABD ALLĀH AḤQAR, 1334 AH (AD 1915-16)

Dimension 250 x 200 mm

Pulicat, Tamilnadu, Al-Masjid al-Musharraf



Figure Q003.1 – Sundial (photo by Premnath, M. S., courtesy Debasish Das)

This sundial is set up on a square pedestal in front of the mosque al-Masjid al-Musharraf, also known as Chinna Pallivasal (small place of worship) at Pulicat (13;25° N 80;19° E) on the southern border of Tamilnadu.

This mosque was established by Muḥammed Bīr Ṣāḥib, Muḥammed ᶜAlī Nainā Ṣāḥib and Muḥammad Bīr Bakkīr Ṣāḥib in 1708. The sundial, however, was added only in 1334 AH (AD 1915-16) at the behest of Ḥājī Muḥammad Hussayn Ṣāḥib of Chennai. It was made by Muḥammd ᶜAbd Allāh, under the supervision of Mawlvī Ḥājī Maḥmūd.



Figure Q003.2 – Pedestal of the sundial (photo by Premnath, M. S., courtesy Debasish Das)

The sundial is engraved on a brass plate which is affixed to the masonry platform. There is a semi-circular arc with the time scale to measure hours from 6 a.m. to 6 p.m. The scale is divided in hours, half-hours and quarter-hours. There are no hour lines connecting the divisions on the scale with the centre of the semi-circle, as in other sundials (at Delhi and Patna). The hour marks are numbered clockwise with Arabic/Persian numerals from 6 to 12 and then from 1 to 6.

A triangular gnomon made of a thick brass sheet is attached to the vertical radius of the semi-circle, from the centre to the outer circumference. In this gnomon, the

hypotenuse of the triangle subtends an angle to the base which is equal to the terrestrial latitude of the place, namely 13;25°.

Above the semi-circular time scale, two *ᶜaṣr* curves are engraved in the upper right. The second curve is longer than the first curve. The first curve indicates the time when the shadow of the gnomon exceeds the its shadow at midday (*n*) by the length of the gnomon (*g*); it is labelled as *ᶜaṣr awwal shāfī* (first [time limit] of the *ᶜaṣr* according to the Shāfī [school of jurisprudence]). The second curve, which is longer, shows the time when shadow of the gnomon is equal to *n* + 2g; it carries the label *ᶜaṣr thānī ḥanīfī* (second [time limit] of the *ᶜaṣr* according to the Ḥanafī [school of jurisprudence]).[1483]

As in the sundial at Hyderabad (Q001), there are sharp bends in the lower part of the two *ᶜaṣr* curves. The points where there bends occur indicate the days when the declination of the sun at midday equals the local latitude; then the sun will be overhead (zenith) at midday and the gnomon's shadow will be nil.

INSCRIPTIONS[1484]

On the upper left corner is engraved the following inscription in four lines:

qāᶜydah ᶜaṣr awwal wa thānī ke liye maqyās ke siray ke sāyah
se waqt lijya. ḥasb farmāish janāb ḥājī muḥammad hussayn ṣāḥib
bin qādir ṣaḥib sākin mutyālpet
madrās

'Method [for finding the times of the] first and second [limits of] the *ᶜaṣr* [prayer].
The shadow of the tip of the gnomon
will give the time. [It was set up] at the behest of respected Ḥājī Muḥammad Ḥussayn Ṣāḥib,
son of Qādir Ṣāḥib, resident of Muthialpet,
Madras.'

1483 According to Mubashir Ul-Haq, the interval between the two limits is longer than the actual time required for the payer which is about fifteen minutes. Therefore, the devotees can generally offer their prayer at any time between the two limits. The Shāfī schools prefers the first half of the interval (*ᶜaṣr awwal*, or *ᶜaṣr Shāfī*), while the Hanafi school prefers the second half of the interval (*mithlayn*, *ᶜaṣr thānī*, or *ᶜaṣr Ḥanīfī*).

1484 Mubashir Ul-Haq Abbasi has kindly deciphered and translated the inscriptions.

Inside the semicircle is engraved to the left and right of the gnomon

ba-taṣḥīḥ ḥaḍrat mawlvī ḥājī maḥmūd ṣāḥib

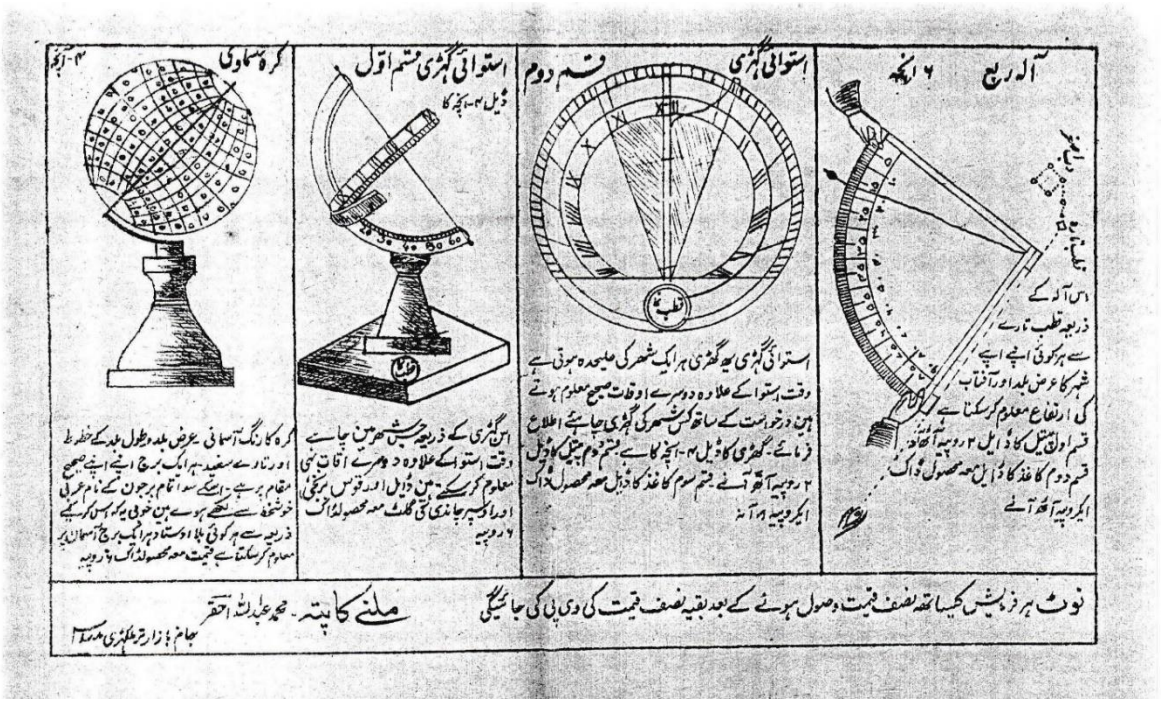
tayār kardah muḥammad ᶜabd allāh aḥqar 1334 hijrī

‘With the corrections by the honourable Mawlvī Ḥājī Maḥmūd,

‘made by the humble (*aḥqar*) Muḥammd ᶜAbd Allāh [in]1334 Hijrī.’

Commercial Production of Instruments

It appears that Muḥammad ᶜAbd Allah Aḥqar commercially produced astronomical instruments with Urdu legends and offered them for sale, as can be seen from the following pamphlet, which was kindly sent by Ahmed Athaullah, Hyderabad.



The descriptions of the instruments are translated from Urdu by Mubashir Ul-Haq Abbasi.

[1] Celestial globe (*kurah samāwī*) 4 inches

The globe is sky-blue in colour, the lines of latitudes and longitudes, and the stars are in white. Every constellation is at its appropriate place; in addition, all the names of the constellations are written in Arabic in good legible handwriting. The advantage is that with this one can identify each constellation in the sky without the help of a teacher. Price with postal charges 6 rupees.

[2] Equatorial Sundial (*istiwāī ghaḍī*), type one

With this clock one can find other times also besides the equatorial time. Dial and arc are of brass and on it is silver gilt. With postal charges 6 rupees.

[3] Equatorial Sundial (*istiwāī ghaḍī*), type two

This clock is different for each city. Apart from the equatorial time other times can be found correctly. Mention the city for which the clock is required. The dial of the clock is 4 inches. Type two brass dial 2 rupees 8 annas, type three paper dial with postal charges 1

rupee 8 anna

[4] Quadrant (*ālah rubᶜ*) 6 inches

One can find the latitude of one's own city and the altitude of the sun with this instrument by using the Pole Star. Type one is brass dial [for] 2 rupees 8 annas, type two paper dial, with postal charges 1 rupee 8 annas.

Note: Remit half of the price with the order; the instrument will be sent by VPP for remaining half of the price. Address for procurement: Muḥammad ᶜAbd Allah 'Ahqar', Jam Bazar, Tarmalkehri, Madras.

BIBLIOGRAPHY

Pulicat & Sadras : Confluence of History, Culture & Environment, [prepared by the Department of Architecture, Anna University, Chennai; sponsored by the Dutch Embassy in India; and published by] Anameka Architects & Designers, Chennai 2010, pp. 70-71.

Q004⊙ SUNDIAL BY SHAH FARIDUL HAQUE EMADI, NOT DATED

20th century, second half

Side of the octagon152 mm

Patna, Managal Talab, Khanqah Emadia



Figure Q004.1 – Horizontal sundial (photo by S. R. Sarma)

This elegantly crafted sundial was made by Shah Faridudul Haque Emadi, the head of the Khanqah, which is a Ṣūfī seminary and a place of worship. The sundial is set up on the roof of the mosque. It consists of an octagonal metal plate, with each side measuring 152 mm, which is embedded into a stone slab. The triangular gnomon is made of brass; its base measures 240 mm and the hypotenuse 270 mm and the angle between the two corresponds to the latitude of Patna at ca. 26°. From the surface of the hypotenuse rises a vertical pin with a pointed tip; its function is not known. The dial is engraved with lines for each hour and each quarter hour. The hour lines are numbered from 5 [am] to 7 [pm] in common Arabic/Persian numerals.

Two horizontal lines are drawn to the east and west of the gnomon at different levels; their function is not known. The cardinal directions east and west are labelled as

al-mashriq wa al-maghrib; al-mashriq is engraved on the east and *wa al-maghrib* on the west. At the north point is engraved *Allāh.* There is no label at the south point.

On the eastern side there are two long curves: these are formed by the words *ẓuhr* and *ᶜaṣr* with elongated strokes, to indicate the times of the midday prayer *ẓuhr* and the after-noon prayer *ᶜaṣr.*



Figure Q004.2 – Inscription (photo by S. R. Sarma)

INSCRIPTION

On the left half of the dial is engraved, in ornate calligraphy, the 38th verse of the 36th chapter of the Qur'an, which translates thus:

> 'And the sun runs his course for a period determined for him: that is the decree of (Him), the Exalted in Might, the All-Knowing.' [1485]

I saw the sundial and photographed it in 1991. Subsequently, I understand, it was removed from its pedestal on the roof and the gnomon was lost.

[1485] I am grateful to Mubashir Ul-Haq Abbasi for explaining the inscription and for providing the translation by Abdullah Yusuf Ali.

Q005 SUNDIAL SET UP BY TIPU SULTAN, 1782

Diameter of the dial 533 mm; height of the pedestal 2.057 m

Srirangapatna, Jamia Masjid or Masjid-i Aᶜlā



Figure Q005.1 – Sundial (photo by Ejaz Ahmed, courtesy Debasish Das)

Tipu Sultan (1750-1799) built at Srirangapatna (Lat. 12;26° N; Long. 76;35° E), near Mysore, a mosque named Masjid-i Aᶜlā or Jamia Masjid in about 1782 and set up a circular sundial atop a vase-shaped ornate pedestal.

The black stone on which the dial is engraved is highly eroded. All that can be seen is a series of nineteen concentric circles to measure the length of the shadow cast by a 7-unit gnomon; these circles are apparently numbered along a radial line. Upon these circles are drawn eight diameters at equal intervals; their tips indicate the cardinal and the intermediate directions. At ends of these eight diameters, there are labels engraved inside rectangular boxes, presumably the names of the compass points. On the left hand side of the dial, there are faint traces of a curve with a sharp bend; it represents *ᶜasr awwal.*

There appears to be much writing in Persian, but nothing can be deciphered. The gnomon is missing.



Figure Q005.2 – Pedestal of the sundial
(photo by Ejaz Ahmed, courtesy Debasish Das)

Q006 SUNDIAL SET UP BY TIPU SULTAN, CA. 1782

Dial 635 x 483 mm; height of the pedestal 940 mm

Srirangapatna, Mausoleum, commonly known as Gumbaz



Figure Q006.1 – Sundial (photo by Ejaz Ahmed, courtesy Debasish Das)

Tipu Sultan (1750-1799) built at Srirangapatna (Lat. 12;26° N; Long. 76;35 E), near Mysore, a mausoleum for his father, which is popularly known as the Gumbaz (dome). He set up a sundial engraved on a square plate of black stone atop a plain square pillar. The sundial has the same design as the one at his mosque (Q005) with nineteen concentric circles to measure the length of the shadow of the 7-unit gnomon, and eight diameters, their tips indicating the compass points. On the left hand side, there are faint traces of two curves of the *ʿaṣr awwal* and *ʿaṣr thānī*; the former has a sharp bend on the 7th circle and the latter on the 14th circle. These points indicate the two days when the sun's declination equals the local latitude and the length of the gnomon's shadow at midday becomes zero, at *ʿaṣr awwal* 0 + 7 units and at *ʿaṣr thānī* 0 + 14 units. There is much writing in Persian, but nothing of it is decipherable. The gnomon is missing.

Q007 SUNDIAL, NOT SIGNED, NOT DATED[1486]

Late 18th or early 19th century

Diameter ?

Jaipur, Khanqah of Hazrat Maulana Ziauddin Sahab



Figure Q007.1 – Sundial (photo by Syed Ziauddin Ziai)

This sundial is set up on the terrace of the Khanqah founded by the Ṣūfī saint Hazrat Maulana Ziauddin Sahab (1730-1816). He was born in Delhi, but migrated to Jaipur during the reign of Sawai Ram Singh (r. 1778-1803) who received him with veneration.

The sundial is marked with 17 *ghaṭī* lines on either side of the triangular gnomon, for measuring time from 2 *ghaṭīs* before sunrise to 2 *ghaṭīs* after sunset. It is obviously made in imitation of the *Palabhā-yantras* which were prevalent in Jaipur (e.g., N001, N005 and N006). The *ghaṭī* lines here are not numbered. Two faint marks in the shape of x can be seen on the 8th line to the left of the midday point and on the 7th line to its right; the purpose of these marks is not known.

[1486] Entry based on the photo and information kindly provided by Debasish Das.

Q008⊙ SUNDIAL, NOT SIGNED, 1246 AH (AD 1830)

Diameter 285 mm

Hyderabad, State Museum of Archaeology (#P. 2266)



Figure Q008.1 – Horizontal sundial (photo by S. R. Sarma)

Circular marble dial with a brass gnomon (length 190 mm) made for the latitude of Hyderabad at 17;30°. The dial is marked with lines for each hour and each ¼ hour; it is designed to show time from 5:30 am to 6:30 pm.

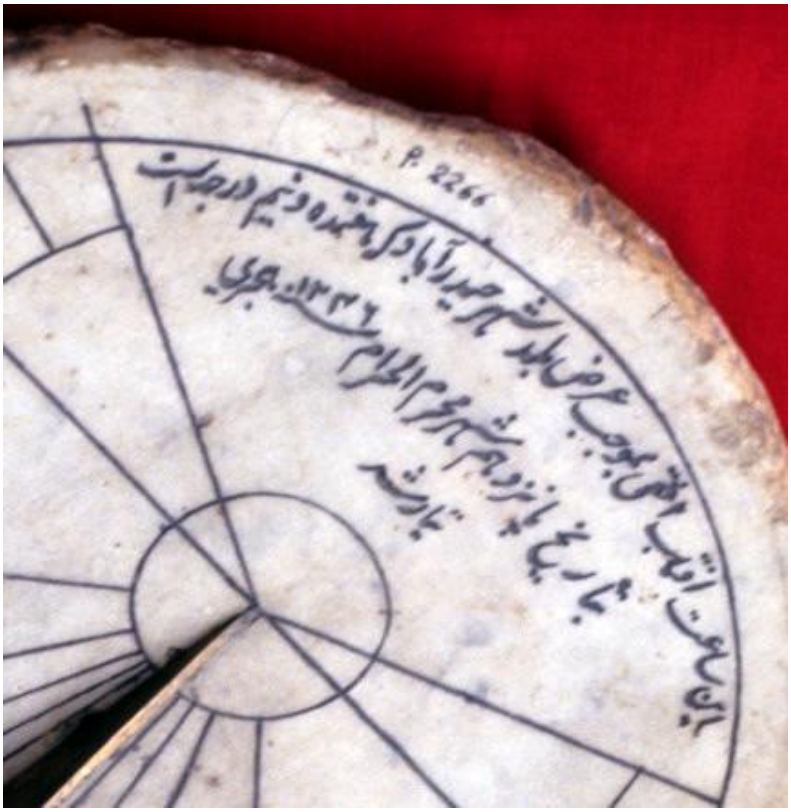


Figure Q008.2 – Inscription (photo by S. R. Sarma)

INSCRIPTION[1487]

این ساعت آفتاب افقی بموجب عرض بلد شهر حیدرآباد که هفتده و نیم درجه است بتاریخ پانزدهم شهر محرم الحرام سنه 1236 هجری تیار شد

‘This horizontal sundial (*sāᶜt āftāb afqī*) was prepared according to the latitude of the city of Hyderabad which is seventeen and half degrees, on the date fifteenth of the holy month Muharram of the year 1246 Hijrī.’

The date corresponds to 5 July 1830.

[1487] I am grateful to Professor Mohammad Bagheri for deciphering and translating this inscription.

Q009⊙ SUNDIAL, NOT SIGNED, 1294 AH (AD 1877)

Diameter 610 mm

Patna, Firdaus Manzil



Figure Q009.1 – Horizontal sundial (photo by S. R. Sarma)

This stone horizontal dial, set up on a square brick pedestal, is designed exactly in the same manner as the previous specimen (Q008), with the dial marked for each hour and each ¼ hour. The hours are numbered in modern numerals from 6 (am) to 7 (pm).

The original triangular gnomon is replaced by a vertical rod which is erected at the centre of the dial.

Q010⊙ SUNDIAL, NOT SIGNED, NOT DATED

20th century

Dimensions ?

Lucknow, in the courtyard of the house of a Ḥakīm



Figure Q010.1 – Horizontal sundial (photo by S. R. Sarma)

This sundial is set up in the courtyard of the house of a Ḥakīm (traditional Muslim physician); it is marked with lines for hours.

Q011⊙ SUNDIAL, NOT SIGNED, NOT DATED

19th century

Diameter 138 mm

New Delhi, National Museum (# 56.98/C)



Figure Q011.1 – Horizontal sundial (photo by S. R. Sarma)

The dial is set up on a 41 mm high stand with three balustrade-shaped legs. The gnomon is decorated with engraved wavy lines on the edges. The hypotenuse of the gnomon measures 132 mm and subtends an angle of about 28° which is roughly the latitude of Delhi. The gnomon can be folded flush with the surface of the dial when not in use. At the centre of the dial is a depression in which a magnetic compass is incorporated for correctly positioning the sundial with the gnomon in the north-south line. A circular lid covers the compass when not in use.

The rim of the dial is marked for hours, half-hours and quarter-hours and numbered from 6 (am) to 12 (noon) and from 1 (pm) to 6 (pm) in both Roman and common Arabic/Persian numerals. The workmanship is very good.



Figure Q011.2 – View from the top (photo by S. R. Sarma)

Q012⊙ UNIVERSAL EQUINOCTIAL SUNDIAL, NOT SIGNED, NOT DATED

19th century

Diameter 172 mm

Patna, Khuda Bakhsh Oriental Public Library



Figure Q012.1 – Universal equinoctial sundial (photo by S. R. Sarma)

This device consists of a circular horizontal plate of 172 mm diameter, set up on four legs of 47 mm height. The legs have adjustable screws so that the plate can be made level. To the horizontal plate is hinged another circular plate of 139 mm diameter. The inclination between the two plates can be adjusted, against a graduated arc on the side,

in accordance with the local latitude. When the angle of inclination is equal to the co-latitude of the place, then the second plate, on which the dial is engraved, will be in a plane parallel to the plane of the celestial equator. Thus it functions as an equatorial sundial. Since the instrument can be used at different latitudes, it is also universal.



Figure Q012.2 – Side view (photo by S. R. Sarma)

Time is measured on the second plate on which the gnomon throws its shadow upon a scale of hours. These hours are marked by common Arabic/Persian numerals in black enamel; these are numbered from 6 (am) on the right to 12 (noon) and then from 1 (pm) to 6 (pm). Each hour is subdivided into units of 10 minutes. There is a built-in compass for the proper orientation of the sundial.

This is a well crafted piece. The triangular gnomon can be folded back flush with the surface of the dial. The dial can be compressed to the level of the base plate. Other raised parts can also be folded back.

BIBLIOGRAPHY

Sarma 1999c.

R. WATER CLOCKS

INTRODUCTION

Water clocks have been the main devices for measuring time in India from the earliest times up to the end of the nineteenth century. Even now, they are used for measuring time of certain rituals in all the major faiths in the Indian sub-continent (see below sub-section %10).

In his monumental work *Science and Civilisation in China*, Joseph Needham classifies the ancient water clocks into three types:[1488] (i) outflow water clocks, i.e. vessels from which a certain quantity of water flows out in a specific time interval through a hole at the bottom; (ii) inflow clocks, where water from a reservoir flows into a vessel and fills it in a specific time span; and (iii) sinking bowl type, where water percolates into the bowl through a hole at its bottom and makes the bowl sink in a specific period of time.

In India, the first and the last type were used, not simultaneously but one after the other. These two types were roughly coeval with two major periods in the history of Indian astronomy: while the outflow clock was mentioned in the *Vedāṅga-jyotiṣa* and related texts, the introduction of the sinking bowl coincided with the beginnings of the *Siddhānta* astronomy.

However, both the types were designed to measure the same unit of time, namely, one-sixtieth part of the nychthemeron, and this has been the standard unit of time throughout the centuries. In the texts where the outflow water clock is mentioned, this time unit is mentioned variously as *nālikā, nālī, nāḍikā,* or *nāḍī.* For the sake of convenience, we shall use the form *nāḍī* in this catalogue. But the instrument itself is not mentioned by any name; it will be called here *Nāḍikā-yantra.* The sinking bowl type of water clock is mentioned as *ghaṭikā-yantra, ghaṭī-yantra,* or *jalaghaṭī-yantra,* and the unit of time measured by it as *ghaṭikā* or *ghaṭī.* Here also, for the sake of consistency, the instrument will be referred to as *Ghaṭikā-yantra* and the time unit as *ghaṭī.*

[1488] Needham 1959, p. 315; for a four-fold classification, see Turner 1984, p. 1 et passim.

1. NĀḌIKĀ-YANTRA

The outflow water clock is described in the *Vedāṅga-jyotiṣa*, Kauṭilya's *Arthaśāstra,* the *Śārdūlakarṇāvadāna* of the *Divyāvadāna* and *Jyotiṣkaraṇḍaka.*[1489] The descriptions here are extremely brief and not very coherent. In the absence of actual specimens, it is difficult to interpret these sources properly. Therefore, the relevant information from these sources will be summarized below, after a short introduction.

The *Vedāṅga-jyotiṣa* (also called *Jyotiṣa-vedāṅga*) is one of the ancillary texts of the Vedic corpus.[1490] It is available in two recensions, one attached to the *Ṛgveda* and the other to the *Yajurveda.* The former (the Ṛk-recension), is variously dated from *ca.* 1370 to 400 BC; the Yajus-recension is of a later period. The *Arthaśāstra* of Kauṭilya underwent several redactions. The version that is available today is said to be roughly from second century AD. The *Śārdūlakarṇāvadāna*, which forms the 33rd chapter of the Buddhist work *Divyāvadāna,* supplies some additional information. It was translated into Chinese in the third century AD, therefore, the original must belong to a period before this century.[1491]

The fourth source is the Jaina text *Jyotiṣkaraṇḍaka*; its date is also uncertain. Malayagiri, a contemporary of King Kumārapāla, wrote a commentary on it between 1150-1175 AD.[1492] In this commentary, Malayagiri states that the author of the *Jyotiṣkaraṇḍaka* is an ācārya of Valabhī (*jyotiṣkaraṇḍakasūtrakartā cacāryo vālabhyaḥ*). It would imply that the work was composed or redacted in the first council of Valabhī which took place in the latter half of the fourth century, between 360 and 373 AD. There is another tradition which attributes the composition of the *Jyotiṣkaraṇḍaka* to *Pādalipta.* His date is uncertain; he is assigned variously to the second or the third century AD. Thus, of the two printed editions we have of this book, the first one published from Ratlam in 1928 attributes it to Vallabhīya Ācārya,[1493] while

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1489 The first three sources are discussed in Fleet 1915 and in Pingree 1973.

1490 Lagadha, *Vedāṅga-jyotiṣa.*

1491 Fleet 1915, pp. 217-218.

1492 CESS, 4, pp. 359-363.

1493 *Vallabhīyācāryīyaṃ Śrījyotiṣkaraṇḍakaṃ Prakīrṇakaṃ, Śrīman-Malayagiry-ācāryakṛta-vṛttiyuktaṃ*, Rishabhdevji Kesharimal Shvetambar Samstha, Ratlam 1928.

the second edition of 1989 from Bombay to Pādaliptasūri.[1494] We follow the second edition.

The outflow water clock or the *Nāḍikā-yantra* described in these texts consists of a large vessel with a very small hole at the bottom through which the water in the vessel flows out and indicates time. The shape and size of the vessel is not clearly mentioned in any of these texts. The names of the time unit *nālikā* or *nālī* are diminutive forms of *nala,* which denotes, among others, a reed or a tube, or a hollow cylinder.[1495] Accordingly the water vessel must have been generally of cylindrical shape. On the other hand, the *Jyotiṣkaraṇḍaka* prescribes the shape of a pomegranate flower (*dālimapupphāgārā*); it would suggest a vessel shaped like a bucket or a truncated cone as in Egypt. In the middle of the second millennium BC, the Egyptians chose a bucket-shaped vessel whose upper diameter was about twice the lower diameter, and graduated its sides in equal divisions. But the size of the vessel is not mentioned in any text.

On the amount of water with which the vessel was to be filled, the texts make contradictory statements.[1496]

Vedāṅga-jyotiṣa: 1 droṇa minus 3 kuṭapas (61|64 droṇa)

Arthaśāstra: 1 āḍhaka (¼ droṇa)

Divyāvadāna: 1 droṇa

Jyotiṣkaraṇḍaka: 2 ādhakas (½ droṇa)

Since these amounts vary, the sizes of the vessels must also have been different. Moreover, since the length of the day varies according to seasons, the *Vedāṅga-jyotiṣa* (Ṛk-recension 7 = Yajus-recension 8), prescribes that a *prastha* (= ¼ *āḍhaka* = 1|16 *droṇa*) of water should be added every day when the duration of the daylight or night

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1494 Pādaliptasūrī's *Joisakaraṇḍagaṃ*, with Prākṛta Ṭippaṇaka by Vācaka Śivanandī, ed. Muni Shri Puṇyavijayajī, Introduction etc., by Pt. Amritalal Mohanlal Bhojak, Jaina-Āgama-Series No. 17 (Part III), Paṇṇiyasuttāiṃ, part III, Shri Mahāvīra Jaina Vidyālaya, Bombay 1989.

1495 In the late medieval period, astronomical texts speak of a *nalaka-yantra,* which is a tube for viewing planets and stars, used like a telescope without lenses; cf. W002.

1496 The *Jyotiṣkaraṇḍaka* (31-32) mentions the units of volume (*meya-pramāṇa*) as follows: 4 *kulava* = 1 *pattha*; 4 *pattha* =1 *āḍhaka* (16 *kulava*); 4 *āḍhaka* = 1 *doṇa* (64 *kulava*); see also Srinivasan 1979, pp. 72-73.

time increases and the amount of water is removed when the duration of the day or of the night decreases. [1497] Other texts do not mention this, but it is probably implied there.

1.1. Dimension of the Aperture

The most remarkable feature is the prescription regarding the size of the hole at the bottom of the vessel through which the water flows out and by doing so denotes time intervals. It is said that the size of the hole should be such that a gold wire of specific length drawn out of a piece of certain weight should pass through it.

The *Arthaśāstra* and the *Jyotiṣkaraṇḍaka* prescribe that the aperture should be so large that a gold wire, 4 *māṣas* in weight and 4 *aṅgulas* long, should just fit into it. The *Śārdūlakarṇāvadāna* prescribes 1 *suvarṇa* weight but retains the length of 4 *aṇgulas.* Gold naturally means pure gold, i.e. as pure as was possible with the contemporary technology. The *Arthaśāstra* indeed exhibits a wide knowledge of gold metallurgy and is the first text to describe the method of gold assaying.[1498] As pure gold is malleable enough, a gold wire of a uniform diameter can be drawn with a given weight of gold. The aperture in question is a minute one, and there is no better way of defining it than by this method. The Babylonian records on outflow water clocks do not appear to be familiar with this method. Therefore, we will not be much wrong in assuming that this method of micro-measurement developed in India, perhaps in the second century AD, when the relevant portions of the *Arthaśāstra* are believed to have been composed. On the face of it, this sounds like a very scientific method of micro-measurement. Even when the outflow water clock was replaced by the sinking bowl type of water clock, the dimension of the aperture in the sinking bowl was defined in a similar manner (see the next section). Therefore, Harry Falk has taken the trouble of estimating that the gold wire mentioned in the *Arthaśāstra* would have a diameter of 1.448 mm.[1499] Drawing gold wire with the help of a hard plate containing holes of gradually diminishing sizes was an ancient art, but to draw a small lump of gold exactly to the length of four digits, no more and no less, is near to impossible.

1497 Lagadha, *Vedāṅga-jyotiṣa,* p. 44.

1498 Cf. Kauṭilya, *Arthaśāstra* 2.13-14; Sarma 1983.

1499 Falk 2000, p. 118.

The *Jyotiṣkaraṇḍaka* adds two more ways of defining the hole: 'Take ninety-six hairs from the tail of a three years old female elephant calf (*gaya-kumārī*; *gaja-kumārī*); straighten them and bundle them together, and with them make the hole in the *nālikā* vessel. Or take twice [the previous number] of hairs (i.e. 192) from the tail of a two years old female elephant calf, and with them make the hole.' What the text means to say is that the hole must be such that ninety-six hairs from the tail of a three years old female elephant calf, or twice that number from the tail of a two years old female elephant calf, can pass through it.

This prescription should not be considered very unusual. The breadth of a strand of hair is considered to be a micro-unit in linear measurement in many cultures as the English expression 'hair's breadth' shows. Though logical, the micro-measurement with the tail hairs of an elephant is not very practical. These are obviously fictitious prescriptions, probably to emphasize the smallness of the hole, but it is remarkable that every text repeats includes them.

1.2. Al-Bīrūnī on the Outflow Water Clock

There is one more description of an outflow clock which is somewhat reminiscent of the one in the *Jyotiṣkaraṇḍaka*, and this occurs in al-Bīrūnī's *India,* where al-Bīrūnī cites the following from the *srūdhava* by Utpala of Kashmir: [1500]

> 'If you bore in a piece of wood a cylindrical hole of twelve fingers' diameter and six fingers' height, it contains three *mana* of water. If you bore in the bottom of this hole another hole as large as six plaited hairs of the hair of a young woman, not of an old one nor of a child, the three *mana* of water will flow out through this hole in one *ghaṭi.*'

Unfortunately we do not know any book of Utpala (fl. 966-69), the well-known commentator of Varāhamihira's *Bṛhatsaṃhitā* and other books, which matches the consonant scheme of *srūdhava*. This description is interesting because this is the only

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[1500] Bīrūnī 1910, 1, p. 334; he also describes a sinking bowl type of water clock which he had seen in *Purshūr* (modern Peshawar), pp. 337-338.

passage which clearly mentions the cylindrical outflow vessel and gives its dimensions as well.[1501]

2. GHAṬIKĀ-YANTRA

The sinking bowl type of water clock consists of a hemispherical bowl (*ghaṭī, ghaṭikā*), made of a thin sheet of copper, with a fine hole at the exact centre of the bottom. When this bowl is made to float on the surface of the water in a larger basin (*kuṇḍa, kuṇḍī*), water percolates into the bowl through the hole and fills it, and the bowl sinks down. The bowl is then lifted up, emptied and set up once again on the surface of the water. The hole is so made that the bowl sinks sixty times in a day-and-night, that is to say, that the bowl takes 24 minutes to fill and sink. Since the bowl is called by the diminutive word *ghaṭikā* or *ghaṭī* (from *ghaṭa,* 'pot'), the time unit measured by this instrument also came to be called *ghaṭikā* or *ghaṭī.*

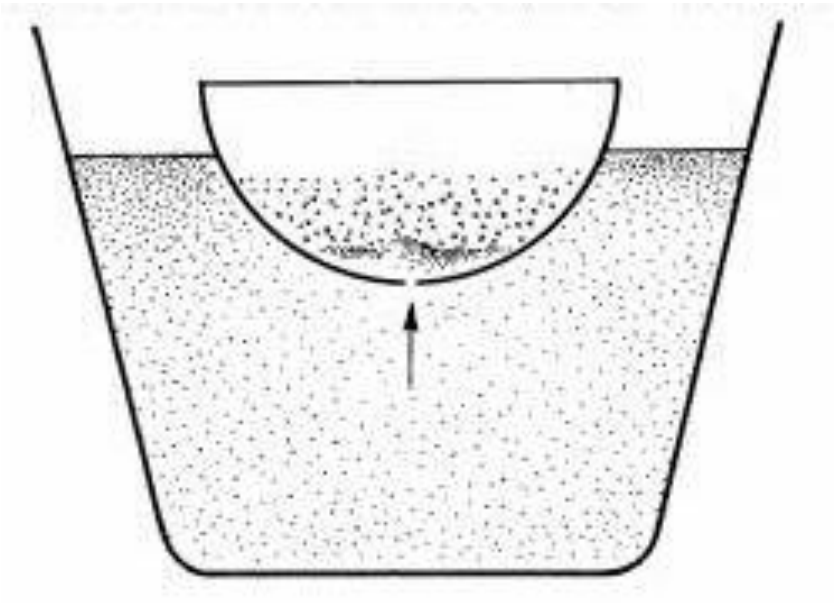


Figure R1 – Working principle of the Ghaṭikā-yantra

[1501] These dimensions agree with those given by Āryabhaṭa for the sinking bowl type, for which see 2.1.1 below.

2.1. Descriptions of the Ghaṭikā-yantra in Sanskrit Texts

2.1.1. Āryabhaṭa I on the Ghaṭikā-yantra

Āryabhaṭa I (b. 476) is the first author to describe the *Ghaṭikā-yantra,* in the *Yantrādhyāya* of his *Āryabhaṭasiddhānta*:[1502]

vṛttaṃ tāmramayaṃ pātraṃ kārayed daśabhiḥ palaiḥ |
ṣaḍaṅgulaṃ tadutsedho vistāro dvādaśānane ||
tasyādhaḥ kārayec chidraṃ palenāṣṭāṅgulena tu |
ity etad ghaṭikāsaṃjñaṃ palaṣaṣṭyāmbupūraṇāt ||
sveṣṭaṃ vānyad ahorātre ṣaṣṭyāmbhasi nimajjati |
tāmrapātram adhaśchidram ambuyantraṃ kapālakam ||

'Get a round (i.e. hemispherical) bowl made with ten *palas* of copper. Let its height be six *aṅgulas* and the diameter at the mouth twelve *aṅgulas.* Get a hole bored at its bottom [so that a gold wire] one *pala* [in weight] and eight *aṅgulas* [in length can pass through it]. This is designated as *Ghaṭikā*[*-yantra*] because it is filled with sixty *palas* of water.

'Alternatively, any other hemispherical (*kapālaka*) copper bowl with a hole at the bottom, which sinks sixty time in a day-and-night, [will serve as] water clock (*ambu-yantra*).'

Āryabhaṭa mentions two ways of making the *Ghaṭikā-yantra*: the first is the standard model with prescribed weight, height, diameter and the size of the hole; alternatively, any vessel with a hole can be used, provided it immerses sixty times in a nychthemeron.

After Āryabhaṭa, the *Ghaṭikā-yantra* is described in several astronomical texts.[1503]

2.1.2. Lalla's Modification

Lalla (8th or 9th century), in his *Śiṣyadhīvṛddhida-tantra,* while retaining the dimensions of the bowl, changed the size of the perforation:

daṣabhiḥ śulbasya palaiḥ pātraṃ kalaśārdhasannibhaṃ ghaṭitam |

[1502] This text is no more extant, but the descriptions of certain instruments are cited by Rāmakṛṣṇa Ārādhya in his commentary on the *Sūrya-siddhānta,* cf. Shukla 1967.

[1503] Some of these descriptions are translated and discussed in Sarma 2014b.

hastārdhamukhavyāsaṃ samaghatavṛttaṃ dalocchrayam ‖
satryaṃśamāṣakatrayakṛtanalayā samavṛttayā hemnaḥ |
caturaṅgulayā viddhaṃ majjati vimale jale nāḍyā ‖ [1504]

'The bowl, which resembles half a pot (i.e. hemispherical), which is made of ten *palas* of copper, which is half a cubit (i.e. twelve *aṅgulas*) in diameter at the mouth and half (i.e. six *aṅgulas*) as high, which is evenly circular, and which is bored by a uniformly circular needle, made of three and one-third *māṣas* of gold and of four *aṅgulas* in length, sinks into clear water in one *ghaṭikā* (*nāḍī*).'

It is difficult to say what caused this shift in the size of the perforation—from the gold needle of one *pala* weight and eight *angulas'* length to a gold needle three and one-third *māṣas* in weight and four *aṇgulas* in length.[1505] According to Śrīdhara, who is a near contemporary of Lalla, sixty-four *māṣas* make one *pala*.[1506] Then the perforation prescribed by Lalla would be 5|48th of that prescribed by Āryabhaṭa. While the size and weight of the bowl remained the same, such stark reduction in the size of the perforation would have greatly increased the duration of the time needed for the bowl to become full and then to sink, and consequently the duration of the *ghaṭī* as well. One is therefore led to suspect that these specifications for the size of the perforation in terms of a gold wire of certain weight and length are fictitious and have no connection with actual practice. Yet this latter specification for the size of the perforation is repeated in several subsequent works.

Sanskrit astronomical texts do not prescribe the dimensions in such detailed manner for any other instrument except the water clock; here too the obsession with the size of the hole in this sinking bowl as well as in the outflow variety is indeed very strange. Defining the minute size of the hole in terms of the diameter of a gold wire of a certain weight and length is, no doubt, very ingenious, but it is very doubtful whether

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1504 Lalla, *Śiṣyadhīvṛddhida-tantra*, *Yantrādhikāra*, 34-35, Part I, p. 246.

1505 Of course, Lalla also adds in verse 36 that the vessel and the perforation can be of any dimension, provided the bowl sinks in one *ghaṭī*: *athavā svecchāghaṭitaṃ ghaṭīpramābhiḥ prasādhitaṃ bhūyaḥ* (Or, it is a vessel made according to one's liking which is adjusted for one *ghati* by repeated trials).

1506 Śrīdhara, *Pāṭīgaṇita*, rule 10, text, p. 5; translation, p. 3.

it has any practical relevance. Therefore, Bhāskarācārya in his *Siddhāntaśiromaṇi* of 1150 dismisses these prescriptions as illogical (*yukti-śūnya*) and difficult to implement (*durghaṭa*).'[1507]

In spite of this confusion in the textual prescriptions, countless specimens must have been throughout the centuries and these must have kept reasonably correct time of one *ghatika* of twenty-four minutes. But it is doubtful whether any artisan has ever produced a bowl according to these textual prescriptions. In the few specimens that survive in modern collections, rarely any bowl has the exact shape of a hemisphere; some are more conical, some are shallower, than a precise hemisphere. The sizes and weights too do not conform to the textual prescriptions, and vary considerably. The holes were obviously made by a trial and error method, by comparing the new bowl with one that showed correct time or with a sundial, and by suitably enlarging the hole or by reducing its size, rather than by means of a gold wire of given dimensions.

2.2. Measuring Fractions of a Ghaṭī

2.2.1. Pala-vṛttas

Āryabhaṭa states that the time taken to utter sixty long syllables (*gurv-akṣara*) is one *vināḍikā* of a sidereal day.[1508] *Vināḍikā* is also called *vighaṭikā,* and more commonly *pala*. Therefore, concluded Varāhamihira, a *ghaṭī* is the time taken to recite 60 times a verse made up of 60 long syllables.[1509] Since each recitation of such a verse takes 1 *pala,* these verses came to be known as *pala-vṛttas.* Bhāskara I's commentary on the *Āryabhaṭīya* contains one such *pala-vṛtta* which reads thus:[1510]

mā kānte pakṣasyānte paryākāśe deśe svāpsīḥ
kāntaṃ vaktraṃ vṛttaṃ pūrṇaṃ candraṃ matvā rātrau cet |
kṣutkṣāmaḥ prāṭaṃś cetaś ceto rāhuḥ krūraḥ prādyāt
tasmād dhvānte harmyasyānte śayyaikānte kartavyā ||

1507 Bhāskarācārya, p. 442; see Sarma (forthcoming).

1508 Āryabhaṭa, *Āryabhaṭīya*, *Kālakriyāpda* 2.

1509 Varāhamihira, 14.32; interestingly, this verse itself is made up of 60 long syllables!

1510 Sarma 2001b.

> 'Do not, O pretty one, at the end of the [bright] fortnight (that is, on the night of the full moon), sleep in a place open to the sky. Should it turn night, the cruel Rāhu, starving with hunger and roaming hither and thither, may eat you up, taking your pretty round face for the full moon. Therefore, after darkness, make your bed at a secluded place inside the house.'[1511]

2.2.2. Marking on the Bowls

Another possibility is to mark the divisions of the *ghaṭī* on the inner side of the vessel, but it is very difficult to graduate geometrically the inner wall of the bowl into 60 *vighaṭīs*.[1512] However, it should be possible to empirically divide the bowl, if not into 60 parts, at least into 10 parts of 6 *vighaṭīs* (= 2 min 24 sec) each. Gilchrist reports in 1795 that in some specimens he saw in Bengal, the bowl (he uses the Bengali/ Hindi word *kaṭorī*) was marked with divisions:

> These *katorees* are now and then found with their requisite divisions, and subdivisions, very scientifically marked in *Sanscrit* characters, and may have their uses for the more difficult and abstruse operations of mathematicians or astronomers, … .[1513]

Thurston also speaks 'nicks on the inside of the cup' (see 9.3 below), but we did not come across any such specimen during our survey.

2.3. Horological Vocabulary

Even after the *Nāḍikā-yantra* was completely replaced by the *Ghaṭikā-yantra,* the terms related to the older device, viz., *nālikā, nāḍikā, nāḍī,* continued to be used along with the new terms *ghaṭikā* and *ghaṭī* to denote the basic unit of time of 24 minutes. From these two sets of terms, two other sets of names are derived to designate the

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1511 For other such verses, see Sarma 2014b.

1512 In his treatise on the astrolabe (*Kitāb al-ᶜamal bi l'asṭurbāb*) of 986, al-Ṣūfī teaches how to graduate the inner surface of a large vessel (*pinkān*) with the help of an astrolabe; cf. Bruin 1968; but here the perforated vessel must be very large, because it is graduated for each hour of the day. This procedure cannot be employed for the much smaller *Ghaṭikā-yantra* to measure *vighaṭīs* of 24 seconds.

1513 Gilchrist 1795, p. 87.

sixtieth part of a *ghaṭī* (i.e. 24 seconds), viz. *vināḍikā, vināḍī* and *vighaṭikā, vighaṭī*. But this unit is more frequently called *pala* in northern India.

The influence of the *Ghaṭikā-yantra* on the horological vocabulary is all pervasive in India. In many modern Indian languages, time-keeping devices, howsoever sophisticated they may be, are still called *ghaḍī* (from Sanskrit *ghaṭī*).[1514] The term *ghaṭikālaya,* originally the designation of the time-keeping establishment, engendered the names of the time-keeping devices in Gujarati (*ghaḍiyāl*), Telugu (*ghaḍiyāramu, gaḍiyāramu*), Malayalam (*gaḍigāram*), and so on. While the Telugu word *gaḍiya* for the traditional unit of 24 minutes is derived from Sanskrit *ghaṭikā*, the Tamil term *nāḻigai* goes back to Sanskrit *nālikā.* Finally, in many Indian languages, when it is, e.g., four o' clock, ones says 'it is sounding four' or something similar; such an expression is not derived from the chimes of the European clocks but from the old practice of striking the *ghatis* and *praharas* on the gong.

2.4. Ghatikā-yantra in Poetry

In the medieval period, the *Ghaṭikā-yantra* became popular enough to be used as a standard of comparison in poetry. In an anonymous Jaina narrative on the life of Kumārapāla, there occurs the following verse:[1515]

> *ghaṭikāpy ekayā ghaṭyā kuṇḍīpayasi majjati |*
> *gotraṃ punar aputrasya kṣaṇān nirnāmatāmbhasi ||*
> "The *Ghaṭikā* [bowl] takes at least one *ghaṭī* to sink in the water of the basin (*kuṇḍī*); the lineage of a sonless man takes but a moment to drown in the waters of namelessness."

In the *Jaiminibhāratamu,* a fifteenth century Telugu poem by Pillalamarri Pinavīrabhadra, a charming imagery woven around the *Ghaṭikā-yantra.* Śiva goes to wed Pārvatī in his usual head-gear, wearing Gaṅgā and the moon on his head. To Pārvatī's maids, the half moon looks like the *ghaṭikā* bowl floating on the waters of

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[1514] On the other hand, in Thai language, the word for the time-keeping device, whether it is a clock or a wrist-watch, is *nāḷikā.*

[1515] *Kumārapāla-caritra-saṃgraha,* ed. Jinavijaya Muni, Bombay 1956, p. 113.

Gaṅgā. They tease Pārvatī by saying, 'Look, who put the water clock on the head of the poor bridegroom?'[1516]

3. Prahara and Yāma

3.1. Prahara-Yāma

While time was measured in equal *ghaṭīs* for astronomical and astrological purposes, for common people broader segments were sufficient, such as the fourth part of the day and of the night. Thus in the *Kāvyamīmāṃsā*, Rājaśekhara recommends to the poet-aspirant:[1517]

> *aniyatakālāḥ pravṛttayo viplavante tasmād divasaṃ niśāṃ ca yāma-krameṇa caturdhā vibhajet | sa prātar utthāya … anuśīlayed āpraharāntam |*
>
> 'Activities without any fixed time lead to disorder. Therefore, the poet should divide the day and also the night into four [parts] by the sequence of *yāmas*. He should get up in the morning …. and study up to the end of the [first] *prahara*.

These time units were probably announced by strokes on a drum at a central place like the royal palace, temple or monastery, and hence were called *prahara* (lit. 'stroke'). The duration of this *prahara / yāma* is variable according to the geographical latitude and the season.

Astronomical texts do not mention this time unit *prahara / yāma* at all; the only exception is Bhāskara I, who, in his commentary on the *Āryabhaṭīya* of Āryabhaṭa, makes a brief reference to *yāma*: *divasa-rātri-caturbhāgo yāmaḥ* (*yāma* is the fourth part of the day and of the night).[1518] But these terms are frequently mentioned in the *Purāṇas* and literary texts, where both are usually treated as synonyms. But there is a subtle difference between the two: *yāma* is used mainly in connection with the night and

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1516 Pillalamarri Pinavīrabhadra Kavi, *Jaiminibhāratamu,* Madras 1959, *Aśvamedha-parvamu*, verse 2.

1517 *Kāvyamīmāṃsā of Rājaśekhara,* ed. C. D. Dalal and R. A. Sastry; revised and enlarged by K. S. Ramaswami Sastri, Baroda 1934 (GOS 1), p. 52.

1518 *Āryabhaṭīya of Āryabhaṭa,* with the commentary of Bhāskara I and Someśvara, critically edited by Kripa Shankar Shukla, Indian National Science Academy, New Delhi 1976, p. 176.

prahara with daytime, occasional occurrences to the contrary notwithstanding. Hence the night is called *yāminī, yāmikā, yāmavatī,* or *triyāmā,* but never *prahariṇī* etc.

About the term *triyāmā* used in the sense of the night, one may ask: if *yāma* is the fourth part of the night, why is the night called *triyāmā,* 'that which consists of three *yāmas*'? Here practical considerations play a role. In theory, night begins at sunset and ends at sunrise. But for some time after the sunset and again for some time before the sunrise, it is bright enough to see and to do things (*ceṣṭākāla*). Hence, half a *yāma* at the beginning of the night and the same at the end are not counted. The remaining part of the night which is really dark consists then of three *yāmas* and therefore the night is called *triyāmā*.[1519]

3.1.1. Night of three Yāmas

This dark part of the night is divided into three *yāmas* probably for monastic reasons, because the Jaina and Buddhist monks were to perform certain observances in each *yāma.* Thus the Jaina canonical work *Ṭhāṇaṃga* 3.2 enumerates the three *yāmas*:[1520]

> *tao jāma pannattā | taṃ jahā paḍhame jāme majjhime jāme pacchime jāme |*

The Buddhist text *Dhammapada* 157 likewise speaks of three *yāmas* of the night:

> *attānaṃ ce ppiyaṃ jañjā rakkheyaṃ naṃ surakkitaṃ |*
> *tiṇṇaṃ añjataraṃ yāmaṃ paṭijaggeyaṃ paṃḍito ||*
> 'If one holds oneself dear, one should diligently watch oneself. Let the wise man keep vigil during any of the three watches of the night (*tiṇṇaṃ añjataraṃ yāmaṃ*).'

3.1.2. Buddhaghoṣa

Here it is not necessary to discuss what the monks did in each of the three *yāmas.* Suffice it to say that they needed to know the passage of each *yāma,* and so must have

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[1519] Thus an anonymous line reads: *triyāmāṃ rajanīṃ prāhus tykvādyantacatuṣṭayam* (they call the night *triyāmā*, after discounting the fourth *yāma,* which occurs [in two halves] at the beginning and at the end). In his commentary on *Amarakośa* 1.4.3-5, Bhānujī Dīkṣita explains that only three *yāmas* are taken into account because the first and last [half *yāmas*] are almost like the day, being the periods of activity (*ādyantayoś ceṣṭākālatvena dinaprāyatvāt*).

[1520] Quoted in the *Abhidhānarājendra,* s.v. *jāma.*

made arrangements to announce it with the help of a water clock. Such an arrangement is described by Buddhaghoṣa in his *Papañcasūdanī* commentary on the *Majjhimanikāya*, which was composed in the first half of the fifth century in Sri Lanka:

> *ajagaravihāre pi kāḷadevathero antovasse yāmagaṇḍikaṃ paharati | āciṇṇaṃ etaṃ therassa | na ca yāmayantanālikaṃ payojeti, aññe bhikkhū payojenti | atha nikkhante paṭhame yāme there muggaraṃ gahetvā ṭhitamatte yeva ekaṃ dve vāre paharante yeva vā yāmayantaṃ patati | evaṃ tīsu yāmesu samaṇadhammaṃ katvā …* [1521]
>
> 'In the rainy season, the monk Kāḷadeva used to strike the gong (*gaṇḍika* < *ghaṇṭika,* bell?) at the end of each *yāma* in the Ajagara monastery. He was so well accustomed to do this that he did not [need to] use a water clock with the duration of one *yāma* (*yāma-yanta-nāḷikā*), but other monks did. As the first *yāma* concluded, and as the monk stood there holding the mallet, or as he just struck once or twice, then the water clock for one *yāma* (*yāma-yanta*) used to sink (*patati*). Thus having performed his monastic duties in the three *yāmas …*'

This is the earliest passage to describe the sinking bowl type of water clock, which is clearly indicated here by the word *patati.* It is interesting that here the water clock is called *yāma-yantra,* instrument for measuring one *yāma.* The bowl here is a larger one for measuring one *yāma,* specially made for the needs of the Buddhist order in Sri Lanka. This island stretches roughly from the latitude of 6° to 8° N and here the seasonal variations in the length of the day or of the night are negligible. Therefore, probably no adjustments were made in the duration of *yāma* and it was maintained at the mean rate of seven and a half *ghaṭīs* (= 3 hours). The monk, appropriately called Kāladeva, 'the Lord of Time', became so adept that he did not need to watch the actual sinking of the bowl; his hand automatically lifted the mallet to strike the bell when the bowl was about to sink.

[1521] *Papañcasūdanī, the commentary on the Majjhima-Nikāya,* vol. 1, ed. U. Dhammaratana and U. Jagarabhivamsa, Nālandā 1975; for an interpretation of this passage, see Hinüber 1978, pp. 224-225.

3.2. Royal Timetable in the Arthaśāstra

While the day and night are divided into four *praharas* or *yāmas* for common pursuits, the *Arthaśāstra* divides them into eight parts for the rigorous timetable of the king and assigns him different tasks in each of these 8+8 periods. However, no name is given to these time units.[1522] These periods are to be measured by means of a water clock or a gnomon. The outflow water clock according to this text has been mentioned above.

The *Arthaśāstra* thus envisages a royal establishment for time-keeping, where time is measured with water clocks and gnomons.[1523] In fact Kauṭilya mentions time-measuring instruments only in connection with the royal timetable of the 8+8 periods.[1524]

3.3. Royal Timetable in the Tamil Country

Similar royal timetable is mentioned also in Tamil Śaṅgam literature, assigned generally to the first three centuries after Christ. The daytime of the king is divided into three periods of 10 *nāḷikais* (= *nālikā*) each. In the first period, the king follows what is traditionally prescribed for a person of high rank; the next ten *nālikās* are meant for public audience, and the third period of ten *nālikās* is devoted to private relaxation and entertainment. The anthology called *Kuruntokai* mentions that a group of officials with the designation *Nāḷikai Kaṇakkar* (Skt. *Nālikā-gaṇaka*) measured time by means of an instrument called *Nāḷikai Vaṭṭil,* a vessel from which water trickled out, i.e. an outflow clock or *Nāḍikā-yantra,* and that these officials kept awake by turns in order to be able to watch the clock day and night. [1525]

This raises the following question: how was the variable *prahara / yāma* or a half of it measured with water clocks, whether outflow type or sinking bowl type, which measure only the fixed units of one *ghaṭī* ? In other words, how were the variable units

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1522 Kauṭilya, *Arthaśāstra,* 1.19.6: *nālikābhir ahar aṣṭadhā rātriṃ ca vibhajec chāyāpramāṇena vā* (the king should divide the day into eight parts, and also the night, by means of *nālikās* or by the shadow-length [of the gnomon]); at 1.19.9-24 his different duties in these 8 + 8 periods are mentioned.

1523 Kauṭilya, *Arthaśāstra,* 1.7.8; 1.19.6 ff.; 2.20. However, no special officer called *Kālamānādhyakṣa* is mentioned at 2.20 where one would expect it.

1524 Pargiter 1915, pp. 702-703, draws attention to the fact that the time table of 8+8 of periods is followed also in the care and training of the royal elephants (cf. Kauṭilya, *Arthaśāstra,* 2.31.5-7).

1525 N. Subrahmanian, *Śaṅgam Polity: The Administration and Social Life of Śaṅgam Tamils,* Bombay 1966, pp. 53, 105, 206-207.

reconciled with the fixed units? On this, no evidence is available from the ancient or early medieval periods, but only in the records from mid-sixteenth century onwards. From these, it appears that, although the *prahara* is one-forth of the daylight, in practice, however, the *praharas* are so arranged that they always consist of an integral number of *ghaṭīs*.

Writing in 1795, John Gilchrist explains how this was done with the help of an elaborate 'Hindoostanee Horal Diagram.' According to him, in a day all the *praharas* were not of equal length but each *prahara* consisted of an integral number of *ghaṭīs*. Thus, on equinoctial days, the first and fourth *prahara* of the day consisted of 8 *ghaṭīs* each, whereas the second and third contained 7 each, making a total 30 *ghaṭīs*.[1526] This would mean that the second *prahara* ends at noon, thus dividing the day into two equal parts. Secondly, the length of the *prahara* cannot be adjusted each day but only when the day or the night becomes longer or shorter by two *ghaṭīs*, i.e. 48 minutes. In other words, the *prahara* length was adjusted infrequently, perhaps once in about two months, and not every day. Neugebauer writes that in Mesopotamia the length was adjusted once in every 15 days.[1527]

Seen in this light the following statements by Abū al-Faḍl and Mrs. Meer Hassan Ali become intelligible. Writing in the second half of the sixteenth century, Abū al-Faḍl reports:

> The Hindu philosophers divide the day and night into four parts, each of which they call *pahr*. Throughout the greater part of the country, the *pahr* never exceeds nine *gharis* nor is less than six.[1528]

Mrs. Meer Hassan Ali, an English woman who was married to an Indian Muslim and lived with him in Lucknow for twelve years from 1816, writes:

1526 Gilchrist 1795, p. 83.

1527 Neugebauer 1947, p. 41: 'In order, e.g., to define the length of a "night watch" at the summer solstice, one had to pour a mana of water into a cylindrical clepsydra; its emptying indicated the end of the watch. One-sixth of a mana had to be added each succeeding half month. At equinox, 3 mana had to be emptied in order to correspond to one watch, and 4 mana were emptied for each watch of the winter solstitial night.'

1528 Abū al-Faḍl 3, p. 17.

> The day is divided into four equal parts, or watches, denominated purrhs (pahar); as, first purrh, second purrh, &c. The night is also divided into four purrhs, each of which is subdivided into ghurries, varying in number with the change of the season : the longest days require eight ghurries to one purrh ; the shortest, only six. The same division is observed for the night. [1529]

It is also in this light that we should understand the following account by I-Tsing.

4. Time-keeping Establishment at Nālanda in the Seventh Century

The Chinese traveller I-Tsing (modern spelling Yi Jing) spent some ten years (ca. 675-685) at the famous Buddhist monastery of Nālanda, and gave a detailed account of the time-keeping establishment at this monastery, where time was measured by means of the water clock with the sinking bowl.[1530]

Besides, clepsydrae are much used in great monasteries in India. These together with some boys are the gifts from kings of many generations, for the purpose of announcing hours[1531] to the monastics. Water is filled in a copper vessel, in which a copper bowl floats. This bowl is thin and delicate, and holds two Shang (prasthas) of water (about two pints). In its bottom a hole is pierced as small as a pin-hole, through which water springs up; this hole is to be made larger or smaller according to the time of the year. This must be well set, measuring (the length of) praharas.[1532]

Commencing from the morning, at the first immersion of the bowl, one stroke of drum is announced, and at the second immersion, two strokes; at the third immersion, three strokes. But, at the fourth immersion, besides four strokes of a drum, two blasts of a conch-shell, and one more beat of a drum are added. This is called first hour, that is when the sun is at the east (between the zenith and the horizon). When the second turn of four immersions of the bowl is done, four strokes (of a drum) are sounded as before, and a conch-shell is also blown, which is followed by two more strokes (of a drum). This is called the second hour, that is the exact (beginning of the) horse-hour (i.e. noon).

1529 Ali 1974, p. 55.

1530 I-Tsing 1896, pp. 144-146.

1531 Here ‘hour’, underlined by us, is used apparently in the sense of *prahara.*

1532 Here ‘prahara’ is used not in the technical sense, but in the sense of the duration of immersion of the bowl.

If the last two strokes are already sounded, priests do not eat, and if any one is found eating, he is to be expelled according to the monastic rites. There are also two hours in the afternoon which are announced in the same way as in the forenoon. There are four hours at night which are similar to those of the day. Thus division of one day and one night together makes eight hours. … This is the regulation of the clepsydra in the Nālanda monastery. …

Owing to the use of those clepsydrae, even in thick clouds and in a dark day, there is no mistake whatever about the horse-hour (i.e. noon), and even when rainy nights continue, there is no fear of missing the watches. It is desirable to set such ones (in the monasteries in China) asking for royal help, as it is a very necessary matter among the Brotherhood.

In order to set a clepsydra, one has first to calculate (the lengths of) the day and night, and then to divide them into hours. There may be eight immersions of the bowl from morn to midday. If it happens that the immersions are less than eight (when it is midday), the hole of the bowl is to be opened a little wider. To set it right, however, requires a good mechanician.

It is a highly complex business to regulate the size of the hole every day. Of course, the hole can be enlarged with a tapering needle, or its size can be reduced by plugging it with wax or hammering the area around it with a hammer. But to do it once every day and every night, i.e. 730 times in the year, is no mean business, especially when it is remembered that the hole in question is an extremely fine one. Moreover, there would be an interruption in time measurement while the hole was being readjusted.

A somewhat simpler proposition would be to use a different bowl each day and each night. Then one would need a series of 183 bowls with holes of gradually increasing size. These can be used successively each day for the first six months from the winter solstice to the summer solstice and then in reverse order for the next six months. At night the contrary sequence is followed.

But what exactly is the daily increase or decrease in the day-length at Nālanda which lies on the latitude of 25° N? The maximum duration of the day here is 13;35 hours. That is, between the vernal equinox on 21 March and the summer solstice on 21 June (roughly 92 days), the increase is 1;35 hours or 95 minutes. Thus in 92 days, the daily increase would amount to a little over 1 minute per day. In a bowl that measures

normally 45 minutes (16 immersions in 12 hours), the daily increase should be 1|16 minutes = 3.75 seconds. Can any 'mechanician', howsoever ingenious he may be, enlarge the hole so that it shows a difference of 3.75 seconds? If the Buddhist monks at Nālanda needed to know the 1|16th parts of the day or of the night for their ritual performances, they probably changed the perforated bowls of the water clock once every week or once every two weeks and certainly not every day and every night.

Therefore Yi Jing's account has to be treated with great caution. More so, as the passage quoted above is followed by this sentence: 'When the day or night becomes gradually shorter, half a ladle (of water) is to be added, and when the day or night grows gradually longer, half a ladle is to be let off.' In the sinking bowl type of water clock, addition of water into the basin, or letting some of it off, does not make any difference. This stipulation actually should pertain to the outflow clock, at Pulo Condore which Yi Jing describes next, or to the outflow water clocks of ancient India. Even in the outflow water clock, water is added gradually when the days grow longer and not otherwise. There is surely an error in Yi Jing's account.

Stranger still is the following sentence: 'It is desirable to set such ones (in the monasteries in China) asking for royal help, as it is a very necessary matter among the Brotherhood.' This conclusion gives the impression as though China did not have water clocks until the end of the seventh century AD. This is rather intriguing because China had made great strides in the manufacture of highly complex models of inflow water clocks. The inflow clocks with a float and indicator rod is attested as early as the Han period. Yi Jing's elder contemporary, Lü Tshai (d. 666) is credited with the invention of a poly-vascular inflow clock consisting of three compensatory tanks between the reservoir and the receiver. [1533]

In view of these inconsistencies, not much credence can be given to Yi Jing's account of the time keeping practice at Nālanda in the seventh century.[1534] It is possible

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[1533] Cf. Needham 1959, pp. pp. 313-329; figures 138-144.

[1534] In Indian historiography, Chinese accounts of India, are usually considered to be very useful because they provide much valuable information about material conditions, with reliable chronology, but strangely this is not the case with Yi Jing; elsewhere (pp. 140-142) he attempts to give a correct interpretation of *pradakṣina,* the circumambulation of sacred objects; instead of observing how it was actually practiced in India, with one's right hand towards the object, he tries to analyse the term etymologically, and comes to the wrong conclusion.

that time was measured there in variable quarter *praharas* for unknown monastic reasons. But that was not the general practice in India, which was to measure time in equal *ghaṭīs* of 24 minutes.

The mode of announcing time by drum-beats, conch-blasts and again drum-beats will become clear from the following table.

Table R1 Scheme of announcing the quarter-praharas and full praharas

No. of immersions of the bowl from sunrise	Drum strokes	Conch blasts	Drum strokes to announce the no. of elapsed *praharas*
1	1		
2	2		
3	3		
4	4	2	1 first *prahara*
5	1		
6	2		
7	3		
8	4	2	2 second *prahara* = noon
9	1		
10	2		
11	3		
12	4	2	3 third *prahara*
13	1		
14	2		
15	3		
16	4	2	4 fourth *prahara* = sunset

Here the two conch blasts merely serve the purpose of separating two sets of drum strokes, announcing respectively quarter *praharas* and full *praharas.*

5. Ghaṭikā-yantra in Inscriptions and Literary Texts

Institutions for time-keeping are attested, from the seventh century onwards, at Buddhist monasteries, royal palaces, town squares and the like, where time was measured constantly with this water clock and the passage of each *ghaṭī* and completion of each quarter of the day (*prahara*) or of the night (*yāma*) was broadcast regularly by means of drums and conch-shells. In the medieval period, the drum and the conch-shell were replaced by the gong, which was called *ghaḍiyālā* in the Middle Indic. The Chinese traveller Yi Jing's account the time-keeping establishment at Nālanda in the seventh century has been cited above, where he states that these water clocks, 'together with some boys are the gifts from kings of many generations, for the purpose of announcing hours to monastics.' At the beginning of the eleventh century, Al-Bīrūnī reports about a time-keeping establishment in Peshawar thus:

> The Hindus have a popular kind of division of the nychthemeron into eight *prahara, i.e.* changes of the watch, and in some parts of their country they have clepsydrae regulated according to the *ghaṭī,* by which the times of the eight watches are determined. After a watch which lasts seven and half *ghaṭī* has elapsed, they beat the drum and blow a winding shell called *śaṅkha,* in Persian *sped-muhra.* I have seen this in the town *Purshūr.* Pious people have bequeathed for these clepsydrae, and for their administration, legacies and fixed incomes.[1535]

5.1. Documents from Gujarat

References to water clocks and to the buildings where such clocks are regularly maintained are to be met with in inscriptions and literary texts mainly from Gujarat on the west coast and the Telugu-speaking regions on the east coast. The buildings which house the water clocks are called *ghaṭikālaya, ghaṭikāgṛha,* or *ghaṭīgṛha* in inscriptions and other documents from Gujarat belonging to the thirteenth and fourteenth centuries.[1536]

[1535] Bīrūnī 1910, I, pp. 337-338.

[1536] Majumdar 1956, pp. 213-215, lists such references, but argues that these were not buildings with water clocks, but educational institutions. Here he confuses between *ghaṭikā-gṛha* and *ghaṭikā-sthāna.* The latter was an institution which flourished in the seventh and eighth centuries in the

5.1.1. References to Ghaṭikā-gṛha

The *Lekhapaddhati,* a collection of model drafts for official and private documents, compiled in the thirteenth century, lists *Ghaṭikāgṛha-karaṇa* among the names of 32 different administrative departments (*karaṇa*); this would then be the department which maintains and supervises time-keeping establishments in different cities in the kingdom. The *Prabandhacintāmaṇi of Merutuṅga* (1306) speaks of the establishment of the *ghaṭikāgṛha,* along with *vyayakaraṇa* (department of state expenditure) and *hastiśālā* (elephant-stable). [1537]

In an inscription dated 1287, a certain Tripurāntaka is stated to have erected five temples, close to the splendid but decaying water-clock (*jīrṇa-ghaṭikālaya*).[1538] In the *Kumārapālacaritra-saṃgraha,* it is said that in the city of Karṇāvatī, the minister Ambaḍa set up three golden *kalaśas*, in the king's *ghaṭikā-gṛha.*[1539]

5.1.2. Illustrations of the Ghaṭikā-gṛha

More valuable than these are two illustrations depicting a small building with the caption *ghaṭikā-graha* on a painted wooden manuscript cover, measuring 762 mm in length and 76 mm in breadth.[1540] It was discovered by Jina Vijaya Muni in the Jñāna Bhaṇḍār of Jaisalmer. It is painted on both sides with events related to the historic debate between Vādi Devasūri of the Śvetāmbara Jain sect and the Digambara monk Kumuda Candra, which took place at the court of Siddharāja Jayasiṃha in the year 1124 and in which Devasūri was victorious.

Pallava kingdom, more particularly in the capital city Kāñcī, but it had nothing to do with time-keeping. In fact, it was an educational institution, wielding at the same time some kind of political authority.[1536] But it must be noted that this meaning of the expression *ghaṭikā* is peculiar to Tamilnadu and surrounding areas and that the term itself is said to be a hyper-Sanskrit form of the Tamil *kaṭakai,* 'place for learning'.

1537 Merutuṅga, *Prabandha-cintāmaṇi,* ed. Jina Vijaya Muni, Santiniketan, 1933, p. 20: *vyayakaraṇa-hastiśālā-ghaṭikāgṛha-sahitam kāritam.*

1538 Bühler, 'The Cintra Praśasti of the Reign of Sarangadeva, *Epigraphia Indica*, I (1892) 271-287, verse 40, on p. 284.

1539 *Kumārapālacaritra-saṃgraha*, ed. Jina Vijaya Muni, Bombay 1956, p. 101: *śrī-udayanacaitye karṇāvatyāṃ śrīśakunikāvihāre rājño ghaṭīgṛhe kauṅkaṇanṛpateḥ kanakamayaṃ kalaśatrayaṃ nyāsthād āmbaḍamantrī rājapitāmahaḥ.*

1540 Chandra 1949, pp. 59-62, Figs. 193-198.

The borders of the front side of the manuscript cover are decorated with rows of geese (*haṃsa-paṅkti*), which is a popular motif of decoration in the miniature paintings of western India, but the reverse side is not so decorated. The front side shows, from left to right, scenes from the city of Āśāpallī:[1541] first the shrine of Neminātha (with the caption *āśāpallyāṃ nemicaityaṃ*), followed by the house of water clock (*ghaṭikā-gṛhaṃ*); thereafter is a picture of Devasūri (*devasūrayaḥ*) seated on a low stool with a high back, giving a discourse to a scholar named *Paṃ[ḍita] Māṇikyaḥ*. The rest of the cover shows Kumuda Candra with his disciples, Devasūri receiving a message from Kumuda Candra, challenging him for a debate, and so on.

The reverse side contains scenes from Patan where the debate was to be held in the court of King Jayasiṃha; the arrival of Devasūri with his entourage on the left half and on the right half the arrival of Kumuda Candra with his followers. The latter, immediately after his arrival, proceeds to the royal harem to meet the queen mother, because her own father was partial towards the Digambaras, but was not allowed to meet her. He is stopped from doing so by the gatekeeper, who is pushing him away unceremoniously.

Interestingly, *ghaṭikā-gṛhas* are depicted on both sides of the wooden cover, indicating their presence at both Āśāpallī as well as Pāṭan; in *Āśāpallī* one sees the front side of the *ghaṭika-gṛha* and in Pātan the backside of the *ghaṭikā-gṛha.*

[1541] Also known as Ashaval, modern Ahmedabad, east of the river Sabarmati.

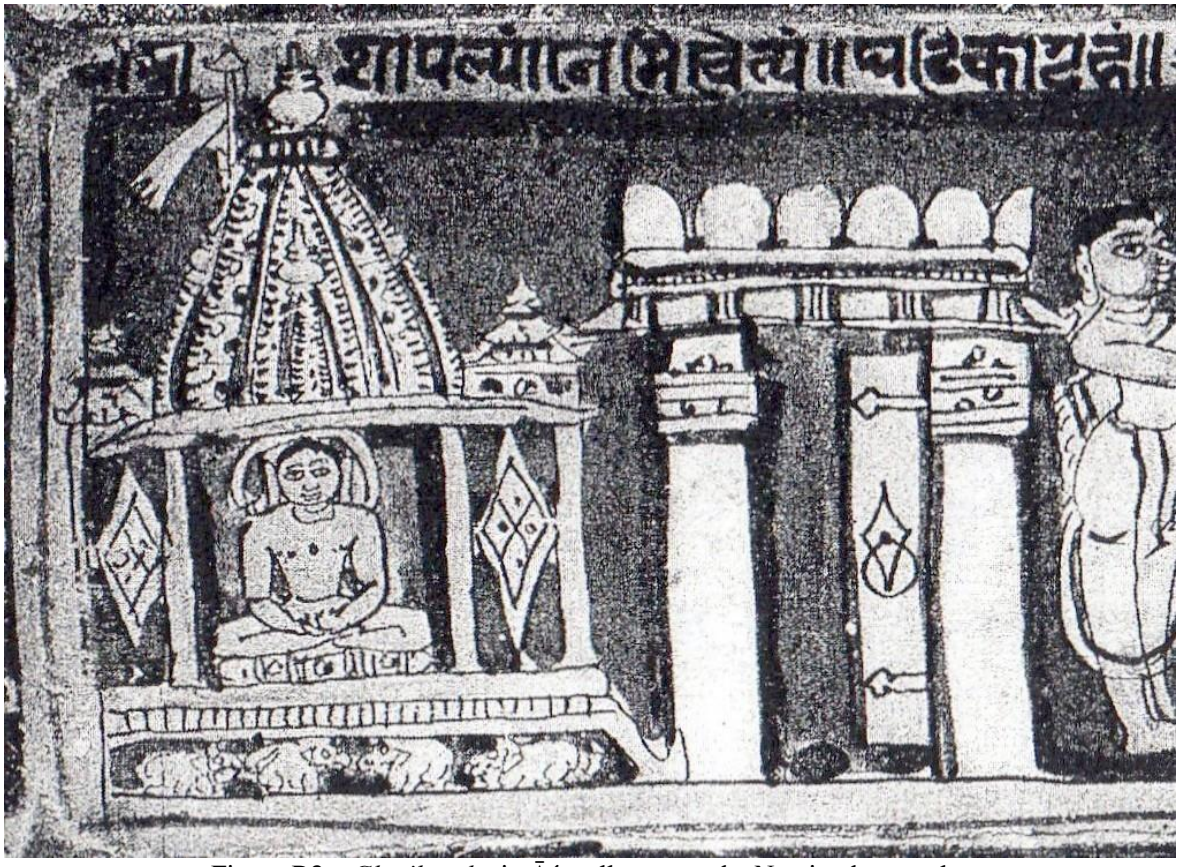


Figure R2 – *Ghaṭikāgṛha* in Āśāpallī next to the Neminātha temple;
caption: *āśāpalyāṃ nemicaityaṃ ‖ ghaṭikāgṛhaṃ‖* (detail from Fig. 193, in Chandra 1949).

On the front of the manuscript cover, on the left is shown the shrine of Neminātha at Āśāpalli. In the shrine can be seen the image of Neminātha. The shrine is surmounted by a tall, tapering tower, with a flag and a finial at the top. To the right of the shrine is the *ghaṭikā-gṛha,* with two thick pillars on either side of the door which is half open; the other half is closed by a door panel, which is joined to the pillar by two long hinges. In the middle of the panel is a rhombus-shaped decoration. To the centre of the rhombus is attached a ring, which is pulled to close the door. Above the two pillars is the roof, upon which there is a parapet consisting of a series of roundish battlements.



Figure R3 – Ghaṭikā-gṛha at Pāṭan;caption: digaṃvaraḥ ghaṭikā-gṛha-pāścātya-pratolī, (detail from Fig. 198, in Chandra 1949)

The reverse side of the manuscript cover shows the Digambara monk Kumuda Candra being turned away from the king's harem by the royal guard in front of the *ghaṭikā-gṛha* of Pāṭan. The monk is clad in nothing, but holds a broom made of peacock feathers; the guard is elaborately dressed. The caption reads: *digaṃvaraḥ ghaṭikā-gṛha-pāścātya-pratolī* (the Digambara monk [at] the thoroughfare (*pratolī*) to the west of the *ghaṭikā-gṛha*). Of the *ghaṭikā-gṛha,* which forms the background, nothing much can be seen except the blank wall at the back of the building, but here the wall, with ten battlements in the parapet, appears to be wider than the one at Āśāpallī depicted on the front side. Probably here this *ghaṭikā-gṛha* is drawn wider in order to accommodate the two figures of the monk and the guard in front of it; but it may also suggest that the *ghaṭikā-gṛha* in the royal capital Pāṭan is larger than the one at Āśāpallī. More important, in both cities, the *ghaṭikā-gṛhas* are located at central places; at Āśāpallī next to the shrine of Neminātha and at Pāṭan next to the royal harem. In the view of the artist who painted this manuscript-cover, the *ghaṭikā-gṛha* must be an important feature in the urban landscape.

About the date of this wooden manuscript cover, Moti Chandra writes: 'According to Jinavijayaji, it is quite possible that this painted wooden cover was prepared within five or six years of the great discussion, when the incidents were still fresh in memory. If this surmise be correct, then the date of the painted cover should fall near about 1130 A. D.' There is not much merit in this reasoning, for this debate was an important event in the Śvetāmbara history and was narrated in several texts of later periods as well. But Moti Chandra also cites stylistic reasons for the early date, which are more convincing; therefore, the wooden book may be assigned to the twelfth century.

5.2. Documents in Telugu

It is very significant that there are available three Telugu inscriptions on the endowment of time-keeping establishments with water clocks (*ghaḍiyāramu*) during the thirteenth and fourteenth centuries, besides several references in literary texts.[1542] An inscription at Warangal dated 1228 states that each household was to pay the tax of a certain measure of rice for the maintenance of the *ghaḍiyāramu*.[1543]

5.2.1. Inscription of 1403

An inscription dated 10 January 1403 found at Tāḷḷūru near Rajamahendravaramu (formerly Rajahmundri, Lat. 16;59° N, Long. 81;47° E), mentions the endowment made by a certain Bhaṃḍāru Seṭṭi of a water clock in the temple of Gopīnātha. [1544]

This inscription is written in Sanskrit and Telugu. It commences with a preamble in Sanskrit which states that Bhaṃḍāru Seṭṭi gifted the water clock (*ghaṭikā-yantra*) for measuring the times of rituals (*arcana-kāla-māna*) and a bell (*ghaṇṭā*) for announcing

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1542 I have not been able to obtain the full text of the first inscription, but the other two will be cited in full and translated.

1543 N. Venkataramanaiah (ed), *Inscriptions of Andhra Pradesh, Warangal District*, Hyderabad 1974, no. 63. p [?]. 197: *maṭhe aśeṣa na(ka)ramunu ghaḍiyārānaku iccina āyamu iṃtanu pāḍika biyyamu* …. The inscriptional passage conveys the meaning that the entire (*aśeṣa*) *nakaram* of Mathe gave one *pāḍika* of rice in every house for the maintenance of the *ghaḍiyāram*, which has the public utility. For this reason only the *nakram* of Mathe has collected the tax (*āyam*) of one *pāḍika* of rice towards the upkeep of *ghaḍiyāram*.'

1544 *Reḍḍi-Saṃcika,* ed. Vaddadi Appa Rao, Andhra Itihāśa Pariśodhaka-Maṃḍali, Rajamahendravaramu 1947, supplement, inscription no. XXIII, p. 35.
(https://archive.org/stream/in.ernet.dli.2015.370460/2015.370460.Reddi-Sanchika#page/n0/mode/2up);
[also https://goo.gl/Nxnb1p, last accessed in January 2018].

the time-intervals. It goes on to say that for the maintenance of the water clock, two brahmins were given in perpetuity a piece of land measuring 8 *khārikās*. Finally it adds that the text of the inscription was drafted by Śrīvallabha, son of Vallabhārya, of Kaṇva-gotra.

The Telugu part elaborates further; that the endowment was made with the consent of Kāṭamareḍḍi Vemāreḍḍi and that it was made to perpetuate the fame of **Komaragiri-reḍḍi** and his queens. It mentions the names of the four brahmins who were to maintain the water clock.

The three verses in Sanskrit that follow are standard verses appended to the land grants and contain an appeal to the future kings not to usurp the land from the descendants of the brahmins.

ambudhi-netra-viśva-gaṇite 'bde citrabhānau raven …
… mahīsurataku (?) bhaṃḍāru seṭṭi-prabhuḥ |
so 'yaṃ rājamaheṃdra-nāma-nagare vaprāṃtare
gopīnāthāyārcana-kāla-māna-ghaṭikā-yaṃtraṃ ca ghaṇṭām adāt ||
gopīnāthasya tasyaiva grāme krītvāṣṭa-khārikāḥ |
kṣetraṃ divijebhyo ghaṭikā-māyibhyo (?) jīvikām adāt ||
śrīvallabhārya-putreṇa kaṇvagotreṇa dhīmatā |
śrīvallabhena racitaṃ śāsanaṃ jayatāc ciram ||
*svasti śrī śaka-varṣaṃbulu 1324 aguneṃṭi citrabhānu saṃvatsara puṣya b|| 2 mnāṃḍu makara-saṃkramaṇa-puṇyakālamaṃdunu **kāṭamareddi vemāreḍḍi**ṃgāri ānatini **komaragirireḍḍi**ṃgārikini vāri devulaku śāśvatamayina kīrtini*
*sukṛtamulu kalugunaṭṭugānu rājamahendrāvarapu koṭaloni śrī-gopīnātha-devarakunu pūjākāla-jñānārthamai ghaḍiyāropacāramu **bhaṃḍāru śeṭṭi**naṃgāru samarpiṃciri.*
yī ghaḍiyāraṃ veṭṭī bhāṃhmalu sūrāojjhala māranna bollāojjhala devaramma peddibhoṭla mānadyoru annamojjhalu yī nalugurukunnū śrīgopīnātha-devaraku vūru
anuparutanu kālocitamūyaṃ peṭṭi pe … maṭham …ḍu kṣetram.
[mi]davuṭlu kṣetraṃ vilciyicciri | yī dharmaṃ ācaṃdrārkam |
maṃgalaṃ mahā śrīśrīśrīṃ jeyun |

svadattāṃ paradattāṃ vā yo hareta vasuṃdharāṃ |
ṣaṣṭivarṣasahasrāṇi viṣṭhāyāṃ jāyate kṛmiḥ ||
svadattād dviguṇaṃ puṇyaṃ paradattānupālanaṃ |
paradattāpahāreṇa svadattaṃ niṣphalaṃ bhavet ||
sāmānyo 'yaṃ dharmasetur nṛpāṇāṃ
kāle kāle pālanīyo bhavadbhiḥ |
sarvānn etān bhāvinaḥ pārthivendrān
bhūyo bhūyo yācate rāmacandraḥ ||

[Sanskrit] 'In the year counted by oceans (4), eyes (2) and worlds (13) [i.e., 1324, in the Jovian year] Citrabhānu, of the sun … (broken)…, Bhaṃḍāru Seṭṭi, the lord, endowed a *ghaṭikā-yantra* for measuring the times of worship of Gopīnātha and a bell (*ghaṇṭā*) in the city named Rājamahendra inside ramparts [of the fort].

'In the same village of Gopīnātha, he bought a piece of land measuring eight *khārikās* and gave it to the brahmins, the *ghaṭikā-māyins* (?), for their livelihood.

'May this inscription (*śāsana*), drafted by the learned Śrīvallabha, son of the illustrious Vallabhārya, of Kaṇva-gotra, flourish forever.'

[Telugu] 'May it be auspicious [*svasti*]. In the *Śaka* year 1324 which corresponds to [the Jovian year] *Citrabhānu*, on the second lunar day of the dark fortnight of the month *Puṣya*, on the auspicious occasion of the *Makara-saṅkramaṇa,* with the consent of the respected **Kāṭamareḍḍi Vemāreḍḍi**, in order that eternal fame and religious merit (*sukṛta*) accrue to the respected **Komaragiri-reḍḍi** and to his queens (*devulaku*), the respected Bhaṇḍāru Śeṭṭi made the endowment of a *Ghaḍiyāra* for knowing the times of worship of the Śrī Gopīnātha Devara.

'He purchased a piece of land for a price appropriate to the times in the vicinity of the village of Gopīnātha, and gave it to the four brahmins, namely Sūrā-ojjhala Māranna, Bollā-ojjhala Devaramma, Poddibhoṭla Mānapadryoru [and] Anna-ojjhalu.

'This religious endowment (*dharma*) [should last as long as there are] the moon and the sun. Let it be auspicious.'

[Sanskrit] 'Whosoever usurps the land given [as an endowment] by oneself or by others will be reborn a worm the in faeces for six-thousand years. Respecting the gifts bestowed by others is twice meritorious as compared to one's own gift. Usurping the others' gifts renders one's own gift fruitless. Rāmacandra entreats all the future kings again and again [saying] "this is the common bridge to attain the religious merit; you must protect it all the time."'

The date of the inscription is Śaka 1324, Jovian year *Citrabhānu,* second lunar day in the dark half of the month *Pauṣa,* which translates to Wednesday 10 January 1403. This is said to be the auspicious day of *Makara-saṅkrānti,* the day on which the *Uttarāyaṇa,* sun's northern progress commences. On this day Hindus make religious gifts (*dāna*), such as gifts of land as a religious endowment.

In the name of the donor Bhaṃḍāru Seṭṭi, the second part is derived from Sanskrit term *śreṣṭhin,* originally the designation of the head of the merchant's guild, later applied to every merchant of Vaiśya caste. The first part of the name is related to Sanskrit *bhaṇḍāra* or *bhāṇḍāgāra,* 'the royal treasury'. That this man may indeed be the head of the royal treasury is indicated by two circumstances. He instituted this endowment, not for his own personal merit (*puṇya*), but for perpetuating the fame of Komāragiri Reḍḍi, presumably the ruling monarch, and his queens. Second, in the Sanskrit preamble, he is referred to as *prabhu* (lord), an epithet usually applied to the nobility and not to merchants.

5.2.2. Inscription of 1404

Endowment made on 9 July 1404 for the installation of a water clock (*ghaḍiyāramu*) at the temple of Bhāvanārāyaṇa in Sarpavaram (Lat. 17;1° N – Long. 82:13° E), near Kakinada, East Godavari District, Andhra Pradesh. The inscription is in Telugu; it is engraved on a stone pillar set up behind the shrine:[1545]

svasti. śrī śakavarṣaṃbulu 1326 aguneṃṭi tāraṇa śrāvaṇa śu 5 gu

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[1545] K. Krishna Sastri (ed), *South Indian Inscriptions,* vol. V, Madras 1925 (Archaeological Survey of India, New Imperial Series, No. XLIX), reprint: New Delhi 1986; No. 10 (A.R.No. 455-B of 1893), p. 4.

śrīsarpapura-śrībhāvanārāyaṇa perumāllaku golisomāreḍḍiṃgāru ghaḍiyāramu veṭṭi

ā brāhmalu aubhalojhu simgā(o)jhumgāri jītālaku tūrputānu (kha) kha 1 na 10 cenu paḍumaṭi-polāna kha (7) na 10 nnu ve(ra)si kha 5 cenikai ṭaṃ 100 kālu samarppimciri.

ī ghaḍiyāramu dharmmamu ācamdrārkasthāyi.

kaimkaryamuna evvaru virodhimpinānu (ta) ma śe(śi)na sukṛtālu (se)ḍunu.

ghaḍiyāramu brāhmalagotrālaku (vri)tti pannu (pa)rayam evvaru gonam dala-

cina brāhmaṇuṃ jaṃpina doṣānaṃ bovāru.

'Let it be auspicious. Śaka year 1326 which corresponds to [the Jovian year] Tāraṇa, Śrāvaṇa [month] bright half, fifth day, Thursday. The respected **Goli Somāreḍḍi**, having set up a *ghaḍiyāramu* in the temple of Bhāvanārāyaṇa Perumāḷ at Sarpapura, [donated] for the wages of the brahmins **Obhalojhu** and **Simgāojhu** one field (*cenu*) in the east … and one field in the west … total *kha* 5; for [acquiring these] fields, he paid 100 *ṭaṃkas*.

This *ghaḍiyāramu* is a religious endowment (*dharma*) and should last as long as the moon and sun [exist].

Whosoever opposes this temple service (*kaiṃkarya*) would lose the merits he had acquired.

If anyone wishes to impose *vritti* taxes on these families of the brahmins connected with the *ghaḍiyāramu*, he would incur the sin of killing a brahmin.'

The date Śaka 1326, Jovian year Tāraṇa, 5th lunar day of the bright half of the month Śrāvaṇa translates to 9 July 1404. Two brahmins were appointed for the maintenance of the water clock; they were given two pieces of land, one on the east of the village and another on the west, with a total area of 5 *kha*; here *kha* probably stands for the area measure *khāri* or *khārika.* This land was purchased for 100 *taṅkas.*

5.2.3. References to the Water Clock in Telugu Literary Works

In the Telugu literary works also there are many references to water clocks. These have been collected by M. Somasekhara Sarma:[1546]

> The water-clock that was in use in the Andhra country during the period under review [ca. 1325-1448] is a late device that worked by drawing in water. The *ghaṭikā-pātra* or the bowl, which draws in water and sinks in the water in the big receptacle within a *ghaṭikā* of time was called *gaḍiya-kuḍuku* in Telugu. Koravi Goparāja compares very aptly the sun setting in the ocean with a *gaḍiya-kuḍuku* sinking in the sheet of water in the big receptacle. That this appliance operated in this way was further made clear by the passages in the *Bhojarājīyam* and the *Vīrabhara-vijayam,* written by Anatāmātya and Potana respectively. They refer to the sinking of the eagerly watched *tāmra-ghaṭikā-pātra* or the copper-bowl. The passage in the latter work referred to above, suggests that this appliance was also set up temporarily at the time of marriages, and other auspicious occasions, to ascertain and announce the precise auspicious *lagna* or moment. No sooner than the bowl sank in water than the time was announced to the public, by either striking a gong with a rod (called *koḍupu* in Telugu) … Time was calculated and announced in *ghaṭikās* of time beginning from sunrise to the sunset, and probably from the sunset to the sunrise. Vallabhāmātya, the author of the Telugu drama *Krīḍābhirāmam,* refers to the *gaḍiyāram* in the *mosāla* (entrance hall) of the Andhra monarch at Warangal. Hearing the *gaḍiyāramu* strike sixteen (*reṇḍ=enimudul*), indicating thereby that sixteen *ghaṭikās* of time elapsed till then from the sunrise, Govinda Mañcana Śarma … suggests to his friend Tiṭṭibha Setti … that it was a little past midday and time to go for dinner …

[1546] SarmaMS 1948, pp. 324-327, esp. 326-327; see also Kumari 1994.

6. Ṭās-i Ghariyāl at the Court of Fīrūz Shāh Tughluq

6.1. ᶜAfīf on the Ṭās-i Ghaḍiyāl

In the first half of the eleventh century, Al-Bīrūnī describes, as was shown above, the mode of announcing time by means of the drum and conch-shell. During the next centuries, these sound-producing instruments appear to have been replaced by the brass or bronze gong (*ghaḍiyāl*) on which a series of rapid blows separated the strokes for the *ghaṭikās* and those for the *praharas.*

Shams-i Sirāz ᶜAfīf, a contemporary and chronicler of Fīrūz Shāh Tughluq (r. 1351-88), writes in his *Tarīkh-i Fīrūz Shāhī* that, soon after returning from the campaign at Thatta in Sind (1365-67), Fīrūz installed at the top of his palace at Fīrūzābād, the *ṭās-i ghadiyāl.*[1547] ᶜAfīf does not provide any description, but dwells eloquently on the 'seven merits' of this device: aside from the fact that it can be used also at night and on cloudy days, its chief merit lay, according to him, in that it can tell the times of Muslim prayers every day and times of breaking fast during the month of Ramaḍān.

In their translation of ᶜAfīf's work, Elliot and Dowson did not translate this chapter, but gave a bare summary, leading to much unwarranted speculation on the nature of this *ṭās-i ghadiyāl,* the invention of which ᶜAfīf attributes to the Sulṭān himself, in accordance with the habit of the courtiers of that age.[1548]

First of all, the Persian word *ṭās* here means 'cup' or 'bowl'. From Bābur's memoirs we learn that *ghadiyāl* is the name for the gong on which the intervals of time are announced with the strokes of a mallet. Therefore, this device set up by Fīrūz Shāh consists of a cup and a gong. Second, the Mughal emperor Bābur and Abū al-Faḍl, the chief chronicler of Bābur's grandson Akbar, give a fairly detailed description of measuring time by means of the sinking bowl water clock and of announcing *ghaṭīs* and *praharas* (or *pahars*) by means of the gong known as *ghadiyāl / ghariyāl.* Extrapolating this information backwards to the time of Fīrūz Shāh in the second half of the fourteenth century, it can be safely concluded that the device which Fīrūz Shāh installed on the top

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1547 *Tārākh-i Fīrūz Shāhī,* Book III, ch. 18.

1548 Elliot & Dawson, III, pp. 338.

of his palace is the same *Ghaṭikā-yantra*, which was being used about the same time in Gujarat and in the Telugu-speaking areas for measuring and announcing time.

On the other hand, ᶜAfīf lays emphasis on the fact that the new device helps in determining the Muslim prayer times and the times for breaking the fast during the month of Ramaḍān. These times are based on the variable seasonal hours which the sinking bowl water clock cannot measure. But one can determine them with the help of the water clock and with a book of tables which show the variable times of prayers for every day of the year. Such books were well known at Fīrūz's times.

6.2. Was the Ṭās-i Ghadiyāl an Automatic Device?

However, several scholars wish to see here some kind of automatic device, such as those designed by ibn al-Razzāz al-Jazarī (1136–1206).[1549] But several factors go against this view. First, if the device set at the palace of Fīrūz Shāh was an automatic machine in the manner of al-Jazarī, then its name would have been different; al-Jazarī calls the water clock incorporated in his automata as *ṭarjahār.* It was also known as *bingān* in Iran. Then Fīrūz's Shāh's device would also have been called by such a name and not *ṭās-i ghadiyāl* where the term *ghadiyāl* is an Indian term denoting the gong.

Second, the device which Fīrūz set up on his palace gate was such that when the *ghaṭīs* or *praharas* are struck, the sound was audible for a long distance. This is possible only with a gong, but not with any of the automata of al-Jazarī.

More important, al-Jazarī's automatic devices function on the regular movement of the various components; in principle, these cannot indicate the variable times of Muslim prayers. This can only done by the astrolabe, or with the water clock in combination with a book of appropriate tables where the times of prayers are listed for every day of the year for different latitudes.

[1549] Cf. Hill 1974.

7. GHAṬIKĀ-YANTRA AT THE MUGHAL COURT

7.1. Bābur on the Water Clock

Bābur (r. 1526-30), the first Mughal emperor, was so impressed by this system of time-keeping that he adopted it, while introducing innovations in the mode of announcement. His lucid account deserves to be cited in full:

> So the people of Hind divide the night-and-day into 60 parts, each called a *gharī.* They also divide the night into four and the day into four, calling each part a *pahr* (watch) which in Persian is a *pās.* A watch and a watchman (*pās u pāshān*) had been heard about (by us) in those countries (Transoxania), but without these particulars. Agreeing with the division into watches, a body of *gharīālīs* is chosen and appointed in all considerable towns of Hindūstān. They cast a broad brass (plate)…, perhaps as large as a tray (*tabaq*) and about two hands' thickness; this they call gharīāl and hang up in a high place (*bī buland yīr-da*). Also they have a vessel perforated at the bottom like an hour-cup (?) and filling in one gharī (i.e. 24 minutes).
>
> These gharīālīs put this into water and wait till it fills. For example, they will put the perforated cup into water at day-birth; when it fills for the first time, they strike the gong once with the mallets; when a second time, twice, and so on till the end of the watch. They announce the end of the watch by several rapid blows of their mallets. After these they pause; then strike once more, if the first day watch has ended, twice if the second, three times if the third, and four times if the fourth. After the fourth day-watch, when the night-watches begin, these are gone through in the same way.
>
> It used to be the rule to beat the sign of a watch only when the watch ended; so that the sleepers chancing to wake in the night and hear the sound of third and fourth *gharī,* would not know whether it was of the second or third night-watch. I therefore ordered that at night or on a cloudy day the sign of the watch should be struck after that of the *gharī,* for example, that after striking the third *gharī* of the first watch, the *gharīālīs* were to pause and then strike

the sign of the watch, in order to make it known that this third *gharī* was of the first night-watch.[1550]

7.2. Abū al-Faḍl on the Water Clock

The same system continued in Akbar's reign also (1556-1605). Abū al-Faḍl describes the practice under the title the 'Institution of Gharyāl,[1551] but there are some errors in his account:

> This is a round gong of mixed metal, shaped like a griddle but thicker, made of different sizes; and suspended by a cord. It may not be sounded except by royal command, and accompanies the royal equipage.
>
> The Hindu philosophers divide the day and night into four parts, each of which they call *pahr.* Throughout the greater part of the country, the *pahr* never exceeds nine *gharis* nor is less than six. The *ghari* is the sixtieth part of a nychthemeron, and is divided into sixty parts, each of which is called a *pal* which is again subdivided into sixty *bipal.*
>
> In order to ascertain and indicate time, a vessel of copper or other metal is made of a hundred *tanks* weight. In Persian it is called *pingān.* … It is in the shape of a bowl narrower at the lower part, twelve fingers in height and breadth. A perforation is made below to admit of a golden tube being passed through, of the weight of one Māshā, and in length the breadth of five fingers.[1552] It is placed in a basin of pure water in a place undisturbed by the wind. When the bowl is full of water, one *ghari* is elapsed, and in order that this should be known to far and near, the gong is struck once, and for the second time twice, and so on. When a *pahr* has elapsed, the number of *gharis* expired therein is first sounded and then more deliberately from one to four (according to the *pahr*), thus announcing the *pahr* struck. Thus when it is two

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1550 Babur, pp. 516-517. Bābur's innovation in the mode of announcing *ghaṭīs* and *praharas* corresponds to the practice at the Nālanda monastery in the seventh century; cf. Table R1.

1551 Abū al-Faḍl 3, pp. 17-18.

1552 It is obvious that a hemispherical bowl with a width (diameter of the mouth) of 12 fingers, cannot have a height also of 12 fingers; the height should be only 6 fingers. Professor A. J. Qaisar kindly compared Jarrett's translation with the Persian original of the Nawalkishore Press: the original also mentions 12 fingers as the height.

> *pahr,* (twelve o' clock), the gong is struck twenty-sixth [sic!] times, taking the *pahr* at eight *gharis.*

This description of the bowl is not the description of an actual bowl used at the court of Akbar; it looks more like an inaccurate rendering from a Sanskrit text. When the *pahr* consists of eight *gharis*, at the end of the second *pahr*, there will be 8 strokes for 8 *gharis* and 2 strokes for 2 *pahrs.* This makes 8 + 2 strokes, and not 26.

7.3. Water Clock in Mughal Miniature Paintings

This clumsy account is redeemed, to a large extent, by two miniature paintings executed at Akbar's atelier in which the *Ghaṭikā-yantra* is depicted very accurately.[1553] In fact, these are the only pictorial depictions of this instrument.[1554] The first painting is related to the birth of Akbar. It shows Akbar's father Humāyūn seated on a throne, with astronomers in attendance. The astronomers have measured the time of the birth by means of a water clock and a ring dial and drew up the native's horoscope. The water clock, with the bowl floating in a large basin is drawn very clearly; in contrast, the ring dial is very small; one sees just the ring with suspension bracket; a sheet of paper with a fold in the middle indicates the horoscope.

The second miniature is related to the birth of Salīm, the future Jahāngīr. It shows Hindu and Muslim astronomers seated together, measuring the birth-time with a *Ghaṭikā-yantra*, and the sun's altitude with a ring dial (*Cūḍā-yantra*), and drawing up the horoscope. Here the perforated bowl and the ornate water basin are painted golden.[1555]

Abū al-Faḍl states that time-keeping and announcing was the royal prerogative under Akbar. In the subsequent centuries, minor rulers also began to maintain water clocks at their palace gates and to regularly announce time.

[1553] Sarma 1992a.

[1554] British Library, Ms. Or. 12988, f. 20b; reproduced in Geeti Sen, *Paintings from the Akbarnama: A Visual Chronicle of Mughal India,* Calcutta 1984, Pl. 57, pp. 130-131.

[1555] Museum of Fine Arts, Boston, #17.3112; reproduced in Stuart Cary Welch *Imperial Mughal Painting,* London 1978, Pl. 16, pp. 70-71.

8. Ghaṭikā-yantra in minor Kingdoms

After the Mughals, smaller kingdoms also introduced this custom of measuring time with the *Ghaṭikā-yantra* and announcing the intervals by strokes on the gong. According to the *Lekhakamuktāmaṇi* of Vatsarājaputra Haridāsa Kāyastha Śrīgauḍa, one of the 36 royal departments (*śālā,* corresponding to the *kārkhānā* of Akbar's court) was called *Tūryagṛha* and contained water clocks for measuring time and various kinds of drums and trumpets for announcing it.[1556] This work is supposed to have been composed between 1550 and 1600 at the court of Amber in Rajasthan and may reflect the state of affairs there.

A later ruler of Amber, Sawai Jai Singh (1688-1743) made use of the water clock in his astronomical researches. In this connection, Irfan Habib writes as follows:[1557]

> A more refined way [of determining longitudes] had been suggested by Ptolemy; that was by measuring time, not distance, to establish relative longitudes. This was repeated in the *zīj* of Ulugh Beg: Lunar eclipse was to be availed of, and the time elapsing between the noon at each of the two places and the beginning and end of the eclipse was to be measured. Each difference of an hour in the periods elapsing at two places meant a difference of 15 degrees of longitude. Jai Singh copies this passage [in his *Zīj-i Muḥammad Shāhī*], but makes a significant addition: As soon as the sun had reached and passed its highest altitude at noon, he says, the observer was to set up the time-keeping water vessel [*finjān-i āb*] or sand-glass (*shisha-i sāᶜat*), and record the time until the eclipse began or ended.

In a contemporary map of Jai Singh's observatory at Jaipur, a small square at the northern boundary is marked as the place of the *ghaḍiālīs* (*ghaḍiyālī-khānā*).[1558]

1556 *Lekhakamuktāmaṇi,* Ms. No. 464, Pothikhānā, City Palace Library, Jaipur, 3.88 cd: *tūryagṛhe saghaṭī-yantrāṇi rasāla-bhery-ānaka-tūryāṇi* (in the *tūryagṛha,* [there shall be] water clocks, drums called *rasāla, bherī* and *ānaka,* and trumpets); I owe this information to the kind courtesy of the late Gopal Narayan Bahura of the Palace Library.

1557 Habib 1977, p. 132.

1558 Sharma 2016, map on p. 128, no. 25.

9. Accounts of European Travellers

Between the seventeenth and nineteenth centuries, several European visitors wrote about the sinking bowl and the mode of announcing time with its help in India. In his *Geographical Account of Countries Round the Bay of Bengal, 1669 to 1679,* Thomas Bowrey informs that most wealthy Muslims have set up water clocks in their front porches with two servants attending all the time, one to lift the bowl and set it up again and the other to strike the gong, and that this custom is emulated also by the English and Dutch in their factories.[1559] These accounts, often inaccurate and full of outlandish transcription of Indian names, do not add much to our knowledge, except to show that this archaic time measurement continued without much challenge from the European clocks. The following three accounts deserve our attention.

9.1. John Gilchrist[1560]

The apparatus with which the hours are measured, and announced, consists of a shallow bell metal pan, named from its office *G,huree,al*, and suspended so as to be easily struck with a wooden mallet by the *g,huree,alee*, who thus strikes the *g,hurees* as they pass, and which he learns from an empty thin brass *cup (kutoree)* perforated at bottom, and placed on the surfaced of water, in a large vessel, where nothing can disturb it, while the water gradually fills the cup, and sinks it in the space of one *g,huree*, to which this hour cup or *kutoree* has previously been adjusted astronomically by an *astrolabe*, used for such purposes in India. These *kutorees* are now and then found with their requisite divisions, and subdivisions, very scientifically marked in *Sanscrit* characters, and may have their uses for the more difficult and abstruse operations of the mathematician or astrologer, but for the ordinary occurrences of life, I believe the simple horology described above suffices (perhaps divided into the fourths of a *g,huree*) the *Asiaticks* in general, who by the bye, are often wonderfully uniformed, respecting everything of this kind.

1559 Thomas Bowrey, *Geographical Account of Countries Round the Bay of Bengal, 1669 to 1679,* ed. Lt.-Col. Sir Richard Carnac Temple, Hakluyt Society, Cambridge 1905, pp. 195-197.

1560 Gilchrist 1795, p. 88.

Six or eight people are required to attend the establishment of *g,huree,* four through the day, and as many at night, so that none but wealthy men or grandees can afford to support one as a necessary appendage of their consequence and rank.

9.2. Mrs Meer Hasan Ali[1561]

Occasionally, of course, some bowls were made to measure the European hours of sixty minutes or half hours. The best of such European accounts is from Meer Hassan Ali's English wife, who lived in Lucknow with her husband's family for twelve years from 1816. In her *Observations on Mussalmauns* in India, Mrs. Meer Hassan Ali shows how the sinking bowl had become an integral part of the upper class Muslim households at the beginning of the nineteenth century:

> They have a simple method of measuring the hour, by means of a brass vessel, with a small aperture at the bottom, which, being floated on a tank or large pan of water, one drop to a second of time forces its way through the aperture into the floating vessel, on which marks are made outside and in, to direct the number of ghurries by the depth of water drawn into it; and in some places, a certain division of time is marked by the sinking of the vessel. Each hour, as it passes, is struck by the man on duty with a hammer on a broad plate of bell-metal, suspended to the branch of a tree, or to a rail: the gong of an English showman at the country fairs is the exact resemblance of the metal plates used in India for striking the hours on, and must, I think, have been introduced into England from the East.
>
> The *durwan* (gate-keeper), or the *chokeedars* (watchmen), keep the time. In most establishments, the watchmen are on guard two at a time, and are relieved at every watch, day and night. On these men devolves the care of observing the advance of time by the floating vessel, and striking the hour, in which duty they are required to be punctual, as many of the Mussalmauns' services of prayer are scrupulously performed at the appointed hours.[1562]

1561 Ali 1974.

1562 Ali 1974, pp. 55-56.

9.3. Edgar Thurston

Edgar Thurston (1855-1935) joined the Ethnographic Survey of India in 1901 and made several valuable contributions such as the *Castes and Tribes of Southern India* (1909); later he became the superintendent of the Madras Museum. His *Ethnographic Notes* (1907) contains the following information on the use of the water clocks in southern India at the end of the nineteenth and beginning of the twentieth centuries: [1563]

> This form of the time-measurer, made of a half cocoanut or copper, is still in use among native physicians, astrologers and others in Malabar. A cup of this nature was employed in the Civil Court at Mangalore in 1852, a peon being posted in charge of it, and beating on a gong the number of gadis [*ghaṭīs*] every time that it sank. At the present day it is used on the occasion of marriage among higher Hindu castes. The Brāhman priest brings the cup, and places the bridegroom in charge of it. It is the duty of the latter to count the gadis until the time fixed for his entrance into the wedding-booth. The apparatus is nowadays often replaced by a clock or watch, but the officiating priest insists on producing the cup, as he receives his fee for doing so.'
>
> The method of computing time by means of a water clock, on which the gadiya [*ghaṭikā*] or nazhigai [*nālikā*] (24 minutes) and jām or jāmam [*yāma*] (7 gadiyas) are indicated by nicks on the inside of the cup, is still in vogue in the huzur and temple at Venkatagiri [Lat. 13;58° N, Long. 79;35° E]. The cup is in charge of a sepoy, who keeps time, and makes it known by beating a gong at the end of each gadiya or jām. To compensate for the seasonal variations of day and night, correction is made in the length of the periods. The hole in the cup, after it has been in use for some time, becomes dilated, and to correct the error, it is contracted by beating the cup with a hammer. A standard cup is kept for the purpose of regulating the water-clock. The computation of time by means of an hour-glass in some Brāhman (especially

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[1563] Thurston 1907, p. 565-566.

> Mādhva) mutts. Mr. Percy Brown[1564] writes to me that Mr. J. L. Kipling[1565] introduced the water-clock for use by the Police at the Lahore Museum, as the clock was always getting out of order. The bowl is a copper one, floated in an earthen bowl, and takes an hour to sink. It is in charge of the policeman on duty, who strikes a gong each time that it sinks. Water-clocks are in use in many places in the Punjāb, and nearly always in connection with native sentry work.

10. WATER CLOCK AT PLACES OF WORSHIP

Even after the *Ghaṭikā-yantra* was replaced by European clocks, the former continues to be used for ritual purposes in the places of worship of all major faiths in the Indian sub-continent.

On the day of Janmāṣṭamī, the birth of Kṛṣṇa is celebrated at all the temples of Mathura in Uttar Pradesh. The festivities commence at midnight when Kṛṣṇa is supposed to have been born. At the Dwarakadhish temple, the precise time of midnight is said to be determined by means of the traditional water clock.

At Jhalawar (Lat. 24;35° N, Long. 76;10° E) in Rajasthan, at the Jain temple dedicated to Tirthankar Shantinath, *Ghaṭikā-yantra* is still used to determine the time of various rituals.[1566]

At Ajmer, also in Rajasthan, at the mausoleum of Khwaja Moinuddin Chisti, there is no water clock to measure time any more, but there is still a *ghaḍyālī,* the time-keeper, who announces in a certain ritual that six *ghaṭīs* have passed (R013).

In the town of Sehwan in Sindh, Pakistan, there is the mausoleum of Shaikh Usman, popularly known as Qalandar Shahbaz. At this mausoleum, the sinking bowl was in use as late as 1973 for regulating the times of various daily rites. According to N. A. Baloch, the bowl must have been in use during the lifetime of the saint in the thirteenth century for determining the times of prayer and the time of the dance of the dervishes (*dhammal*) just after the Maghrib prayer. After the saint's death, the

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1564 Percy Brown is a well known art-historian.

1565 J. L. Kipling was the father of Rudyard Kipling.

1566 Reported in *The Hindu,* New Delhi Edition, 24 April 1994; cf. Sarma 1994a.

ceremonies which became more elaborate were still performed according to the time measured by the water clock. In Sindhi, the bowl is called *wato*, the water basin in which it is made to float is known as *degrro*, and the gong *gharryal.*[1567]

11. Origin and Diffusion of the Sinking Bowl Water Clock

The sinking bowl type of water clock was not confined to India, it was used in many countries from Iran to Spain in west and from Myanmar to Indonesia in the east. It was used not only for regular time-keeping, but also to measure certain segments of time for the distribution of irrigation water in the west and to measure certain segments of time in cock-fights in South-East Asia. But where did it originate?

The earliest mention of the sinking bowl, as shown above (3.1.2), occurs in the commentary of the *Majjhimanikāya,* written by Buddhaghoṣa in the first half of the fifth century in Sri Lanka. Here the bowl is not the basic model which measures the *ghaṭī,* but one that was specially prepared to measure one *yāma,* which unit is roughly equal to three *ghaṭīs* at the low geographical latitude of Sri Lanka. Bowls that measured one *ghaṭī* must then be still older. Therefore, it is reasonable to suppose that the sinking bowl type of water clock was developed some time in the fourth century in the Indian Ocean region, either in Sri Lanka, or on the southern coast of India, or in one of the islands of the Malay Archipelago. It is also likely that the original inspiration for the sinking bowl came from the coconut shell, which is naturally endowed with a hole; water clocks made of well-scrubbed halves of the coconut shell survive in museums.

However, there is one problem in this scenario. The use of the sinking bowl in Iran was mainly associated with the distribution of irrigation water from the underground system water channels called *Qanāt.* While this *Qanāt* system is said to be very ancient,[1568] it is not known when the distribution of irrigation water to individual farmers began to be regulated by means the sinking bowl. Therefore, it is difficult to say whether the sinking bowl used with the *Qanats* reached India and from there spread to South-East Asia, or whether it originated either in Sri Lanka or India, and thence spread westwards and eastwards.

[1567] Baloch 1979.

[1568] On *Qanāts,* see Wulff 1966, pp. 249-256; Wulff 1968; English 1968.

11.1. Sinking Bowl Water Clock in the West

Early records of the use of the sinking bowl in the west are not many; these go back only up to the tenth century. In his treatise of the astrolabe, *Kitāb al-ᶜAmal bi l'Asṭurlāb,* dated 986, al-Ṣūfī laid down a procedure to graduate the inner sides of a very large sinking bowl into twelve hours.[1569] At the beginning of the thirteenth century, al-Jazarī, the author of the *Kitāb fī maᶜrifat al-ḥiyal al-handasiyya,* incorporated the sinking bowl in two of his automatic clocks. On this Donald R. Hill says[1570]

> 'Another mechanism used by al-Jazarī was the submersible bowl (*ṭarjahār*); this had an orifice in its underside which caused it to submerge in pre-determined time. This was used in two water-clocks (category I, Chapters 3 and 4), both of which operated on the closed-loop principle. The *ṭarjahār* was used before this to time the allocation of irrigation water.'

The sinking bowl was also mentioned by Giyāth al-Dīn al-Kāshī who was associated with the Samarqand observatory in the fifteenth century, according to Aydin Sayili:

> 'Giyāth al Dīn speaks of water clocks constructed in the form of bowls with a hole at their bottom. They were placed upon the surface of the water, and they became filled gradually with the passage of time. … It may be conjectured that these bowls were in use in the Samarqand observatory.'[1571]

11.1.1. Sinking Bowl as an Irrigation Clock in Iran

The *Qanāt* system spread from Iran to other areas in the Middle East and then to North Africa and Spain; in some of these places, the distribution of water to individual cultivators was regulated by sinking bowls. About their use in Iran, Hans E. Wulff offers a very detailed account:[1572]

> The distribution of irrigation water, especially that of *qanāt* water gained after so much effort, is regulated by custom and law, often going back to pre-

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1569 Bruin 1968a, p. 56.

1570 Hill 1998, I, pp. 26-27 (drawings), III, p. 205.

1571 Sayili 1960, p. 288.

1572 Wulff 1966, pp. 254-256.

> Islamic times and early Islamic codification. … The water bailiff (*mīr-āb, āb-māl, āb-bargardān, ābgār, lāvān, pākār, qāsem-āb, bārāndar*), who supervises the distribution from a hut near the distribution basin, has a large bowl (*kūzeh, tašt*) filled with water near him on the floor. When he begins time he places a small dish (*taštak, piyāleh, finjān, finkāl, peing*) on the surface of the water so that it floats. Water gradually enters this dish through a small hole (*sūraḥ, lūbeh*) in its bottom until it eventually sinks down with a noise. This marks one time unit. As most customers are allotted a number of time units, a pebble is transferred from one jar into another each time the dish has gone down. When the last pebble has been transferred and the customer's time is up, the water is directed to another channel.

According to Steingass, the sinking bowl is also called *bingān* in Persian, which he explains as follows:

> a copper bowl or basin with a hole bored in the bottom, which being placed in water is suffered to fill, and thus serves to measure the time that each cultivator is allowed to have water turned upon his land from a canal for the purposes of irrigation.[1573]

11.1.2. Sinking Bowl as an Irrigation Clock in North Africa and Spain

About the use of water clocks for regulating the distribution of irrigation water, Thomas F. Glick published an important study, mentioning the types of water clocks used and their duration: [1574]

> Sinking clocks have been continuously associated with the practice of irrigation in the Near East, particularly Persia and the Yemen … It is still commonly used in many parts of North Africa and was the traditional measuring device of the small irrigation district of the Vall de Segó north of Valencia [in Spain]. In the Vall de Segó there were two such clocks, the *olla,* which sank in about an hour, and a smaller version, the *carapit,* which sank in seven and a half minutes. …

1573 F. Steingass, *A Comprehensive Persian-English Dictionary,* London 1892, reprint: Delhi 1996, s.v.

1574 Glick 1969, pp. 425-426.

The most typical clock of the North African oases was the *qadus* — that is, the bucket of a *noria* (hydraulic wheel), which when punctured with a hole became an outflow clepsydra.

11.1.3. Sinking Bowl as an Irrigation Clock in India and Nepal

Although the sinking bowl must have been used, aside from regular measuring of time, also as an irrigation clock in several parts of India, there do not seem to be any published records. The only tangible evidence we have is the copper bowl (R004) from Rampet, Pallar Valley, in Tamilnadu, now preserved in the Pitt Rivers Museum of Ethnology at Oxford. The village officer who superintends the distribution of the irrigation water was said to be designated as *Nerkatti* in Tamil and *Nīrganti* in Kannada.

Recently Olivia Aubriot studied the irrigation system in Aslewacaur, a village in central Nepal, and noticed that a sinking bowl is used there for distributing the irrigation water to different clients.[1575]

11.2. Sinking Bowl in South Asia and South-East Asia

About the eastward diffusion of the sinking bowl, there can be no doubt that it spread from India, in some cases along with Indian terminology as well. Aside from its use for the regular measurement of time, the sinking bowl was also employed in timing the duration of cockfight in Bali and Thailand. While cockfights were held in Bali in religious rituals, in Thailand they were held to commemorate a legendary event.[1576] The only mention of this nature in India occurs in the encyclopedia called *Mānasollāsa,* composed in 1129, by King Someśvara of the Western Chālukya dynasty, in connection with the regulation of the duration of quail (*lāvaka)* fights: the quails are to fight for 24 seconds and then rest for another 24 seconds:

mātrāśatena viṃśena pūryate toyadhārayā |
tāvat pātraṃ prakurvīta sā nāḍī kathitā budhaiḥ ||
ekāṃ ca yodhayen nāḍīm ekāṃ viśrāmayet tathā |

[1575] Cf. Olivia Aubriot, *L'eau, miroir d'une société—Irrigation paysanne au Népal central,* CNRS [Centre national de la recherche scientifique] Éditions, Paris 2004, pp. 175-182: L'horloge à eau : de l'astronomie à l'hydraulique (water clock ; from astronomy to hydraulics). I owe this information to Dr Jérôme Petit, Paris.

[1576] In both countries, betting in cockfights is now strictly prohibited.

viśrāmanāḍīḥ saṃtyajya yodhayet pañcanāḍikāḥ ||[1577]

'Let a vessel be made which can be filled with a jet of water in 120 *mātrās*. That [duration] is called *nāḍī* by wise men. Let the quail fight for one *nāḍī* and rest for another *nāḍī*. Leaving aside the *nāḍīs* of rest, let it fight for [a total of] five *nāḍīs*.'

Obviously Someśvara is referring to the sinking bowl water clock. But he defines *nāḍī* as consisting of 120 *mātrās*, i.e. time taken to utter 120 short syllables (or 60 long syllables), which constitute just 1 *vighaṭikā* or 24 seconds. Therefore, his *nāḍī* is entirely different from the standard *nāḍī* which is equal to 24 minutes. Probably this shorter *nāḍī* is used only in the fight of quails.

Fred B. Eiseman writes that in Bali, the water clock used in cockfight has a duration of 10 seconds only, which is the time allowed for one round of fight.[1578]

11.2.1.Sri Lanka (formerly Ceylon)

Mention has been made above (3.1.2) of the large sinking bowl that measured one *yāma* in the fifth century. It is not known how time was measured in subsequent centuries in Buddhist monasteries. In the seventeenth century, however, measuring time with the sinking bowl became the exclusive privilege of the king, according to Robert Knox (1681), who reports as follows: [1579]

> Their day, which they call *Dausack*, they divide into Thirty *Pays*, hours or parts, and begin their account from the Sun rising, and their Night also into as many, and begin from Sun-setting: So that the Fifteenth *Pay* is Twelve a Clock at Noon. They have a *Flower* by which they judge of the time, which constantly blows open seven *Pays* before Night.
>
> They have no *Clocks*, *Hour-glasses*, or *Sun-Dials*, but keep their time by guess. The King indeed hath a kind of Instrument to measure time. It is a

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1577 *Mānasollāsa of King Bhūlokamalla Someśvara,* ed. G. K. Shrigondekar, vol. II, Baroda 1939 (GOS 84), p. 257.

1578 Fred B. Eiseman, Jr. *Bali: Sekala and Niskala, Essays on Religion, Ritual, and Art,* Berkley-Singapore 1990, p. 248.

1579 Robert Knox, *An Historical Relation of the Island Ceylon in the East Indies,* [London 1681], with an Introduction and Afterword by Dr H. A. I. Goonetileke, third facsimile reprint, Navrang, New Delhi 1995, p. 111.

> *Copper Dish* holding about a Pint, with a very small hole in the bottom. This Dish they set a swimming in an Earthen Pot of water, the water leaking in at the bottom till the Dish be full, it sinks. And then they take it out, and set it empty on the water again, and that makes one *Pay*. Few or none use this but the King, who keeps a man on purpose to watch it continually. The People will use it upon some occasions, as if they are to sow their Corn at any particular hour, as being the good lucky Season, then they make use of the *Copper Pan*, to know the time exactly.

But in later times, sinking bowl appears to have been used even outside the royal palace. The Pitt Rivers Museum of Ethnology, Oxford, owns a specimen from Sri Lanka which must have been made at the end of the nineteenth or the beginning of the twentieth century (R005).

11.2.2. Nepal

On the use of the sinking bowl in Nepal for regular time-keeping, Thurston reports as follows: [1580]

> In Nepāl the measurement time is regulated in the same manner [as in India]. Each time the vessel sinks, a gong is struck, in progressive numbers from dawn to noon. After noon, the first ghari struck indicates the number of gharis which remain of the day till sunset. Day is considered to begin when the tiles on a house can be counted, or when the hairs on the back of a man's hand can be discerned against the sky.

At Hanumandhoka Palace, and also at Gorkha Palace, it is said that time was measured with a water clock and announced regularly up to the beginning of the twentieth century. Recently Olivia Aubriot studied the irrigation system in Aslewacaur, a village in central Nepal, and noticed that sinking bowl water clock was used there for distributing the irrigation water to individual farmers. [1581]

[1580] Thurston 1907, pp. 563-564.

[1581] Cf. Olivia Aubriot, *L'eau, miroir d'une société—Irrigation paysanne au Népal central,* CNRS Éditions, Paris 2004, pp. 175-182: L'horloge à eau : de l'astronomie à l'hydraulique" (water clock, from astronomy to hydraulics). I owe this information to Dr Jérôme Petit, Paris.

11.2.3. Myanmar (formerly Burma)

About Myanmar, fortunately there exists a sinking bowl which was used at the emperor's palace in the nineteenth century (R006) as well as a description of it by John Nisbet of 1901:[1582]

> Each day was under Burmese rule divided into sixty hours (*Nayi*), and subdivided into eight watches, each of about three hours, which varied in length at different seasons of the year according as the days and nights were relatively longer or shorter. The *Nayi* or 'time measurer' was a copper cup having a tiny perforation at the base, which, being inserted in water, sank to a particular mark within a given time. The *Nayi* had various subdivisions from 'ten winks of an eye' (*Kaná*) upwards, but these terms were seldom used except in astrological works. As each *Nayi* was thus measured off a gong was beaten, and at every third hour the great drum-shaped gong was sounded from the *Pahózin* or time-keeper's tower within the inner precincts of the royal palace at the eastern gate. One beat of the drum denoted nine o'clock in the morning or evening, two beats twelve o'clock, three beats three o'clock, and four beats six o'clock. From Pah*ó* the beats were repeated on large bells by all the guards throughout the palace. To ensure the attention to this matter in the olden days, the timekeeper could be carried off and sold in the public market if he were negligent in the discharge of his duties, being then forced to pay a fine in the shape of ransom.
>
> Now, under British rule, wherever there are jails, police stations, treasury guards, and so forth, the hours are marked off by beat of a gong. Hence, in towns, the word *Nayi* has now come to mean both the hour, measured by the European method, and the clock or watch by which it is measured.

[1582] John Nisbet, *Burma under British Rule - and before,* Archibald Constable & Co, Westminster 1901, vol. II, pp. 288-289.

11.2.4. Indonesia

In Indonesia, there is a considerable influence of Sanskrit language and Hindu religion in the islands of Java and Bali. Consequently, many Indian units of time measurement have been absorbed there, as described by Lewis Pyenson:[1583]

> Indian astronomy was certainly present in Old Javanese texts of Brahman inspiration dating from the ninth and tenth centuries. The Indian time units of day and night — divasa for 24 hours; muhurta, ksana for 48 minutes; ghati, ghatika, nadi, nadika for 24 minutes (30 kala); kala for 48 seconds— all are present in the language. In Old Javanese poetry composed in Indian meter, however, the natural day is divided into equal parts of 8 hours, calculated from sunrise to sunset. The word for 'hour' is also that for 'stroke' or 'fall', suggesting hours being signalled by a striking device.

It is not known whether the sinking bowl was ever used for time-keeping, but in the island of Bali, it was used for timing the cockfight. Here cockfight was not a sport for amusement, but part of the ritual of exorcising evil spirits by spilling the blood of cocks. It was generally held in temples, but sometimes also in private homes as a purification ceremony. Fred B. Eiseman describes the use of the sinking bowl in these cockfights thus: [1584]

> When the birds are pulled apart, the time keeper starts his clock, called *ceeng*. It is a half coconut shell with a hole in the bottom, placed, large side up, in a bucket [*cobek*] of water. It sinks in about 10 seconds, or one *ceeng*. The cocks are allowed three *ceengs* to recoup between rounds.

11.2.5. Thailand (formerly Siam)

In Thailand, on the other hand, cockfights were held to commemorate the victory of the Siamese prince Naresuan over a Burmese prince in their legendary cockfight in

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1583 Lewis Pyenson, 'Assimilation and Innovation in Indonesian Science' in: Morris F. Low (ed), *Beyond Joseph Needham; Science, Technology, and Medicine in East and Southeast Asia*, [special issue of the] OSIRIS, A Research Journal devoted to the History of Science and its Cultural Influences, Second series, Volume 13, 1998, pp. 34-47.

1584 Fred B. Eiseman, Jr. *Bali: Sekala and Niskala*: *Essays on Religion, Ritual, and Art,* Berkley-Singapore, 1990, pp. 240-250, p. 244 illustration of the water clock.

the second half of the sixteenth century. In these cockfights time was measured with a sinking bowl water clock (*nāliga nām*), as the illustration below shows.



Figure R4 – Cockfight with a water clock in Thailand
(illustration from a popular book on folklore, courtesy Professor Ampha Otrakhul)

11.2.6. China

In China, the prevailing water clock was the inflow type with a series of water tanks, but the sinking bowl type was also known, according to Needham who states: [1585]

> The Chinese also knew another archaic device, the inverse variant of the outflow clepsydra, a floating bowl with a hole in its bottom so adjusted that it took a specific time to sink. … A Chinese example is afforded by the work of Thank monk Hui-Yuan, who arranged a series of lotus-shaped bowls to sink one after another during the twelve double-hours (*Thang Yü Lin,* ch.5, p. 31b).

[1585] Needham 1959, p. 315 and footnote h.



Figure R5 – Water Clocks in the Pitt Rivers Museum of Ethnology, Oxford (photo by S. R. Sarma)
First row, left to right: Mirzapur, Mandalay (Myanmar), Lord Shand's 1;
second row: Rampet, Lord Shand's 2, Uva, Sri Lanka;
third row: Malabar.

12. Extant Specimens

The sinking bowl type of water clock was in use throughout India (and also in South Asia and South-East Asia) until end of the nineteenth century. Writing in 1872, Baden Powell, reports thus: 'This article is in common use, and by it all police guards, &c, keep the time, striking their gong as each hour comes round.'[1586] One would therefore expect scores of water clocks to be surviving in every part of India. But people usually recycle unused copper or brass vessels and therefore there are few specimens extant.[1587] Of late, some former Maharajas have established museums inside their palaces and began to display artefacts of historical interest. Thus in the palace museums at Bharatpur, Bundi, Kota, Udaipur (all in Rajasthan) and Ramnagar (in Uttar Pradesh) there are displayed ensembles of the perforated bowl, water basin and gong.

The largest collection of water clocks---of different shapes, sizes and materials---is to be found in the Pitt Rivers Museum of Ethnology at Oxford. While some of these

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1586 Powell 1872, p. 200.

1587 It is not known whether any specimens are preserved in any South-Asian or South-East Asian countries; a friend informs me that he saw a specimen in the Ankor Wat Museum in Cambodia.

were made to measure the traditional Indian unit of *ghaṭī* or its fractions, others were made to measure the hour of 60 minutes, introduced by the British Colonial administration, or its fractions. Yet there is one more specimen which was not intended to measure time as such, but to measure the duration of irrigation water supply into different fields.

There are said to also bowls that measured three *ghaṭīs* (72 minutes). The German Baron Hermann von Schlagintweit-Sakünlünski, who undertook a scientific expedition to northern India between 1855 and 1857, collected two such bowls from Panipat and Varanasi and one metal gong.[1588] Some of the Indian artefacts collected by him are now with different museums in Germany;[1589] but there is no trace of the two water clocks, nor of the gong.

In the following pages, the water clocks of the Pitt Rivers Museum will be described first and then a few other specimens that I have seen.

1588 Schlagintweit-Sakünlünski 1871, pp. 129-130.

1589 Armitage 1989.

R001⊙ WATER CLOCK FROM MIRZAPUR, UTTAR PRADESH

Diameter 160 mm, height 66 mm

Oxford, Pitt Rivers Museum of Ethnology (# 1892.49.108)



Figure R001.1 – Water Clock (photo by S. R. Sarma)

Low, shallow bowl made of copper, not quite hemispherical in shape. According to the museum records, it was manufactured at Mirzapur for the use of police guards. Its original duration must have been 60 minutes but now, possibly because the orifice had become enlarged through constant use, the bowl is said to sink between 55 to 58 minutes. It was presented to the Museum by the well-known ethnologist William Crooke (1848-1922) of the Bengal Civil Service in 1892. Since the bowl is calibrated to measure the European hour of 60 minutes instead of the traditional *ghaṭī* of 24 minutes, it must have been manufactured in the 19th century.

R002⦿ WATER CLOCK

Diameter 160 to 173 mm, height 100 mm

Oxford, Pitt Rivers Museum of Ethnology (# 1916.40.1)

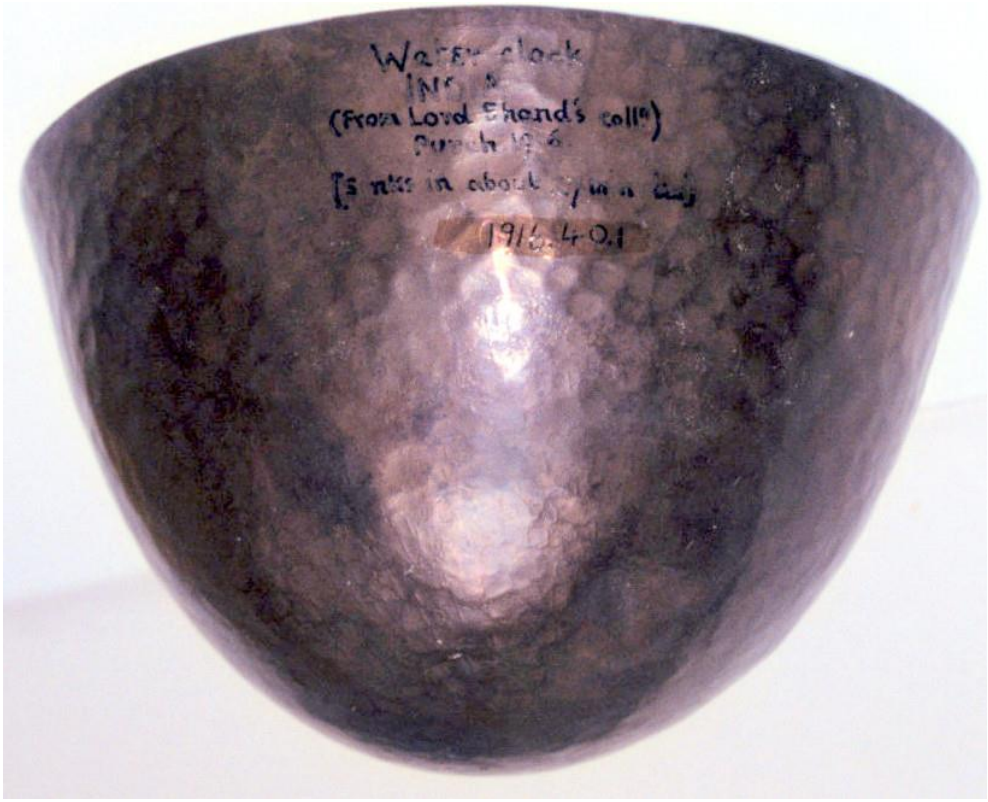


Figure R002.1 – Water clock (photo by S. R. Sarma)

Bowl made of hammered copper with an oval mouth and conical shape. The duration of immersion is 27 minutes. Originally it must have been made to measure half-an-hour of 30 minutes. Through constant use, the orifice became larger and the bowl sinks faster. The exact place of its manufacture is not known.

From Lord Shand's collection; bought at Steven's Auction Rooms, lot 108, May 1916.

R003⊙ WATER CLOCK

Diameter 140 to 145 mm, height 75 mm

Oxford, Pitt Rivers Museum of Ethnology (# 1916.40.2)

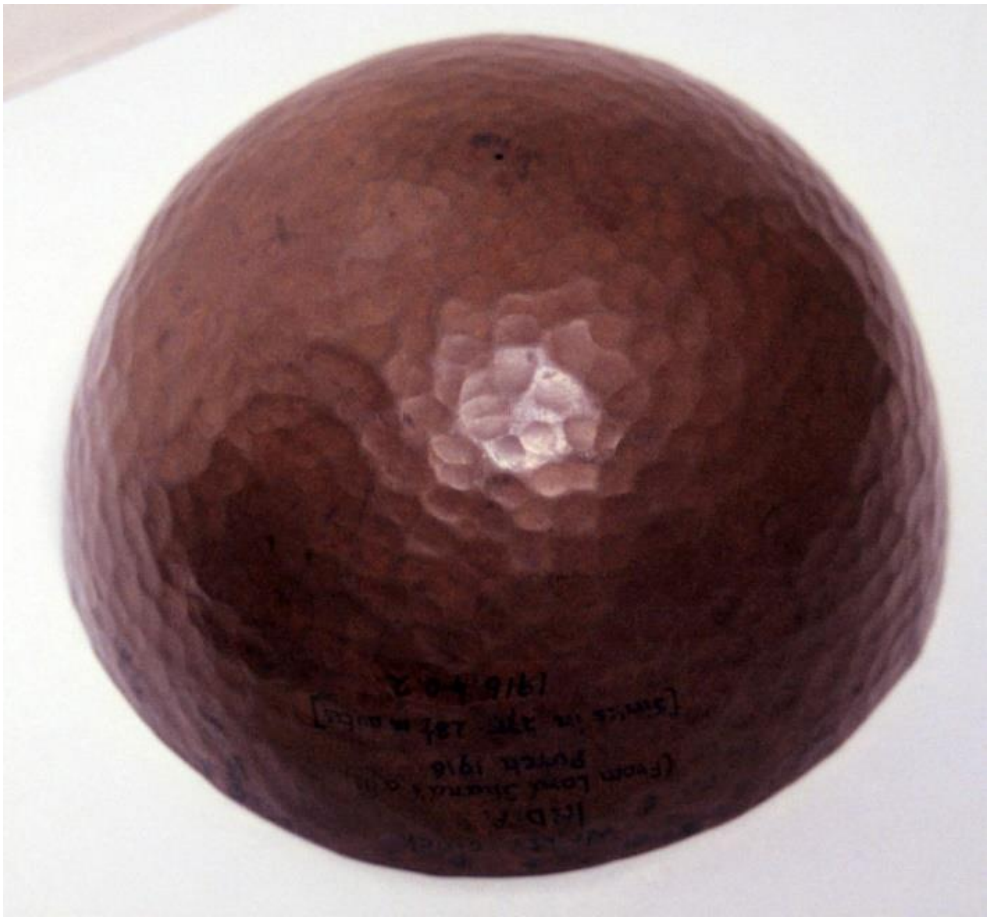


Figure R003.1 – Water clock (photo by S. R. Sarma)

Bowl made of hammered copper with an oval mouth and conical shape. Its duration of immersion is said to be 27 to 28½ minutes. Like the previous one, this too must originally have been made to measure 30 minutes. Through constant use, the orifice became larger and the bowl sinks faster. The exact place of its manufacture is not known.

From Lord Shand's collection; bought at Steven's Auction Rooms, lot 108, May 1916.

R004⊙ IRRIGATION WATER CLOCK FROM RAMPET, TAMIL NADU

Diameter 119 mm, height 68 mm

Oxford, Pitt Rivers Museum of Ethnology (# 1916.32.1)

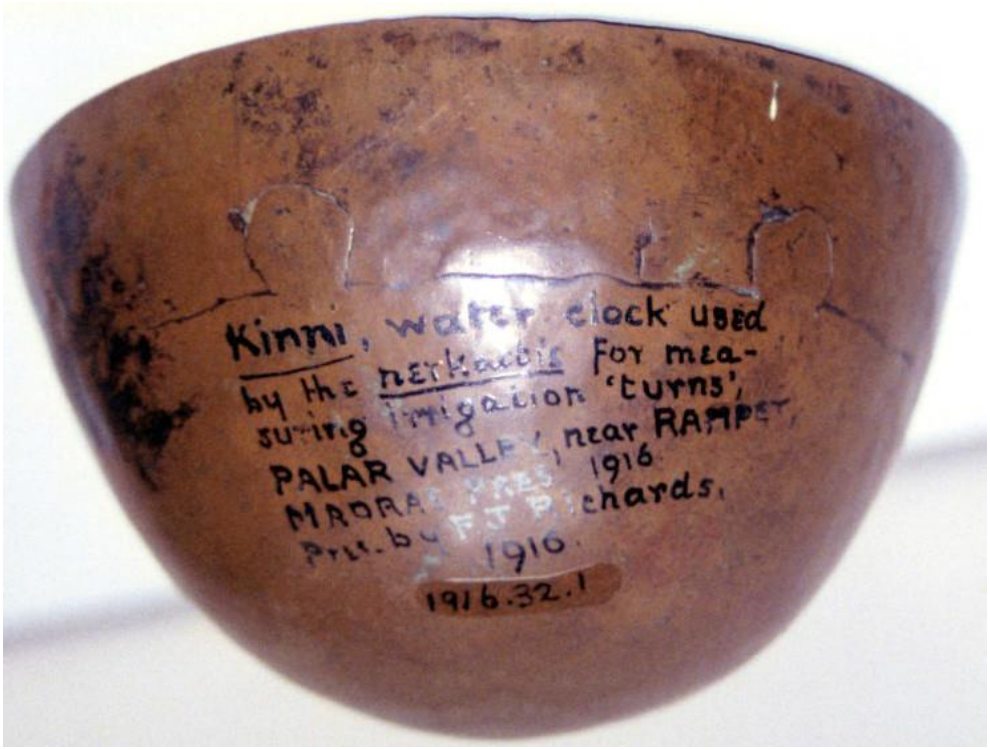


Figure R004.1 – Irrigation water clock (photo by S. R. Sarma)

The bowl is made by joining two copper pieces, with interlocking teeth. The museum label reads: 'Kinni, water clock used by the nerkattis. For measuring irrigation 'turns', Palar Valley, near Rampet, Madras Presi[dency], 1916. Presented by F. J. Richards, 1916.' The duration of immersion is not recorded.

Professor K. Ramasubramanian informs me that the term *kinni* denotes in Tamil a small hemispherical bowl; the cognate term in Telugu is *ginne.* The synonym in Hindi is *kaṭorā,* which word is indeed used to refer to the bowl of the water clock. According to H. H. Wilson's *A Glossaryof Judiacial and Revenue Terms,* the terms *niragante, nirugante, nirganti* (the first *i* is long) in Kannada refer to a 'a village officer who superintends the distribution of water for irrigation'. *Nerkatti* in Tamil must be a related term.

R005⊙ WATER CLOCK FROM UVA PROVINCE, SRI LANKA

Diameter 100 mm, height 49 mm

Oxford, Pitt Rivers Museum of Ethnology (# 1923.75.1)



Figure R005.1 – Water clock (photo by S. R. Sarma)

Very thin copper bowl; the duration of its immersion is said to be 11 minutes; probably it was originally made to measure a half *ghaṭī* of 12 minutes.

It was bought from A. M. Hocart in June 1923.

R006⊙ WATER CLOCK, CALLED *NAYI*, FROM THE EMPEROR'S PALACE AT MANDALAY, MYANMAR

Diameter at the base 132 mm, at the mouth 149 mm, height 105 mm

Oxford, Pitt Rivers Museum of Ethnology (# 1892.41.37.1)



Figure R006.1 – Water clock (photo by S. R. Sarma)

The copper bowl is rather large with an almost cylindrical shape. The duration of immersion is not recorded, but possibly it is one *nayi* of 24 minutes, which is the Burmese equivalent of the Indian *ghaṭī*. This bowl is accompanied by eight large bone beads strung in a wire for counting the *nayis* as they are completed. The Burmese equivalent of *prahara* varied from 7 or 8 *nayis* according to the seasons. As explained in the introduction, at the completion of each *nayi,* a gong was beaten, and after each *prahara* or at every third hour a drum-shaped gong was sounded from the timekeeper's tower in the royal palace.

Donated by Major R. C. Temple in September 1892.

R007⊙ WATER CLOCK MADE OF COCONUT SHELL FROM MALABAR

Diameter 112 mm, height 37 mm

Oxford, Pitt Rivers Museum of Ethnology (# 1905.8.3)



Figure R007.1 – Water clock made of coconut shell (photo by S. R. Sarma)

It is made of coconut shell, the duration of its immersion is not recorded. It was gifted by in 1905 by Edgar Thurston, the well-known ethnographer and one time superintendent of the Madras Government Museum, who writes as follows: [1590]

> 'This form of time-measurer, made of a half coconut or copper, is still in use among native physicians, astrologers, and others in Malabar. A cup of this nature was employed in the Civil Court at Mangalore in 1852, a peon being posted in charge of it, and beating on a gong the number of gadis [=*ghatis*] every time that it sank. At the present day it is used on the occasion of marriage among higher Hindu castes. The Brahmin priest brings the cup, and places the bridegroom in charge of it.'

[1590] Thurston 1907, p. 565.

R008 ⦿ WATER CLOCK, NOT SIGNED, NOT DATED

Diameter 115 mm , height 39 mm

London, The Guildhall Library, The Worshipful Company of Clock-Makers' Collection (# 646)



Figure R008.1 – Water clock (photo by S. R. Sarma)

Low shallow cup made of copper. At the bottom, there is a small dimple-like depression around the orifice. When the orifice became enlarged after long use, a gold bush was inserted into the orifice and hammered flush with the surface, thus restoring the orifice to the original size.

The duration of immersion and the provenance are not known.

R009⊙ WATER CLOCK FROM KANDY, SRI LANKA

Diameter 116 mm, height 50 mm, thickness 1 mm

London, Horniman Museum (# 19-140)

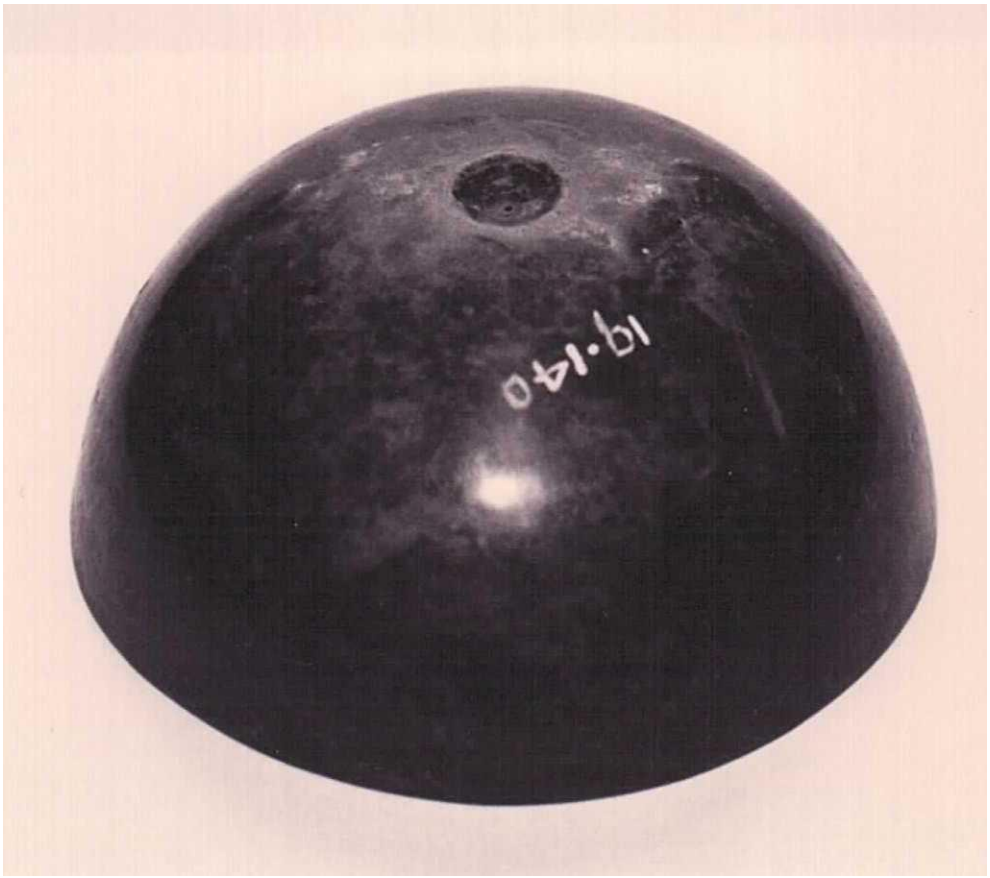


Figure R009.1 – Water clock (photo by S. R. Sarma)

Very thin copper bowl with a small dimple-like depression around the orifice. The duration of its immersion is not recorded.

R010 WATER CLOCK MADE OF COCONUT SHELL

Diameter ?

Chennai, Government Museum



Figure R010.1 – Water clock made of coconut shell (photo by Prof. S. Ramaratnam)

Edgar Thurston, the then superintendent of the Madras Museum, wrote in 1907 that ‘the Madras museum possesses several specimens of a primitive form of horologe, or water clock.’[1591] But in 1994, there remained just one specimen which was made of coconut shell. At my request, Prof. S. Ramaratnam visited the museum; he was allowed to float the bowl in a bucket of water and it sunk exactly in 24 minutes (= *ghaṭī*).[1592]

[1591] Thurston 1907, p. 562.

[1592] Sarma 1994b, p. 513.

R011 WATER CLOCK, FULL ENSEMBLE OF BOWL, BASIN AND GONG[1593]

Diameter of the bowl 150 mm; diameter of the larger vessel 310 mm
Kota, Rao Madho Singh Museum

A full ensemble of bowl, basin and gong are displayed on an iron stand in this museum established in the royal palace of Kota in Rajasthan. Professor Virendra Nath Sharma examined the duration of the immersion of the bowl; his report reads thus:

> 'In January 1993, the author took several readings with the *ghaṭī* instrument of Kota and found that its little bowl sank in water once every 24 min 17 sec ± 6 sec. However, when the author repeated his readings a few years later, in January 2000, he found that the little bowl sank at the rate of every 22 min 38 sec ± 6 sec. Evidently, the hole at the bottom of the little bowl had become a bit wider by then. One of the readings of the author, which was discarded by him, was as high as 28 min 24 sec. The author noticed that at that moment, the little bowl was touching the side of the larger bowl, and thus took a longer time to sink. It seems that one has to constantly watch the little bowl as convection currents in water keep pushing it towards the side of the larger bowl causing an error. Further surface tension of the water can also cause a delay in sinking of the bowl.'

[1593] Entry based on Sharma 2000, pp. 241-243.

R012⊙ WATER CLOCK: BOWL AND BASIN (MODERN RECONSTRUCTION)

Diameter of the basin 464 mm, diameter of the bowl 317 mm

PLU



Figure R012.1 – Water Clock Bowl and Basin (photo by S. R. Sarma)

It is a modern reconstruction in copper; it is not known where it was produced.

PROVENANCE

Hagens Clock Manor Museum, Evergreen, Colorado; The Time Museum, Rockford, Ill. (# D1004); Christie's, London, auction 14 April 1988; Brussels, PC; PLU

BIBLIOGRAPHY

Turner 1984, pp. 54-55, no. 3

Christie's, South Kensington, *Time Measuring Instruments from the Time Museum,* auction catalogue, Thursday 14 April 1988, p. 19, lot 24.

R013 WATER CLOCK IN THE DARGAH OF KHWAJA MOINUDDIN CHISHTI AT AJMER[1594]

The mausoleum (*dargah*) of Khwaja Moinuddin Chishti is a renowned place of pilgrimage at Ajmer in Rajasthan. Because of the Dargah, the city itself is respectfully referred to as Ajmer Sharīf (the holy Ajmer).

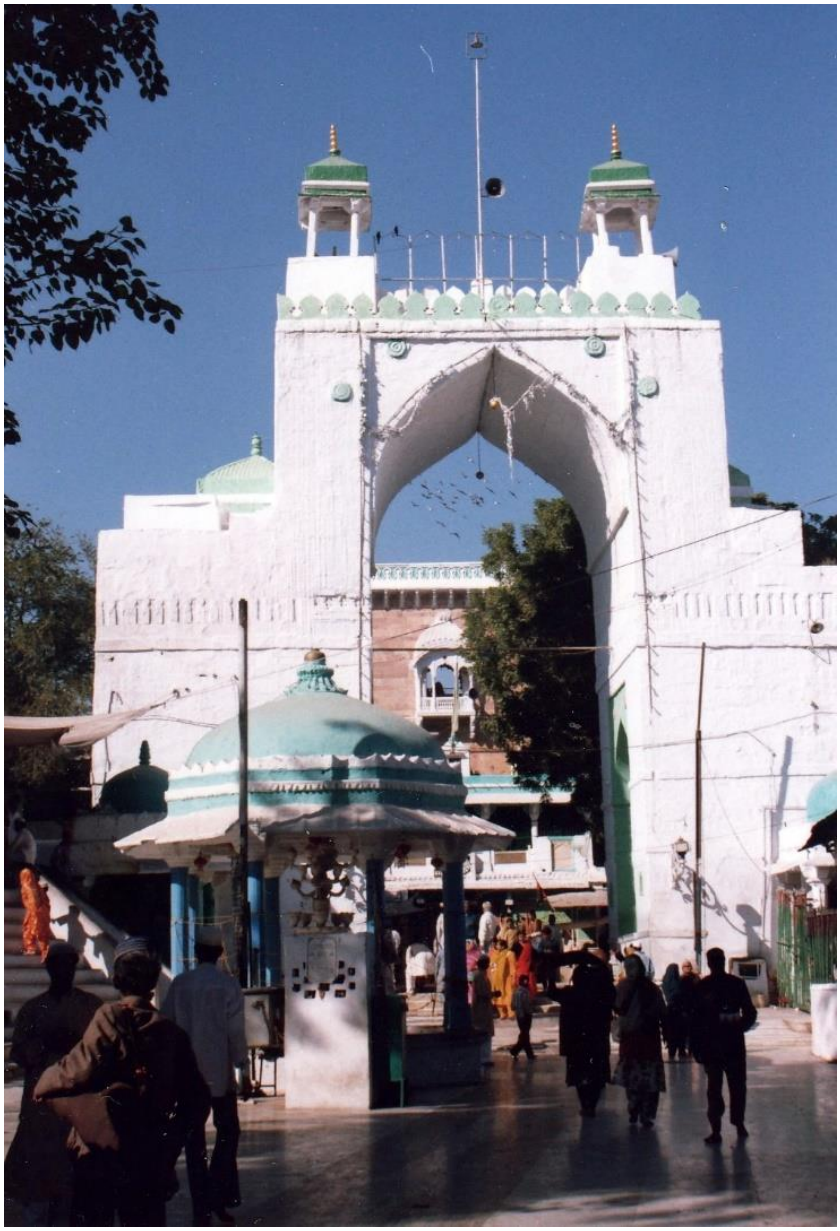


Figure R013.1 – The gate built by Mahmud Khalji of Malwa
(photo by S. R. Sarma)

[1594] I am grateful to Dr Syed Liyaqat Hussain Moini of Aligarh Muslim University for facilitating my visit to the Dargah.

Dr Syed Liyaqat Hussain Moini of Aligarh Muslim University, the members of whose family hold hereditary offices at the Dargah, wrote extensively on this Dargah. In a paper entitled 'Rituals and Customary Practices at the Dargah of Ajmer,' he mentions the *Ghaḍiyālī,* the timekeeper of the Dargah, announcing in a ritual that six *gharis* have passed.[1595]

When I read this, I became curious to know whether a water clock was still used for measuring time at the Dargah, and I contacted Dr Moini. He told me that they do not use water clock any more, but some equipment is still there. He also added that the *Ghaḍiyālī*'s position has been hereditary. Since the family of the present incumbent can be traced back to the time of Akbar, the practice of measuring time with the water clock and announcing it with strokes on a gong must have prevailed at least from the time of Akbar in the sixteenth century.



Figure R013.2 – Water clock room with the build-in marble basin, gongs and mallets (photo by S. R. Sarma)

[1595] Moini 1989, p. 68.

With this knowledge of the background, I visited Ajmer on 7 February 1998; Dr Moini kindly arranged that a member of his family accompanied me to the Dargah. On the south side of the second inner gate built by the Sultan Mahmud Khalji of Malwa, who paid a visit to the shrine in 1455, there is a small room at the middle level which houses the ensemble of the water clock. In a corner of the room is a small platform with a sunken marble basin of about 275 mm diameter. It used to be filled with water and the perforated bowl was made to float on the water for measuring time. The floating bowl is not extant any more.

The original gong, said to be from the time of Akbar, is extant, but broken. At the moment, there are two modern gongs, with diameters of 448 mm and 198 mm respectively and three wooden mallets of different sizes. With these, they ring the hours, not regularly but at certain prescribed hours.



Figure R013.3 – Marble basin filled with water and a modern cup was made to float for photography (photo by S. R. Sarma)

S. METAL INSTRUMENTS DESIGNED BY SAWAI JAI SINGH

INTRODUCTION

The focus of this section will be on the metal instruments used by the astronomer-prince Sawai Jai Singh of Jaipur before he replaced them with large masonry instruments.[1596] But first a brief introduction to his life and work. [1597]

1. SAWAI JAI SINGH

Jai Singh was born on 3 November 1688. When he was barely 11 years old, he ascended, on 25 January 1700, the throne of Amber in Rajasthan, which was a semi-autonomous kingdom under the Mughal rule. He served several Mughal rulers, taking active role in their struggles for succession. Through his diplomatic skill, he expanded his kingdom several-fold and became the most powerful of the feudatories of the Mughal emperor, who gave him the title *sawāī*, meaning that he is one quarter more brilliant than his illustrious ancestor who bore the same name. After an active life of nearly half a century - active in political intrigue, warfare, city building and learned activities - he died on 2 October 1743.

In spite of the incessant political upheaval, Jai Singh's rule ushered in a golden era of arts and sciences. His lasting contributions are architectural and astronomical. He built the new capital city Jaipur with its broad and straight roads in a rectangular grid pattern, to which he attracted a large number of scholars, artists and craft-persons. In the realm of astronomy, in order to prepare an accurate calendar, he gathered at his court astronomers of various faiths and traditions—at first Hindus and Muslims, and later, also Europeans—and initiated a systematic programme observations. Initially he experimented with portable instruments of diverse types, but finally designed majestic

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[1596] Jai Singh's masonry instruments will not be covered in this catalogue; they are adequately and competently described in Sharma 2016.

[1597] Cf. V. S. Bhatnagar, *Life and Times of Sawai Jai Singh,* Delhi 1974; Garrett & Guleri 1902, pp. 9-13; Kaye 1918, pp. 1.7; Sharma 2016, pp. 1-4; see also Pingree 1978b; Pingree 1999; CESS, 3, pp. 63-64; 5. pp. 117-118.

instruments in masonry with which he set up five observatories at Delhi, Jaipur, Varanasi, Ujjain and Mathura.[1598]

1.1. Jai Singh's Astronomical Efforts

Jai Singh appears to have been initiated at an early age into the study of Sanskrit astronomical texts by his religious preceptor Jagannātha Samrāṭ. Aware of the discrepancy between the computed and observed positions of the heavenly bodies, Jai Singh decided to prepare new astronomical tables based on his own observations. Since the Islamic world paid greater attention to observational astronomy and hence possessed more sophisticated instruments, he turned to Muslim astronomers and to their Arabic and Persian manuals on instruments. At first he took observations with small portable brass and wooden instruments that were available at that time, but was not satisfied with the results. In order to obtain as minute readings as possible, he ordered much larger instruments in metal, but mounting and pivoting the heavy metal parts proved to be problematic.

Therefore he abandoned brass instruments altogether and began designing huge instruments in masonry. The inspiration for large masonry instruments came from the Samarqand observatory. But Jai Singh's genius lay in elegantly translating the designs into stone and plaster. These instruments are starkly functional and, unlike his other constructions, have no ornamentation whatsoever. Particularly ingenious is the idea of complementary pairs of the *Jayaprakāśa-yantra* and the *Rāma-yantra*, where the observer could walk into the instruments and note the readings on the scales accurately. While his workmen could not cope with the problems connected with making large metal instruments, his architects and masons could elegantly solve the problems of masonry instruments.

With these masonry instruments, the first observatory was set up at Delhi around 1724. The observatory at Jaipur may have been built between 1727 and 1734; the others at Ujjain, Benares and Mathura thereafter between 1734 and 1738. The one at Mathura does not survive any more. After the completion of the Jaipur Observatory, it became

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[1598] The simple elegance of these masonry instruments inspired many imitations in India and abroad. Some of these will be described in Apx.E.

the principal centre of observation. Here are assembled the largest number of instruments.

About 1727, when the Delhi observatory was already erected and the others were in the planning stage, Jai Singh heard that the European nations had made great progress in astronomy. Therefore, he sent a delegation to Portugal in 1727. This delegation returned in 1730, bringing with them, among others, the astronomical tables *Tabulae astronomicae Ludovici* of the French astronomer Philip de la Hire which were published in 1702. These tables were received with great enthusiasm, and a French physician named Josef Du Bois was entrusted with their translation.[1599]

Jai Singh found certain discrepancies between La Hire's tables and the observed values regarding the longitude of the moon. As Du Bois and other Europeans could not explain the discrepancies, Jai Singh addressed a set of five specific questions to a Jesuit by name Claude Boudier who was then at the French colony of Chandernagore, and invited him to Jaipur. Boudier set out for Jaipur in January of 1734. On the way, while observing the solar eclipse on 3 May 1734 at Delhi, he too noticed that the observed time of the eclipse did not agree with La Hire's tables. Boudier spent about two years at Jaipur and returned to his mission in 1736.[1600]

1.2. Zīj-i Muḥammad Shāhī

Jai Singh got prepared a set of new astronomical tables in Persian and named them *Zīj-i Muḥammad Shāhī* after the reigning Mughal emperor Muḥammad Shāh.[1601] There are said to be some fifty manuscripts extant, but the full text has not been published so far. Of this work, the star catalogue is dated 1725-1726 and the preface was written after 1734. However, these tables are not based on the observations carried out at the five observatories with the aid of the masonry instruments designed especially for this purpose. Instead, these were derived in large parts from the tables of Ulugh Beg and

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1599 Sharma 2016, pp. 301-302; see also Mercier 1993.

1600 Sharma 2016, pp. 302-303.

1601 On the contents of this work, see Hunter 1799, pp. 205-209; Mercier 1984, pp. 153-157; Sharma 2016, pp. 238-265; 323-341.

Philip de la Hire. Raymond Mercier[1602] and Benno van Dalen[1603] argue convincingly that the star catalogue in the *Zīj-i Muḥammad Shāhī* is substantially the same as that in Ulugh Beg's *zīj*, but updated to Jai Singh's time by the addition of the precession, and that the tables of the sun, moon and planets are all identical with those of La Hire, apart from a mere change of meridian from Paris to Delhi.

It is obvious that Jai Singh's endeavours did not lead to any new discovery in astronomy. But there is no doubt that under his auspices, Hindu and Islamic traditions of mathematical astronomy were cultivated, perhaps for the last time, very intensively, before they were overshadowed by the new astronomical theories and instruments coming from Europe.

1.3. Translation Programme

As the work on the observatories progressed, Jai Singh's interest in Islamic astronomical tradition deepened and he launched also an ambitious programme of translation of the major works of Islamic mathematical astronomy into Sanskrit.[1604] Under this programme, Jagannātha translated Euclid's *Elements*[1605] and Ptolemy's *Almagest,* [1606] both from the Arabic versions prepared by Naṣīr al-Dīn al-Ṭūsī (1201-1274). Nayanasukha Upādhyāya rendered, with the help of Muḥammad ᶜĀbid, the *Spherics* of Theodosius from the Arabic version of Qusṭā ibn Lūqā al-Ba'labakī into

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1602 Mercier 1984.

1603 Dalen 2000.

1604 Cf. Pingree 1978a; Pingree 2000; Sarma 1998; Sarma 2002.

1605 *The Rekhāgaṇita of Jagannṭha,* ed. H. Dhruva & K. Trivedin, Bombay Sanskrit Series 61-62, Bombay 1901-1902.

1606 Jagannātha 1967-69; Jagannātha 1976. Some of the available manuscripts contain, besides the translation of the thirteen books of the *Almagest*, five more chapters entitled *Yantrādhyāya, Jyotpatti, Madhyamādhikāra, Spaṣṭādhikāra* and *Tripraśnādhikāra.* These five chapters can be treated as an independent work in the style of the traditional *siddhāntas.* These chapters are edited by Muralīdhara Caturveda under the title *Siddhānta-samrāṭ* (Jagannātha 1976). Under the aegis of Indian Institute of Astronomical and Sanskrit Research, a team of scholars headed by Ram Swarup Sharma, published the thirteen books constituting the translation of the *Almagest* and the additional five chapters in three large volumes; this edition is practically unreadable as it violates all principles of textual criticism and also the basic norms of book production.

Sanskrit. He also translated chapter 11 of the second book of Naṣīr al-Dīn's *Tadhkira* together with the commentary of al-Birjandī.[1607]

1.4. Hindu, Muslim and European Astronomers at Jai Singh's Court

In these tasks of designing instruments and translating Arabic and Persian texts into Sanskrit, Jai Singh was assisted by a large number of astronomers, both Hindu and Muslim. Notable among the Hindus were Jagannātha Samrāṭ, Nayanasukha Upadhyāya and Kevalarāma. The translations by the first two scholars have been mentioned above. Kevalarāma, who was awarded the title of the *Jyotiṣarāya* (Astronomer Royal), helped in rendering La Hire's tables in Sanskrit.[1608]

Among the Muslim Nujūmīs, mention may be made of Muḥammad ᶜĀbid who helped Nayanasukha translate Arabic texts, Shaykh Asad Allāh Nujūmī who was a member of the delegation dispatched to Europe and Muḥammad Sharīf who was sent to take observations in the southern hemisphere.[1609] Abū al-Khayr Khayr Allāh Khān is said to have drafted the *Zīj-i Muḥammad-Shāhī,* but Virendra Nath Sharma contends that there is no evidence for this.

Information about Jai Singh's Muslim astronomers comes primarily from the *Dastūr Kaumvār,* a 32-volume set of books in the Rajasthan State Archives, which records favors, honors and gifts that the rulers of Amber or Jaipur granted over a period of several generations. The *Dastūr Kaumvār* records go back to the time of Man Singh (1550-1617); however, they are more detailed for the Jai Singh period. The records list Muslim astronomers under *Kaum Musalmān* (Muslim caste) and identify them by the title *nujūmī* (astronomers or astrologers).[1610]

Khairu'llah has been called the chief assistant of the Raja and the author of the *Zīj-i Muḥammad-Shāhī.* However, these titles appear doubtful when one does not find any mention of gifts or honors bestowed upon him in the *Dastūr Kaumvār.* It is inconceivable that the Raja, generous as he was in bestowing honors upon his scholars,

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1607 Cf. Takanori Kusuba and David Pingree, *Arabic Astronomy in Sanskrit: Al-Birjandī on Tadhkira II, Chapter 11 and its Sanskrit Translation,* Brill, Leiden, 2002.

1608 Sharma 2016, ch. XII, pp. 261-284.

1609 Sharma 2016, pp. 285-290.

1610 Sharma 2016, p. 285.

would totally ignore his "chief assistant" and the "author" of an important work such as the *Zīj-i Muḥammad-Shāhī*.[1611]

Of the Europeans at Jai Singh's court, the French physician Josef Du Bois and the Jesuit Claude Boudier have been mentioned above.[1612] Unfortunately, there are no records about Boudier's activities at Jaipur, in particular, how he answered Jai Singh's queries. Nor is there any record of the astronomical activities of another Jesuit Andreas Strobl who was with Jai Singh from 1740 until the latter's death in 1743. In spite of these close contacts with European astronomers, Jai Singh remained ignorant of the telescope which heralded a revolution in the observational astronomy, and of the heliocentric theory of Copernicus which likewise drastically changed the traditional view of the solar system.

1.5. Jai Singh and the Astrolabe

Although Jai Singh preferred large masonry instruments for astronomical observation, he had a great esteem for the astrolabe. Besides commissioning a Sanskrit translation of Naṣīr al-Dīn al-Ṭūsī's popular Persian manual *Risālat al-usṭurlāb*,[1613] he himself composed in Sanskrit prose a manual on the astrolabe with the title *Yantrarāja-racanā.*[1614] In the Sarasvati-Bhavan library of the Sanskrit University at Varanasi, there is a unique manuscript (no. 50258) in which al-Ṭūsī's Persian manual on the astrolabe is transliterated in Devanagari script; it is most likely that it was transcribed at Jai Singh's court.

1.5.1. Indo-Persian Astrolabes collected by Jai Singh

Being a connoisseur of instruments, Jai Singh collected some of the best and most ornate Mughal astrolabes. One of these was the universal *Zarqālī* astrolabe crafted by Ḍiyā' al-Dīn Muḥammad in 1681 (A091). After acquiring this unique astrolabe, Jai Singh caused the composition of a Sanskrit manual entitled *Sarvadeśīya-Jarakālī-Yantra* on the construction and use of this instrument. Other important Indo-Persian

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1611 Sharma 2016, p. 288.

1612 Cf. Mercier 1984, pp. 159-161; Mercier 1993.

1613 Bhattacharya 1979.

1614 *Yantrarāja-racanā,* ed. Kedāranātha Jyotirvid, Rajasthan Oriental Series 5, Jaipur 1953.

astrolabes collected by him are the zoomorphic astrolabe attributable to Muḥammad Muqīm (A051), a standard astrolabe with an exquisitely crafted rete by Ḍiyā' al-Dīn Muḥammad of 1656 (A072), a unique north-south astrolabe by Ḍiyā' al-Dīn of 1674 (A090) and some others (A131).[1615]

1.5.2. Production of Sanskrit Astrolabes

There is evidence to show that Jai Singh established a manufactory to produce astrolabes with Sanskrit numbers, legends and labels. It is quite likely that C021 and C022 were made for him. In order to popularize the astrolabe among his Hindu astronomers, this manufactory produced a great number of Sanskrit astrolabes, with a single plate calibrated to Jaipur's latitude of 27°.[1616]

2. Metal Instruments used by Jai Singh

In the introduction to the *Zīj-i Muḥammad Shāhī,* Jai Singh describes how he had first used metal instruments and, finding them not suitable for his purpose, how he designed large masonry instruments. Speaking in third person, he narrates

> He … constructed here (at *Dehly*) several of the instruments of an observatory, such as had been erected at *Samarqand*, agreeably to the *Musalman* books : such as *Zatul-huluk,* of brass, in diameter three *guz* of the measure now in use, … and *Zat-ul-shobetein,* and *Zat-ul-suchein,* and *Suds-Fukheri,*[1617] and *Shamilah.*

[1615] These are now displayed in a new gallery built inside the Jaipur Observatory. Unfortunately, these portable instruments are arranged indiscriminately: historically valuable astrolabes are displayed side by side with unfinished astrolabes, technically unique items along with models of masonry instruments of no particular merit. The labels do not express the specific nature of the instrument, and the descriptions are rudimentary, sometimes even misleading. Nearly every instrument is said to be useful for finding the sun's transit from one zodiac sign to the other, the ascendant, and the actual position of the planets and stars in the zodiac sign. All instruments, whether Sanskrit, Indo-Persian or even French, are described as 'commissioned by Sawai Jai Singh II'. Even the *Zarqālī* universal astrolabe made by Ḍiyā' al-Dīn for a high Mughal dignitary in 1690 is shown as 'commissioned by Sawai Jai Singh II'.

[1616] See Introduction to section D.

[1617] It is surprising that *Suds-Fukheri* is listed among the metal instruments discarded by Jai Singh. On the contrary, it is incorporated in the *Samrāṭ-yantra* at Delhi and Jaipur under the name *Vṛtta-ṣaṣṭhāṃśa-yantra,* which, according to Virendra Nath Sharma, 'is by far the most sensitive and easy-to-use instrument' (Sharma 2016, p. 151).

> But finding that brass instruments did not come to the ideas which he had formed of accuracy, because of the smallness of their size, the want of division into minutes, the shaking and wearing of their axes, the displacement of their centres of the circles, and the shifting of the planes of instruments;[1618] …
>
> he constructed in *Dar-ul-kheláfat Shah-Jehanabad,* which is the seat of empire and prosperity, instruments of his own invention, such as *Jey-pergás* and *Ram-junter* and *Semrát-junter,* the semidiameter of which is of eighteen cubits, and one minute on it is a barley-corn and a half; of stone and lime, of perfect stability, with attention to the rules of geometry, and adjustments to the meridian, and to the latitude of the place, and with care in the measuring and fixing of them; so that the inaccuracies, from the shaking of the circles, and the wearing of their axes, and displacement of their centres, and the inequality of the minutes, might be corrected.

At first Jai Singh collected descriptions of various kinds of astronomical instruments from diverse sources and got these translated into Sanskrit. Thus from Naṣīr al-Dīn al-Ṭūsī's recension of Ptolemy's *Almagest,* the descriptions of the following five instruments were translated: 1. solstitial armillary (*Yāmyottara-yantra*), 2. mural quadrant (*Yāmyottara-bhitti-yantra*); 3. armillary sphere with 6/7 rings (*Dhāt al-Ḥalaq*), 4. triquetrum (*Dhāt al-Shuᶜbatayn*), 5. dioptra (*Dhāt al-Thuqbatayn*). Sanskrit translations were also made of the description of the instruments used at the observatories of Maragha and Samarqand, especially al-ᶜUrdi's improved version of the armillary sphere, consisting of 5 rings, and of the Fakhrī sextant (*Suds Fakhrī)*. Some of the descriptions of these instruments which he thus collected, and possibly also some of the instruments which he began designing on his own, were compiled in the *Yantraprakāra*.

According to the designs he thus assiduously collected, Jai Singh got instruments made in wood and brass. It is quite apparent that, in order to obtain as minute divisions as possible, Jai Singh ordered enormously huge enlargements from designs meant for

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[1618] Jagannātha also describes the difficulties in the use of large wooden and metal instruments; cf. Pingree 1987, pp. 315-316.

portable instruments. But making large-scale brass instruments and the consequent problems of mounting and pivoting them was beyond the engineering skills of the artisans.[1619]

None of the metal or wooden instruments which Jai Singh caused to be made according to the Islamic sources are extant now. Besides these, he also designed some metal instruments of his own.[1620] Some of these are extant now and will be described in the following pages. The main purpose of these instruments appears to have been to determine the position of the heavenly bodies in terms of the horizontal, equatorial and ecliptic systems. Thus an instrument was designed to measure the horizontal coordinates, namely the altitude and the azimuth. There survives a small specimen (S001), which is now slightly damaged. It is not known whether any attempt was made to prepare a larger version. But there exists a very large ring for measuring the latitude (S002). Both have been superseded by the *Rāma-yantra* built in masonry. But there is a separate instrument in masonry to measure the azimuth, named *Digaṃśa-yantra.* It is not known what advantage this offers over the *Rāma-yantra.* Second, for measuring the equatorial coordinates (declination and hour angle), Jai Singh designed a metal instrument which goes today under the colourless names *Cāpa-yantra,* three specimens of which are extant (S003). Third, for determining the ecliptic coordinates (celestial longitude and latitude), an instrument called *Krāntivṛtta-yantra* (ecliptic instrument) was prepared. There are extant two specimens, one small and one very large, both unfinished. Jagannātha says that he got made a small specimen in which the ecliptic ring had a diameter of an artisan's cubit; probably that was complete, but it is not extant anymore.

However, these three types of instruments were superseded by the masonry instrument *Jayaprakāśa-yantra* where measurements can be done in all the three planes, horizontal, equatorial and ecliptic.

[1619] It is said, for example, that he caused to be made an armillary sphere with a diameter of about 2.7 m; this is no more extant. At Jaipur there survives still a huge astrolabe with a diameter of 2.17m , which is not at all convenient for observation (D001), and also a huge *Unnatāṃa-yantra* with a diameter of over five metres (S002).

[1620] Some of these are described in the *Yantraprakāra* and also by Jagannātha in the *Yantrādhyāya* of his *Samrāṭ-siddhānta*.

Even though these metal instruments became redundant by the newly designed masonry instruments, the some of the metal instrument were not discarded but included in the Jaipur Observatory.

3. Masonry Instruments

3.1. Jayaprakāśa-yantra and Samrāṭ-yantra

At the beginning of the *Yantrādhyāya* chapter of his *Samrāṭ-Siddhānta,* Jagannātha enumerates the masonry instruments in the following verses:

nāḍīyantaṃ golayantraṃ digaṃśākhyaṃ tathaiva ca |
dakṣiṇodakbhittisaṃjñaṃ vṛttaṣaṣṭhāṃśakaṃ tathā ||
yantrasamrāḍ-iti khyātaṃ yantrāṇām uttamottamam |
jayaprakāṣaṃ tadvac ca sarvayantraśikhāmaṇiḥ ||

These are *Nāḍīvalaya-yantra* (equatorial instrument)*, Gola-yantra* (armillary sphere), *Digaṃśa-yantra* (azimuth instrument)*, Dakṣiṇottara-bhitti-yantra* (south-north wall instrument, or mural quadrant), *Vṛttaṣaṣṭhāṃśa-yantra* (one-sixth-of-the-circle instrument, i.e., sextant, known as *Suds Fakhrī* in Arabic); *Yantra-samrāṭ* or *Samrāṭ-yantra* and *Jayaprakāśa-yantra.* Surprisingly, the masonry instrument *Rāma-yantra* is excluded and the metal instrument *Gola-yantra* or armillary sphere is included in this enumeration of the masonry instruments with which the observatories were erected. Be that as it may, it is noteworthy that the last two are named after Jagannātha Samrāṭ and Jai Singh respectively as *Samrāṭ-yantra* and *Jayaprakāśa-yantra.* About the former, it is said that it is 'the best among the best of all instruments' (*uttamottama*) and about the latter that it is the crest-jewel of all instruments (*sarva-yantra-śikhāmaṇiḥ*).

The *Jayaprakāśa-yantra* to which Jai Singh lent his name is a versatile instrument, containing the projection of the great circles and small circles of the armillary sphere upon the concave surface of the hemispherical bowl facing upwards. Built in two complementary halves, this instrument allows measurements on all the three planes, horizontal, equatorial and ecliptic. These were built only at Delhi and Jaipur.



Figure S.1 – Jayaprakāśa-yantra at Jaipur (photo by Professor Michio Yano)

The most imposing, however, is the lofty *Samrāṭ-yantra*, rising to a height of 20.72 m at Delhi and to 27.35 m at Jaipur. Of all the instruments designed by Jai Singh, this is unique in being accurate, architecturally pleasing, and perhaps easy to replicate. It exists in all the observatories, and moreover, it is executed in two different media: while at Delhi and Jaipur it is built of bricks and mortar, in Benares the quadrants are made out of carved sandstone blocks. Leaving aside the size, the utter simplicity of the design is truly impressive.

It is an equinoctial sundial with the gnomon in the form of a right-angled triangle situated on the north-south meridian line, its hypotenuse pointing to the north pole. Therefore the angle between the base and the hypotenuse is equal to the local terrestrial latitude. The gnomon throws its shadow on two graduated quadrants which project on either side of the gnomon wall, thus indicating the local solar time.

But the *Samrāṭ-yantra* is not just an instrument for measuring time; it is designed to measure the declination as well. For this purpose, the hypotenuse is graduated to read the tangent of the angle of declination. At night the declination and the hour angle of the stars can also be read.



Figure S.2 – Samrāṭ-yantra at Jaipur (photo by Dr Jean Michel Delire)

Inside the structures supporting the quadrants of the *Samrāt -yantra,* Fakhrī sextants (*al-suds al-fakhrī*; Sanskrit: *vṛttaṣaṣṭhāṃśa-yantra*) are incorporated, both at Jaipur and Delhi. At midday the sun's ray passes through a pinhole in the roof and falls on the graduated arc of 60° built in the plane of the meridian within a dark chamber, thus indicating the sun's meridian altitude. This type of sextant was originally designed by Abū Maḥmūd al-Khujandī who built it with a diameter of 20 m at Rayy near the modern Tehran in 994, but it does not exist any more. A similar sextant with a diameter of 60 m was erected in 1420 in the Samarqand observatory, which is now in ruins. Therefore, of the Fakhrī sextant originally invented in Iran, the only functional specimens are now in Jaipur.

3.2. Modern Studies of the Masonry Instruments

Sawai Jai Singh's masonry instruments attracted the attention of European scholars soon after their construction. Joseph Tieffenthaler, an Austrian Jesuit, who arrived in India a few years after Jai Singh's death, travelled extensively and produced

a very valuable historical-geographical description of India in Latin.[1621] He visited the observatories at Jaipur, Mathura, Delhi and Ujjain and gave brief descriptions of the instruments there.[1622]

William Hunter was the first scholar to provide a full report of the instruments at the four observatories at Delhi, Ujjain, Mathura and Varanasi in 1799 in his celebrated publication 'Some Account of the Astronomical Labours of Jayasinha, the Rajah of Ambhere, or Jayanagar', where he reproduced Jai Singh's preface to his *Zīj-i Muḥammad Shāhī,* in original Persian together with an English translation, and added a summary of its contents.[1623] Lieutenant A. ff. Garrett, who restored the instruments at Jaipur in 1901-02, described these instruments.[1624] G. R. Kaye, 'Honorary Correspondent of the Archaeological Department India', published in 1918 a very competent description of the masonry instruments set up by Jai Singh in the four observatories of Delhi, Jaipur, Varanasi and Ujjain, and also of some metal instruments available in Jaipur, together with many useful tables, astronomical, geographical and astrological.[1625]

Subsequently many books, booklets and articles have appeared.[1626] The most valuable of these is the *Sawai Jai Singh and his Astronomy* by Professor Virendra Nath Sharma of the University of Wisconsin. The great merit of this book (first published in 1995 and revised in 2016) is that Sharma spent several months in 1981-82 making observations with the instruments at Jaipur and other observatories and thus estimated the level of accuracy of these instruments. According to him, the *Jayaprakāśa-yantra* and *Rāma-yantra* belong to the medium-precision category, while the *Samrāṭ-yantra* and *Vṛttaṣaṣṭhāṃśa-yantra* are the most sensitive instruments with a high degree of precision. He has also examined the archival records related to Jai Singh's observatories

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1621 A German translation under the title *Historisch-Geographische Beschreibung von Hindustan* was published by Johann Bernoulli in 1785.

1622 These descriptions are reproduced in English translation in Sharma 2000, pp. 85 (Delhi), 124-125 (Jaipur), 218 (Ujjain), 237 (Mathura).

1623 Hunter 1799.

1624 Garrett & Guleri 1902.

1625 Kaye 1918.

1626 Those published up to 1985 are listed in Sarma 1986-87b, pp. 122-131.

in the Rajasthan State Archives at Bikaner and thoroughly studied the relevant Sanskrit sources like the *Yantraprakāra* and Jagannātha's *Yantrādhyāya*. His book *Sawai Jai Singh and his Astronomy,* therefore, offers the most comprehensive description of each instrument in all the observatories, starting with the description of the instrument in the Sanskrit sources, and then providing its physical description and its use in observation, its level of precision and so on.

3.3. Problematique of the Miśra-yantra

The *Miśra-yantra* is the most attractive instrument of the Delhi Observatory, but it raises many problems.[1627] Its gnomon is split into two parts which enclose four semi-circular arcs with the strange name *niyata-cakras.* This and other names are apparently due to Gokul Chandra Bhavan, who, as the court-astrologer of Jaipur, was responsible for the restoration of the Delhi Observatory in 1909-1910 on the behalf of the Maharaja of Jaipur. He also seems to be the only source for the interpretation of the various elements in this *Miśra-yantra.*

This instrument is not mentioned in the *Yantraprakāra* or in Jagannātha's *Yantrādhyāya*, nor in any archival record; Joseph Tieffenthaler who visited the Delhi Observatory in 1747, just four years after Jai Singh's death, does not mention it either. Therefore, concludes Virendra Nath Sharma, that it was not built by Jai Singh, but by Madho Singh between 1750 and 1754 when he was in the good graces of the Mughal ruler Aḥmad Shāh.[1628]

But when one looks at Madho Singh's creation of small instruments (in the next section T), it is difficult to accept the view that he could be the author of this large masonry instrument with an unusual design. Moreover, he was supposed to succeed Jai Singh in 1743, but due to palace intrigues, his claim was ignored and his step-brother Isvari Singh succeeded Jai Singh. It is only after Isvari Singh's untimely death in 1750 that Madho Singh could become the ruler of the Jaipur kingdom. His first priority would naturally be to consolidate his authority at home and not build a large instrument at Delhi. He could not have built the *Miśra-yantra* later, because Aḥmad Shāh was deposed

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1627 For the description of all the various elements in the *Miśra-yantra*, see Sharma 2016, pp. 109-118.

1628 Sharma 1994, p. 94.

in 1754 and the political situation in Delhi deteriorated. In 1764, Jats led by Jawahar Singh vandalised the observatory. Therefore, Madho Singh could not have built it during the short span between 1750 and 1754.

But this is not to argue that the *Miśra-yantra* was built by Jai Singh himself before his death in 1743, for it does not quite fit into Jai Singh's instrument design either. The available sources do not permit a resolution of this conundrum, although the attractive design of the *Miśra-yantra* engendered many imitations (Apx.E.4.)

3.4. The Nomenclature of the Instruments

Because of the various changes that took place in these observatories, certain new names came into circulation, which are not quite appropriate.

Jantar Mantar: Jai Singh did not give any name to his observatories; he merely referred to them as *yantras* (in the sense of a collection of instruments), or *jantra* or *jantar* in the vernacular. The archival records examined by V. N. Sharma also refer to the observatories at *jantra.*[1629] In Delhi, people on the street who did not understand the purpose of these strange structures added a rhyming word *mantar* and began to call these structures *Jantar Mantar.* This pair of words denote 'magical diagrams and magical incantations' in the occult realm, which is far removed from observational astronomy. Now this vulgar name came to be applied not only to the Delhi Observatory, but to all the observatories. It is improper to call this unique set of scientific instruments by the unscientific name. It would be better to call them Jai Singh's Observatories.

Nāḍīvalaya-yantra: The *Nāḍīvalaya-yantra* consists of two graduated plates set up parallel to the plane of equator; here the term *nāḍī-valaya* (lit. circle of *nāḍīs,* i.e., *ghaṭīs* of 24 minutes) denotes the equator. In the British colonial tongue, it became *Nārīvalaya-yantra* and this name is still being used by Indians. There is no justification for this; in fact, it is misleading, because *nārī* in Indian languages means woman, and *nārī-valaya* would mean a feminine ring or bracelet. This instrument should be called *Nāḍīvalaya-yantra.*

Dakṣiṇodak-bhitti-yantra: While translating Arabic texts into Sanskrit, Jagannātha unwisely chose the rare term *udaṅ* for north and accordingly called the wall set up on

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[1629] Sharma 2016, pp. 96-97.

the south-north line *Dakṣiṇodak-bitti-yantra*, which became *Dakshino Writti Yantra* in British colonial tongue and continues to be used in this form. It is better to call it *Dakṣiṇottara-bhitti-yantra.*

Cakra-yantra: The name *Cakra-yantra,* lit., wheel or ring, or circle instrument, is a colourless name; it can be applied to nearly every instrument, because there are rings or circles in almost every instruments for measuring angles.

In fact, the instrument in the Varanasi observatory was originally called *Krānti-vṛtta* in the sense of 'ring to measure declination'.[1630] John Lloyd Williams, in his report of 1793, describes it as follows:

> A brass circle in the line of equator, facing north and south. It has a movable index, turning on a pivot in the centre; the circle is divided into 360 degrees, or *unse* [= *aṃśa*], subdivided again in 60′, and again into 60″, and into 1/4ths. This instrument is called *cund-brit,* or *cranti-brit* [= *krānti-vṛtta*], but I could not learn the use of it.[1631]

William Hunter objected to the name *Krānti-vṛtta* with the following argument:

> The literal meaning of the *Sanscrit* term *Kranti-writ,* is a circle of *declination,* which may, with some propriety, have been applied to this instrument, as mentioned by Mr. *Williams.* But this name is, in the *Hindu* astronomical books, peculiarly appropriated to the ecliptic; and as the *Sem'rat Sid-dhanta* contains the description of an instrument called *Kranti-writ-yunter,* wherein a circle is made, by a particular contrivance, to retain a position parallel to the ecliptic, I am inclined to believe that the appellation has been erroneously given by the ring above mentioned.'[1632]

Either because of Hunter's objection, or because people in later times did not know how to call it, it was named *Cakra-yantra.* It would be more appropriate to call it *Krānti-yantra* (declination instrument).

1630 Also, in a map of the Jaipur Observatory, reproduced in Sharma 2016, p. 128, the two rings are named *Krānti-vṛtta.*

1631 John Lloyd Williams, 'Further Particulars respecting the Observatory at Benares,' *Philosophical Transactions of the Royal Society at London,* 83.1 (1793) 45-49, esp. 47-48.

1632 Hunter 1799, p. 204.

3.5. Jai Singh's Observatories Today

The observatory at Mathura was set up on the roof of a building in the fort on the banks of river Yamuna. William Hunter described the instruments in 1799.[1633] This fort, together with Jai Singh's astronomical instruments, was pulled down sometime before 1857 and there are no remains of the instruments. The other four observatories are extant in different states of preservation. Virendra Nath Sharma gives a detailed account of the restorations undertaken at the four observatories at different times. The observatory at Ujjain appears to have been substantially modified since the middle of the last century.

The observatory at Varanasi was set up on the roof of a palace on the banks of Ganga river. The palace was built by Jai Singh's ancestor Man Singh (1550-1614) and therefore came to be known as Man Mandir; accordingly the observatory was called 'Man Mandir Observatory'. It could be reached through a lane from the bank of the Ganga. Since Varanasi is the most important centre of pilgrimage and since the river front is full of temples and other places of interest, rarely anybody used to visit this Observatory. When I went to live in Varanasi 1967, it took me one full month to find a person who knew where the observatory lay. Sometime before 2000, the old entrance through a small lane from the riverfront was closed, and a new entrance was opened on the side of the Dashashvamedh Ghat, and also an entrance fee was introduced. This was not a wise move; the Dashashwamedh Ghat is considered the most holy place for ritual baths, with many important temples in the vicinity. With such preponderance of religious and other places of interest, hardly anybody would visit the observatory, that too with an entrance fee. In the absence of human visitors, monkeys took over Jai Singh's astronomical instruments. When I visited the observatory in 2000, the attendant had to accompany me with a stick to prevent monkeys from attacking me, and I could see that the instruments were full of simian excreta.

The **Delhi Observatory,** the first one set up by Jai Singh, was vandalised 1764; it was completely restored in 1909-1910. Here the lofty *Samrāṭ-yantra* was partly built below the ground-level so that the shadow of the gnomon may fall on the quadrants soon after sunrise. But water began to seep into the base of the *Samrāt-yantra* and to collect

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[1633] Hunter 1799, pp. 200-201; see also Sharma 2016, ch. X, pp. 229-233; on p. 231 is reproduced an old drawing of the Mathura Fort.

there as a muddy pool. To avoid this, the base was filled with concrete at some point, thus burying large parts of the quadrants under the concrete. Even so, water still collects there. The Fakhri sextant incorporated in one of the wings of the *Samrāṭ-yantra* was also sealed up. In recent years, high-rise buildings came up in the vicinity; the sun reflecting from their glass facades burns down the grass and other greenery around the instruments. Moreover, the observatory is situated on a road leading to National Parliament; and 'Jantar Mantar' is the usual venue where all the political protest marches gather.

The **Jaipur Observatory** was originally set up within the palace complex so that Jai Singh could walk from his living quarters straight to the instruments. At the beginning of the twentieth century, however, the observatory was separated from the palace (known as the City Palace) by a public thoroughfare, but the instruments were completely restored by Garrett. Since then, the instruments are well maintained. In 2010, the UNESCO included the Jaipur Observatory on the World Heritage list.

S001 ⊙ UNNATĀṂŚA-DIGAṂŚA-YANTRA

Early 18th century

Diameter of the horizontal ring 390 mm; diameter of the vertical ring 330 mm

Jaipur, Jai Singh's Observatory



Figure S001.1 – Unnatāṃśa-Digaṃśa-yantra (photo by S. R. Sarma)

This instrument is designed to measure the two horizontal coordinates, namely, the altitude (*unnatāṃśa*) and azimuth (*digaṃśa*), of heavenly bodies simultaneously. Thus, it is the forerunner of the large masonry instrument *Rāma-yantra* which was built as a complementary pair.



Figure S001.2 – Vertical ring (photo by S. R. Sarma)

This metal instrument consists of two rings, one vertical and the other horizontal, their ensemble mounted on a quadruped stand. At present, one of the legs of the stand is broken. The vertical ring is strengthened by a horizonal bar and a vertical bar which intersect at the centre of the ring. The circumference of the ring, on both sides, is divided in 2° and groups of 6° are numbered from 6 to 90 in Devanagari numerals, separately in each quadrant, starting from the two ends of the horizontal bar and ending at the two ends of the vertical bar. The vertical bar is attached to the vertical rod or pillar set up at

the centre of the horizontal ring. At the centre of the vertical ring is a short pin at right angles of the plane of the ring. A sighting tube with a pointer can be pivoted to this pin so that its other end can slide along the scale on the ring for observing the objects in the sky. The sighting tube is now missing.

The horizontal ring is also supported by two cross-bars which intersect at the centre of the ring. The circumference of the ring is graduated in 1° and 6°. Groups of 6° appear to have been numbered, but the numbers are faded and cannot be deciphered now. The four arms of the cross-bars are engraved with longitudinal lines in the middle and are divided into 15 units.

The vertical pillar carrying the vertical ring is pivoted at the centre of the horizontal ring. To the base of the pillar are attached four arms at right angles to one another in such a manner that they can slide upon the horizontal ring and thus rotate the vertical pillar and the vertical ring attached to it. Like the four arms of the horizon ring, these four arms are also marked with longitudinal lines in the middle and are divided in 15 units. The ends of these arms which move along the scale on the horizontal ring are sharpened to a point.

For sighting an object in the sky, these arms are moved along the horizontal ring so that the central pillar as well as the vertical ring rotate in the desired direction; then the sighting tube is rotated along the circumference of the vertical ring; when the object is sighted through the sighting tube, the pointer attached to it indicates the altitude of the heavenly body on the scale on the vertical ring; the azimuth is indicated upon the scale on the horizontal ring by one of the arms at the base of the central pillar.

S002 ⊙ UNNATĀṂŚA-YANTRA

Early 18th century

Diameter of the ring 5.334 m

Jaipur, Jai Singh's Observatory

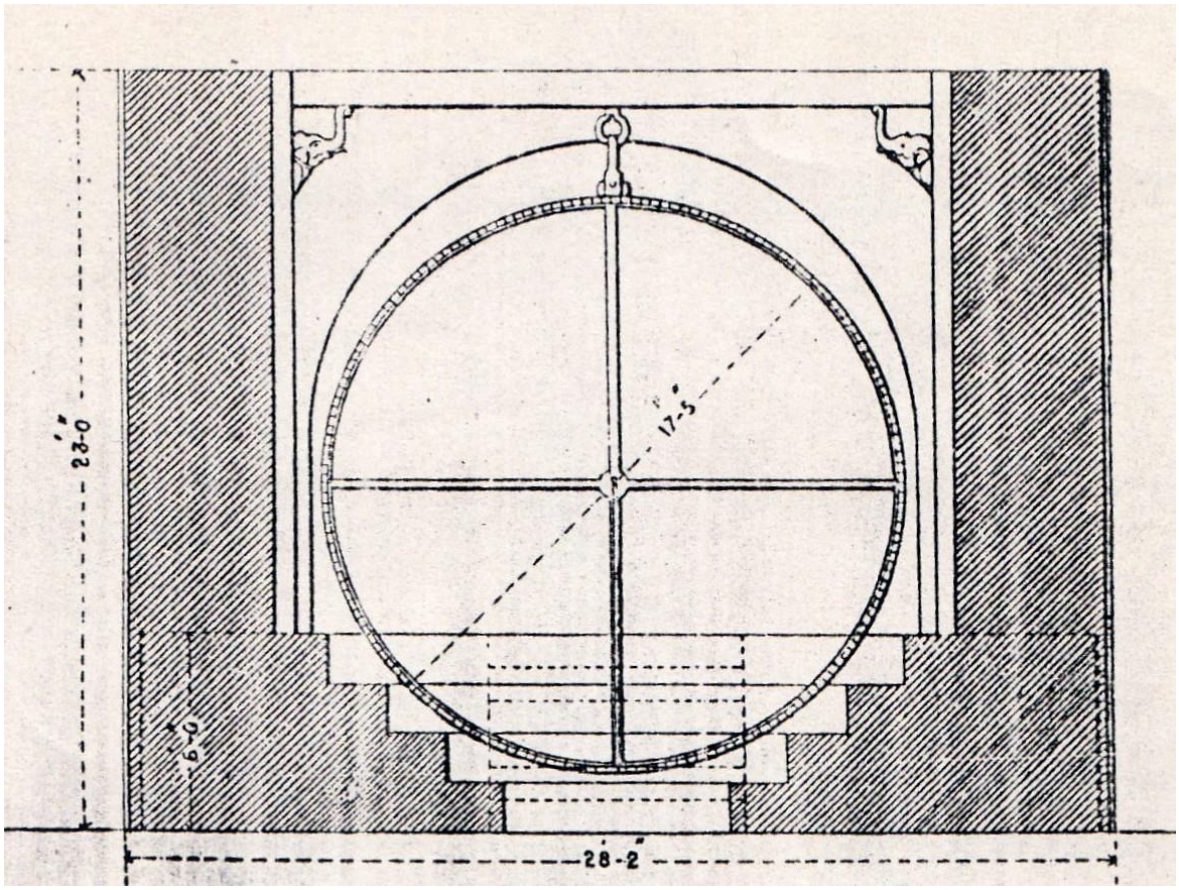


Figure S002.1 – Unnatāṃśa-yantra (sketch from Garrett & Guleri 1902, plate VIII)

This instrument consists of a huge graduated brass ring suspended from a wooden beam resting on two masonry pillars so that it can rotate around a vertical axis. Two bars, one vertical and the other horizontal, are attached to the ring; these intersect at the centre of the ring. There is a hole at the centre for mounting a detachable sighting tube with a pointer. The circumference of the ring is divided into 6° and 1°; each degree is subdivided into ten parts of 6 minutes each, but none of these divisions are numbered.

Below the brass ring are a series of circular steps in masonry for the convenience of the observer. For observing an object in the sky, the observer rotates the sighting tube about its horizontal axis along the scale on the ring and turns the ring about its vertical axis until the object is sighted through the tube. Then the pointer attached to the tube indicates the altitude of the celestial object on the circular scale of the ring.

However, it would be quite cumbersome to use this instrument. Garrett & Guleri state: ‘As the instrument is merely hung from a support, there is nothing to prevent it from swinging sideways when an observation is being taken, and it would therefore probably not give as good results as some of the masonry altitude instruments, which are necessarily quite rigid.’

The detachable sighting tube appears to have been lost; I did not see it in the stores of the observatory.

BIBLIOGRAPHY

Garrett & Guleri 1902, p. 49.
Kaye 1918, p. 32.
Sharma 2016, pp. 178-180.

S003 ⦿ CAKRA-YANTRA (KRĀNTI-YANTRA)

Early 18th century

Diameters of the rings 1.79 m; 1.84 m

Jaipur, Jai Singh's Observatory



Figure S003.1 – Two Cakra-yantras at Jaipur (photo by S. R. Sarma)

While the instrument S001 was designed to measure the horizontal coordinates of the heavenly bodies, the *Cakra-yantra* was designed to ascertain the equatorial coordinates, namely, the declination (*krānti*) and the hour angle (*nata*). There are two specimens of the *Cakra-yantra* at the Jaipur Observatory and one at the Varanasi Observatory. These consist of graduated metal rings set up so as to revolve about an axis parallel to the earth's axis.

In the *Yantraprakāra,* this instrument is called *Krāntivṛtta-yantra,* in the sense that it consists of a ring (*vṛtta*) on which declination (*krānti*) can be measured; but the same text names another instrument (S005) also by this name because it consists of a ring which represents the ecliptic (*krānti-vṛtta*). The former is named *Cakra-yantra* in recent times; *cakra* means a wheel, circle or ring and the term *cakra-yantra* would therefore denote 'the instrument that contains a ring or a circle'. But this name can be applied to

nearly every astronomical instrument because all instruments contain rings or circles. Perhaps it is better to call the present instrument *Krānti-yantra* (declination instrument) and the one to be described under S005 *Krāntivṛtta-yantra* (ecliptic instrument).

CAKRA-YANTRAS AT JAIPUR

At Jaipur, the two rings are set up between stone pillars which are situated on the north-south line. The two rings are of slightly different sizes, the southern ring has a diameter of 1.79 m and the northern one 1.84 m. A cross-bar is attached in each ring in a direction perpendicular to the axis. At the centre of the bar is a hole where a sighting tube can be mounted for observation.

The circumference of the northern ring is divided into 6° and 1°; each degree is sub-divided into 10 parts of 6 minutes each. The southern ring is divided in 6° and 1°. The divisions to do not seem to have been numbered. On the stone pillars where the southern ends of the axis are inserted, there are attached circular brass plates so that they are parallel to the plane of equator. These brass plates are graduated in 1°.

For measuring the equatorial coordinates of a celestial object, the observer mounts a sighting tube with a pointer attached to it at the centre of the ring; by rotating the ring about its axis and the sighting tube about the centre of the ring, he sights the object through the tube. The declination is read on the circular scale on the ring and the hour angle on the circular plate attached to the stone post.

CAKRA-YANTRA AT VARANASI

The *Cakra-yantra* at Varanasi is smaller with a diameter of about 1 metre. It is set up between a wooden post on one side and masonry support on the other. A cross-beam passing through its centre is extended on either side of the circumference and inserted between the posts so that it is parallel to the axis of the earth.

The circumference of the ring is divided in 1° and 6 minutes. Groups of 6° are numbered from 6 to 90, separately in each quadrant. The 90° marks are near the pivots and 0° marks are half-way between.



Figure S003.2 – Cakra-yantra at Varanasi (photo by S. R. Sarma)

Around the southern pivot, a circular scale is engraved on a stone slab, which is perpendicular to the axis of the ring and parallel to the plane of the equator. It is divided in 6° and 1°, but not numbered. Here also a detachable sighting tube was meant to be used.



Figure S003.3 – Scales on the Cakra-yantra at Varanasi
(photo by S. R. Sarma)

CAKRA-YANTRA IN THE YANTRAPRAKĀRA

The *Yantraprakāra* describes an instrument consisting of a single ring that turns around an axis parallel to the earth's axis and is equipped with an alidade; with this instrument the declination can be measured, but not the hour angle.[1634]

> Now, for determining the declination (*krānti*) of the planets and stars, an instrument called *Krāntivṛtta* is constructed. This is as follows. Prepare a ring of any diameter, either in metal or in wood, with uniform breadth and thickness [its four surfaces forming] a square. On this [ring] mark 360 degrees and 21,600 minutes [and also the south and north points, and the east and west points]. Attach to it a sturdy bar running diagonally from the east point to the west point. At the middle of the bar is the centre of the circle. To the centre affix a pin on which a bar is so pivoted that, when rotated, it touches the ring everywhere. Attach to the bar two sighting vanes (*karṇa*) with apertures at equal distances on either side of the centre as in the astrolabe. Now the instrument is complete.
>
> Now the method of erecting this instrument. On a ground made level with water, draw east-west and south-north lines. There on the south-north line, set up two wooden pillars and make them firm by burying a part in the ground. Then on the south and north pillars mark the points of south and north poles, the points being separated [from the horizontal] by the degrees of local latitude. At the south and north points of the ring affix two pins so that they project outside. Pivot these south and north pins loosely at the south and north poles marked on the wooden so that, when rotated, the ring turns freely around [the axis].
>
> Now, finding out the declination through observation (*vedha*). Observe the planet or star through the two apertures in the bar. At the moment of observation, make a mark on the ring for measuring the declination (*krānti-vṛtta*) where the tip of the bar touches. The interval on the circumference of the ring between the mark and the east-west line is the desired declination.

[1634] Sarma 1986-87b, pp. 63-64.

> It is north if [the mark] is north of the equator (*nāḍīvṛtta*) [represented here by the east-west line], or south if the mark is south.

This appears to be the first model designed by Jai Singh. Subsequently, he added a dial on the southern post for measuring the hour angle and replaced the alidade pivoted to the centre of the ring by a sighting tube which is more convenient for observation. This improved model is the *Cakra-yantra* that is available in three specimens.

However, in all the three specimens, the detachable sighting tube is missing. Therefore, we do not know how this sighting tube was designed by Jai Singh. It should have a pointer which reaches up the circular scale on the ring and indicates the amount of declination on the circular scale. But there should be also another pointer which moves around the circular scale on the southern pillar and indicates the amount of eastward or westward tilt of the ring, this amount being the hour angle. In the absence of the sighting tubes, we do not know how Jai Singh may have designed this second pointer.

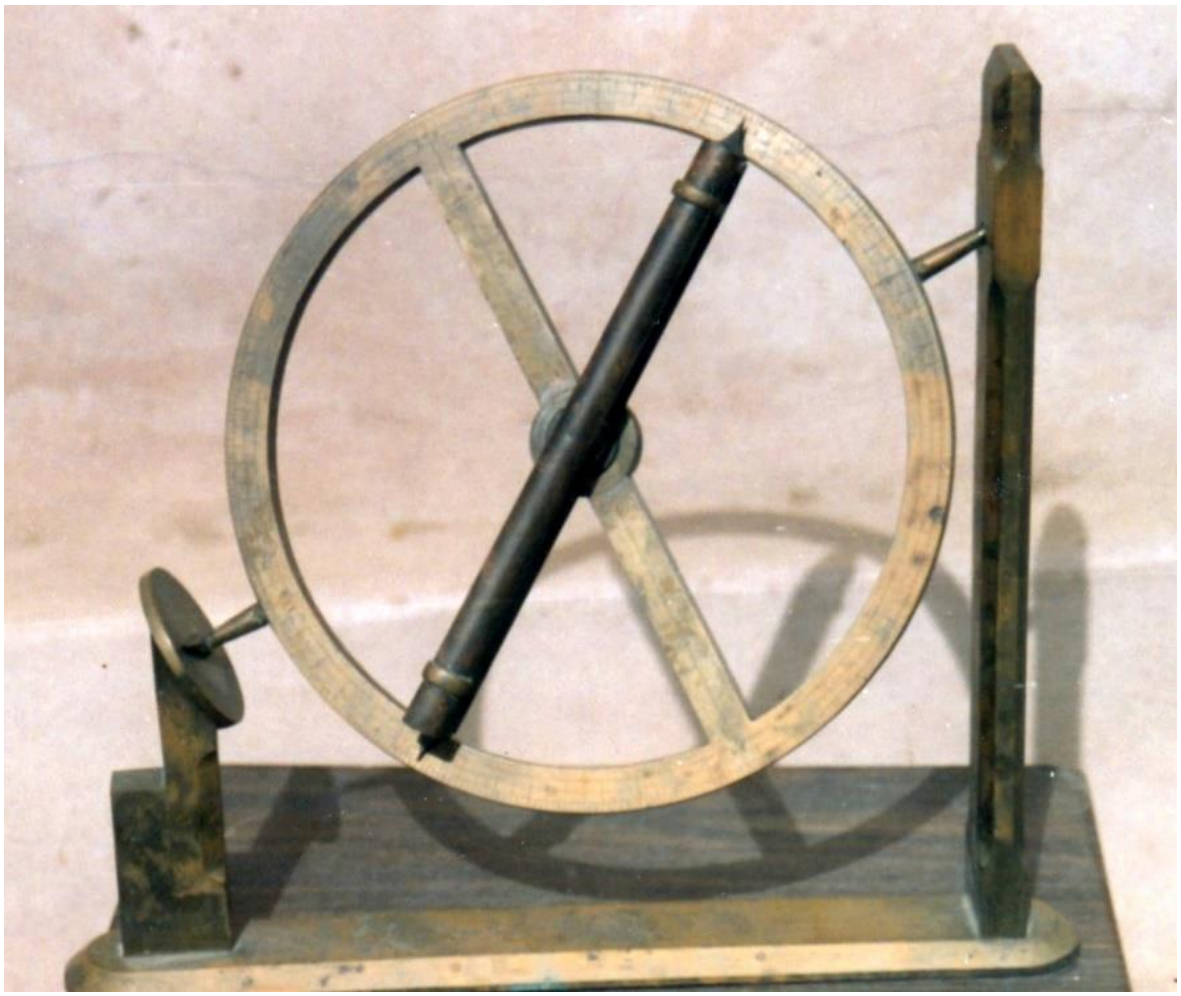


Figure S003.4 – Replica of the Cakra-yantra at Jaipur (photo by S. R. Sarma)

In the Jaipur Observatory, there is a small replica of the *Cakra-yantra,* made in the twentieth century. It contains a very thick sighting tube with pointers at both ends that can indicate the declination on the scale of the ring, but there is no pointer to indicate the hour angle on the disc set up on the southern pillar.

BIBLIOGRAPHY

Garrett & Guleri 1902, p. 49.
Kaye 1918, p. 32.
Sharma 2016, pp. 177-178, 211-212.

S004 ⦿ KRĀNTIVṚTTA-YANTRA 1

Early 18th century

Diameter of the plates 820 mm; height of the stand 1.5 m

Jaipur, Jai Singh's Observatory

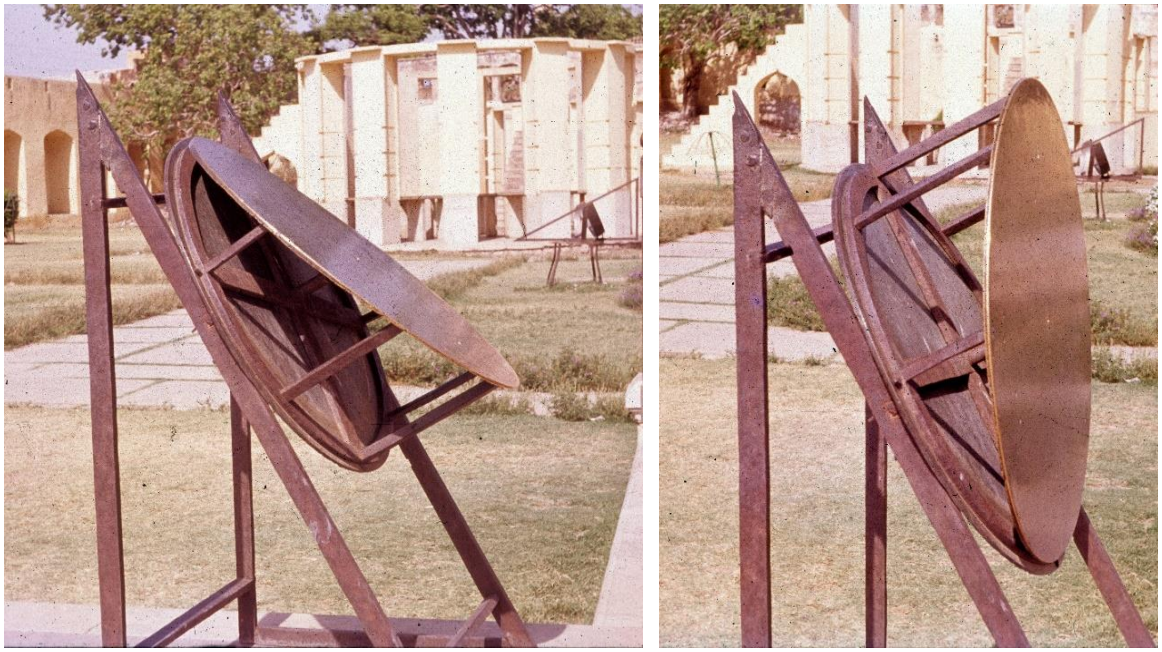


Figure S004.1 – Krāntivṛtta-yantra, two views (photos by S. R. Sarma)

After designing two instruments for determining respectively the horizontal coordinates (S001) and the equatorial coordinates (S003), attempts were made to prepare a third instrument for measuring the ecliptic coordinates, namely the celestial longitude (*dhruvaka*) and the celestial latitude (*śara*). The *Yantraprakāra* describes a prototype where provision was made to measure only the celestial longitude,[1635] while the *Yantrādhyāya* (chapter on instruments) in Jagannātha's *Samrāṭ-siddhānta* describes an advanced model with which both the celestial longitude and latitude can be measured.[1636]

The description in the *Yantraprakāra* reads as follows:[1637]

> Now for measuring the celestial longitude, expressed in terms of signs etc. (*rāśyādi-dhruvaka*), of planets and stars, an ecliptic instrument (*krānti-vṛtta-*

1635 Sarma 1986-87b, pp. 23, 68-70.

1636 Jagannātha 1976, pp. 13-14; Jagannātha 1967-69, pp. 1046-1048.

1637 Sarma 1986-87b, pp. 68-69, slightly modified.

yantra) is designed. This is as follows. First on a ground made level with water draw east-west and north-south lines. On the east-west line erect two right-angled triangles whose hypotenuses are parallel to the plane of the celestial equator (*palabhā-kṣetra*) at equal distance on either side of the centre. On them (i.e., the hypotenuses on the plane of the equator) set up firmly a round sheet of metal of any size. On this draw east-west and south-north lines. Mark also degrees and minutes [on its circumference]. This is called the equator.

Next prepare two rings of equal size but somewhat smaller than the plate designated as the equator. Mark both the rings with degrees, minutes and also zodiac signs. Join the two rings together at the first point of Capricorn (*Makara*) and affix them firmly by means of pins and the like so that the distance between them at the first point of Cancer (*Karka*) is equal to the obliquity of the ecliptic.[1638] Let the second ring be called the ecliptic (*krāntivṛtta*). This ecliptic ring should be pivoted loosely to the centre of the equator so that it can rotate all over the surface of the equator. Again, at the centre of the ecliptic, pivot loosely a metal bar (*paṭṭikā*) as in an astrolabe.

The metal alidade moving along the surface of the ecliptic ring can measure only the celestial longitude. For measuring also the celestial latitude, Jagannātha prescribes the following attachment to the ecliptic ring:

Having made a small mark at the centre of the ecliptic circle, attach there for observation a metal bar, whose length is slightly more than the diameter of the ecliptic ring, in such a manner that its lower surface can move along the divisions of degrees marked on the rim of the ecliptic ring. On the upper surface [at both ends] attach quadrants (*vṛtta-turīya*) so that their centres lie on the metal bar. On the rim of the quadrant mark ninety degrees. At the centres of the quadrants, pivot metal bars with sighting tube (*nalikā*) so that the tips of the bars move on the degree scales on the rims of the quadrants.

[1638] The *Yantraprakāra* and also Jagannātha's *Samrāṭ-siddhānta* read here erroneously *parama-krānti-dviguṇita-antareṇa* (at a distance which is twice the obliquity of the ecliptic).

> With this attachment, both the coordinates can now be measured; the longitude on the scale engraved on the ecliptic circle and the latitude on the scale on the quadrants.

Jagannātha also adds that he got prepared a specimen consisting of a ring with a diameter of the artisan's cubit (*karmakāra-hasta*). But it is not extant anymore. What are extant are two unfinished specimens of Jai Singh's times; one of them is completely in metal (S004) and the other just a masonry base without the metal rings (Figure S005.2). At the beginning of the twentieth century, Garrett got prepared a small specimen according to Jagannātha's prescriptions (Figure S005.1).

The present specimen closely follows the prescription of the *Yantraprakāra.* It consists of two large circular plates of brass (d. 820 mm, t. 10 mm); the upper plate represents the plane of the ecliptic and the lower plate the plane of the equator and the angle between them measures 23;30° which is the obliquity of the ecliptic. The lower plate subtends an angle of 28;47° with the vertical. This angle is closer to the geographical latitude of Delhi at 28;39°. Therefore, it is probable that this instrument was originally made for the Delhi Observatory. The two plates are so arranged that the upper plate rotates along the circumference of the lower plate in such a manner that one edge of the upper plate is always in contact with the circumference of the lower plate.

The scales engraved on the circumference of both plates are divided in signs, 6° and 2°. The ring to which the upper plate is attached and which rotates on the circumference of the lower plate is also graduated in 6° and 1°.

The ensemble of the two plates is mounted on an iron stand, of about one and a half metres height, consisting of two triangles as prescribed in the *Yantraprakāra.* However, no alidade was attached for measuring the celestial longitude; for unknown reasons, it was left unfinished.

BIBLIOGRAPHY

Jagannātha 1967-69, pp. 1046-1048.
Jagannātha 1976, pp. 13-14;
Sarma 1986-87b, pp. 23, 68-70.
Sharma 2016, pp. 186-187.

S005 ⊙ KRĀNTIVṚTTA-YANTRA 2

Early 20th century

Diameter of the ecliptic ring 915 mm

Jaipur, Jai Singh's Observatory



Figure S005.1 – Krāntivṛtta-yantra set up by Garrett (photo by S. R. Sarma)

It appears that for measuring the celestial longitude and latitude, first an instrument was made completely in metal, but it was left unfinished (S004); then another was began with a huge masonry base with a diameter of about 3 metres, but that too had been left unfinished (Figure S005.2).

During the restoration of the Jaipur Observatory at the beginning of the twentieth century, Garrett prepared a new *Krāntivṛtta-yantra* in a smaller scale according to Jagannātha's prescriptions because it 'is an interesting instrument'.

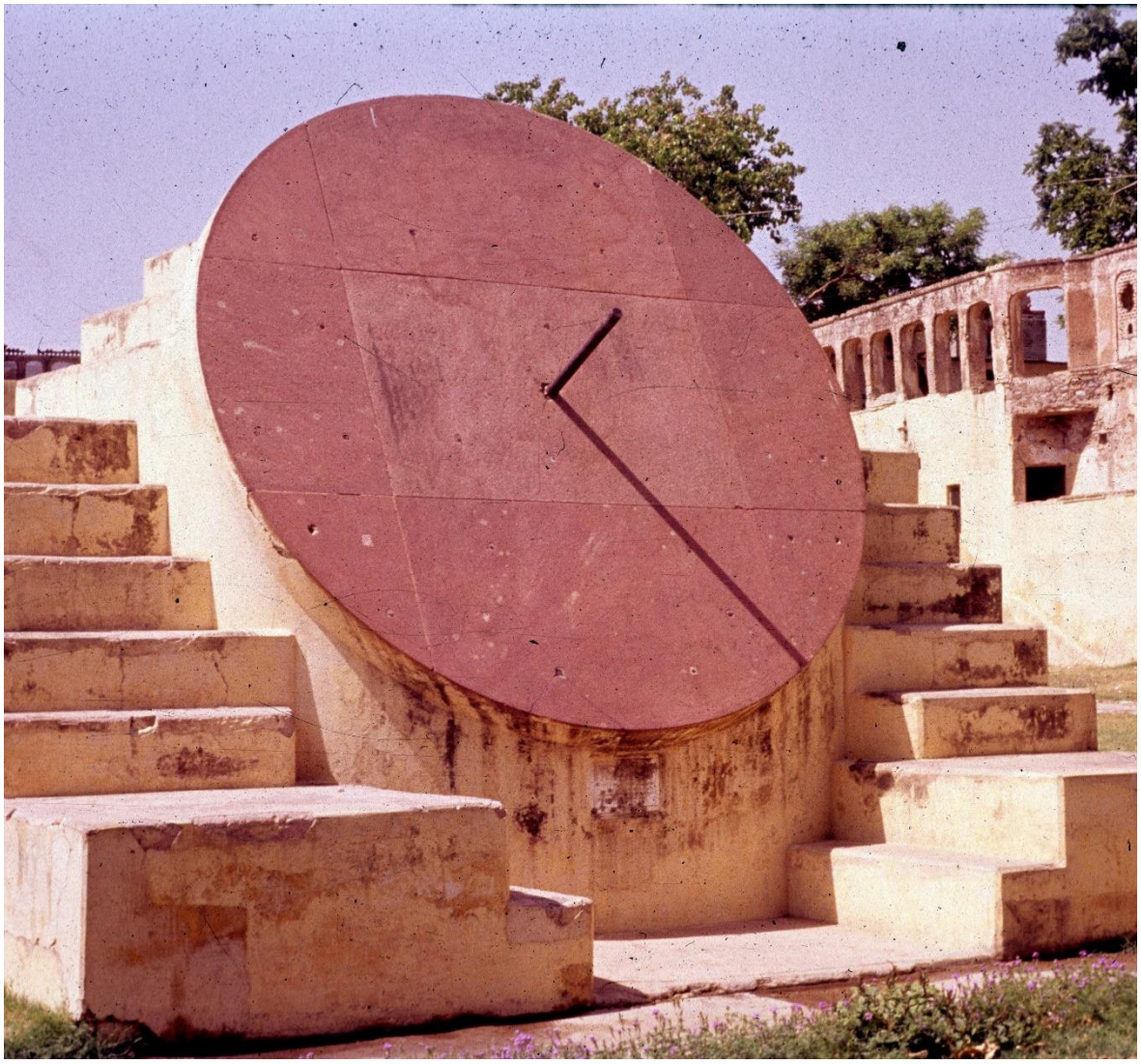


Figure S005.2 – Masonry base of an unfinished Krāntivṛtta-yantra (photo by S. R. Sarma)

The new instrument, as constructed by Garrett, consists of a masonry base, which subtends with the vertical an angle equal to the latitude of Jaipur. Upon this base are two rings, the lowing ring representing the plane of the equator and the upper ring the plane of the ecliptic, inclined at each other at an angle equal to the obliquity of the ecliptic. At the centre of the ecliptic ring is pivoted a bar so that it rotates along the surface of the ecliptic ring. Two graduated quadrants with sights are attached to the two ends of the bar.

For making observations with this instrument, the ecliptic ring should first be aligned with the ecliptic in the heavens. The *Yantraprakāra* lays down the following procedure:

> Now the method of observation. If a certain zodiac sign reaches the zenith at certain *nataghaṭikās,* arrange the same sign at the zenith at the same *nataghaṭikās,* by rotating the ecliptic ring. Then sight the planet or star through the alidade. The interval between the first point of Aries and the point where the alidade touches the ecliptic at the time of sighting is the position (i.e., longitude) of the planet in terms of the zodiac signs (*rāśydika graha*) or the celestial longitude of the star (*nakṣatra dhruvaka*).

Virendra Sharma suggests another procedure in the following words:

> For measuring the coordinates of a celestial object, the ecliptic scale is aligned with the ecliptic in the sky. This may be done by sighting a 'guide star' first whose longitude is already known. Line up the sighting bar with the star's longitude on the ecliptic scale. Next rotate the entire ecliptic plate along with the sighting bar such that the guide star is visible through one or the other sighting slits. The procedure orients the ecliptic plate in proper position. For observing the object in the sky rotate the sighting bar around so that its sighting strip and the slit mounted on one of the quadrants line up with the object under observation. The longitude of the object is then read off the ecliptic scale and the latitude from the quadrant scale. Because the orientation of the ecliptic continuously changes with the rotation of the earth, the instrument is somewhat cumbersome to work with. The instrument may also be used for indicating the signs of the zodiac at the horizon and the meridian by merely aligning the ecliptic scale in proper position with the sun or with a guide star whose longitude is known, and then reading off the signs on the scale intercepted by the prime vertical and the meridian on the instrument.

BIBLIOGRAPHY

Garrett & Guleri 1902, pp. 45-47.
Kaye 1918, pp. 32-33.
Sharma 2016, pp. 184-186.

Yantraprakāra, pp. 23, 68-70.

Jagannātha 1976, pp. 13-14.

Jagannātha 1967-69, pp. 1046-1048.

T. INSTRUMENTS DESIGNED BY SAWAI MADHO SINGH

INTRODUCTION



Figure T1 – Sawai Madho Singh
(contemporary pencil sketch, photo courtesy late Yaduendra Sahai)

When Sawai Jai Singh died in 1743, his elder son Isvari Singh became the ruler of Jaipur, but he had a short span of reign and died in 1750. Then his step-brother Madho Singh ascended the throne. He had a relatively peaceful rule from 1750 to 1767, and during this period he could cultivate his interests in literature and astronomy.[1639] He is said to have patronised many poets and artists; the artists painted him in elaborate costumes and in different postures. Several of these paintings can be seen in the internet.

[1639] James Tod, the well-known chronicler of Rajasthan, extols Madho Singh in these words: 'He inherited no small portion of his father's love of science, which continued to make Jaipur the resort of learned men, so as to eclipse even the sacred Benares'; cf. Lieut. Col. James Tod, *Annals and Antiquities of Rajasthan, or The Central and Western Rajput States of India,* ed. with an Introduction and Notes by William Crooke, Oxford University Press, London 1920, vol. 3, p. 1361.

Like his father, he too was interested designing new instruments, but with a difference. While Jai Singh designed huge instruments in masonry, Madho Singh, himself a huge person, liked to make small portable instruments. There are extant five instruments and a diagram painted on cloth that bear his name as the creator.

Madho Singh's instruments are variations of horary quadrants and column dials, calibrated for the latitude of Jaipur at 27°. The first of these, named *Yantrādhipati* (T001), is shaped like an astrolabe with a circular plate surmounted by a suspension bracket; the two sides of the circular plate are filled with eight horary quadrants containing scales, which display the half-durations of daylight in different periods of the year, measured in *ghaṭīs.* There are 61 scales, one for each 3° solar longitude.

The next one is made of wood (T005) in the shape of a column with four equal sides, each of which carries five *ghatī* scales; these scales are extended on flaps which are hinged to each side and which can be folded back when not in use. On the four sides there are 20 scales, one scale for each 10° of solar longitude.

The last three are named *Śoṭā-yantras*; these are hollow columns made of brass, consisting of four sides of equal width. The fist two among these are meant for the daytime (T002 and T003), with *ghaṭī* scales to measure the half-durations of daylight throughout the year. These are constructed on the same principle as column dials, but made more complex with no special advantage. The third *Śoṭā-yantra* is also a hollow square column, but with it time is measured at night by sighting one of the eight junction stars of the lunar mansions.

The one common feature among those designed for use in the daytime (viz. T001, T002, T003 and T005) is that each *ghaṭī* scale on them is drawn for two solar longitudes whose sum is tantamount to 6 signs or 180°. However, none of these creations by Madho Singh represents any real advance in instrument design. The *Yantrādhipati* which is equipped with eight horary quadrants is an interesting innovation, but this cannot said about the rest of the instruments. The complexities introduced in these column dials can at best be termed 'clever'. These are clearly the attempts of a dilettante trying to emulate his illustrious father, but they fall far short of the majesty and simplicity of Jai Singh's creations in stone.

To the instruments he has designed, Madho Singh added Sanskrit verses proclaiming his authorship of these instruments. Chronologically, he appears to have been the first to sign his instruments in Sanskrit verse.[1640] He is said to be an accomplished poet who compiled an anthology of Sanskrit poems and rendered them into Brajabhāṣā.[1641] But surprisingly the signature verses on the instruments do not betray his poetic talents. They are full of empty rhetoric, poor in syntax, and say very little about instruments themselves. Bulhomal of Lahore appears to have been inspired by Mado Singh's example and added metrical signatures to some of his own Sanskrit instruments (H003, K005, L006, U001 and U002); his verses are more successful than those of the royal predecessor.



Figure T2 – Copper plaques with the names of the instruments
(photo by S. R. Sarma)

1640 Sarma 2010, p. 80.

1641 Bahura 1976, pp. 75-77.

Besides designing new instruments, Madho Singh appears to have equipped the various portable instruments collected by his father and the instruments which he himself designed with copper plaques on which the name and function of the instrument is engraved. Some are small which just the name of the instrument (as in Figure T2) and some are very large with an elaborate listing of the functions of the instrument (e.g. Figure A091.9, which is attached to the Zarqālī astrolabe made by Ḍiyā' al-Dīn Muḥammad). The uniformity in their make and in the style of engraved letters suggest that all these plaques must have been made about the same time, most likely at the instance of Madho Singh.

Unfortunately, these plaques are attached to the instruments with a thin wire and not very securely. Every time these instruments are shifted, some of the plaques get detached from the instrument. Figure T2 shows four small plaques. The first three belong to the three *Śoṭā-yantras*; they have now been attached to the respective instruments (see Figure T003.1). The fourth one carries the label *jātula halaka yaṃtra vṛtta sāt kī* (instrument named *Dhāt al-Ḥalaq,* with 7 rings). *Dhāt al-Ḥalaq* is the Arabic name for the armillary sphere. It indicates that Jai Singh's collection of portable instruments included an Indo-Persian or Arabic armillary sphere with 7 rings. There is no trace of it now in Jai Singh's observatory. It was mentioned neither by Garrett & Guleri 1902, nor by Kaye 1918. At Jai Singh's Observatory, there exists a Sanskrit armillary sphere (I001), but that one is equipped with another and larger plaque (Figure I001.2).

T001 ⊙ YANTRĀDHIPATI BY SAWAI MADHO SINGH

18th century, second half

Diameter 348 mm

Jaipur, Jai Singh's Observatory



Figure T001.1 – Yantrādhipati, obverse side (photo by Dr Jean Michel Delire)

While the astrolabe is called *yantrarāja,* 'king of instruments' in Sanskrit, Madho Singh chose for his creation a grander title *Yantrādhipati,* 'overlord of instruments'. It is a very large circular plate made of burnished brass. Like the astrolabe, this too has a *kursī* or the crown-like suspension bracket on which its name has been inscribed on both sides and filled with red enamel. All the engraved lines, numbers and letters are filled with black and red enamel, and a high degree of sophistication is visible in its manufacture.

In spite of its grand name, it is just a horary quadrant, repeated eight times on the two sides of the circular plate. Like the horary quadrant, this too measures the altitude of the sun in degrees and translates them into *ghaṭīs*. This is the first time a horary quadrant was attempted in Sanskrit, specific to a particular terrestrial latitude. It is designed for the latitude of Jaipur, roughly at 27°.[1642]

The outer rim on both sides carries altitude scales as on the back of the astrolabe. The rim is graduated in 1° and 6° and groups of 6° are numbered from 6 to 90, separately in each quadrant, the numbering commencing at the east and west points and ending at the north and south points. Inside the degree scale are concentric circles bearing in each quadrant a set of horary scales. On the obverse side, there are 7 scales in each quadrant; on the reverse side, 9 in the upper two quadrants, 7 in the lower left quadrant and 8 in the lower right quadrant. Thus there are altogether 61 scales on both sides; these display the half-durations of daylight in different periods of the year, measured in *ghaṭīs.* These *ghaṭī* scales are designed for every 3° solar longitude.

Above each scale are written two solar longitudes, in signs and degrees, for which this particular *ghaṭī* scale can be employed. At the end of each scale can be seen the maximum duration in *ghaṭīs* and *palas.* The value in *palas* is written above the line.

[1642] Inspired by this *Yantrādhipati*, Bulhomal of Lahore produced several horary quadrants. While K005 and U005 carry a single quadrant, in U001, U002 and U003, the four quadrants on a circular plate are filled with horary quadrants exactly in the manner of the *Yantrādhipati.* Dharm Chand also incorporates horary quadrants in all the four quadrants on the reverse side of his perpetual calendars in the same manner (X015, X016, X017, X018 and X019).

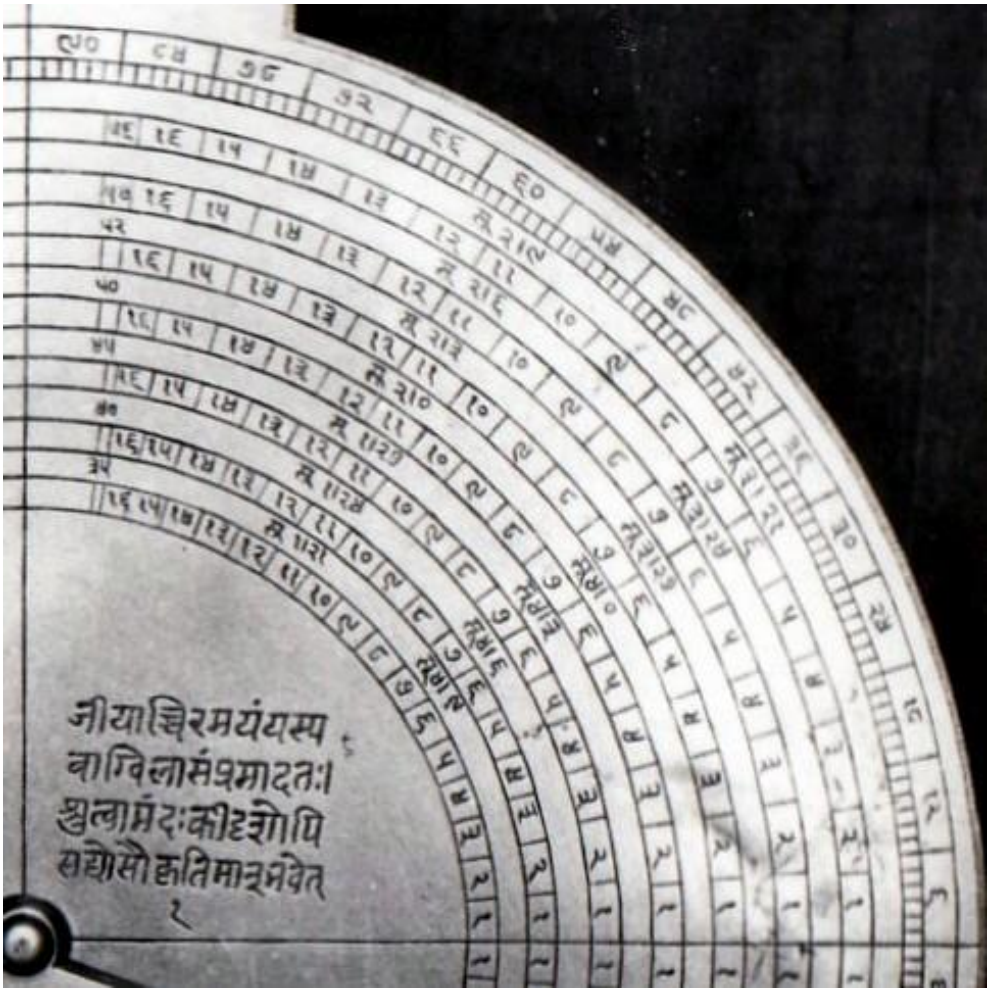


Figure T001.2 – Obverse side, upper right quadrant (photo by S. R. Sarma)

For example, in the upper right quadrant on the obverse side, the lowermost scale is numbered from 1 to 16 and above is written 35. This means the maximum duration is 16 *ghaṭīs* and 35 *palas.* Above this scale are written two solar longitudes: *sū 1|21* and *sū 4|9.* Here *sū* is an abbreviation for *sūryāṃśa* (sun's longitude in degrees); *1|21* denotes 1 sign and 21 degrees. Since the signs are counted from 0 to 11, *1|21* stands for 21° in Taurus; likewise, *sū 4|9* represents 9° in Leo. In all cases, the two longitudes are so chosen that their sum (*1|21 + 4|9 = 6.00*) is equal to 6 signs or half of the ecliptic circle. In a few cases on the reverse side the sum is 18 signs which is also, in effect, equal to 6 signs.[1643]

[1643] In the topmost scale, the penultimate scale is numbered 16 and also the last one 16; this is obviously a scribal error; the last one should be 17. In the scale below, the last two cells are correctly numbered as 16 and 17.

Table T001-1 and Table T001-2 display the details of the *ghaṭī* scales in the four quadrants on the obverse side and in the four quadrants on the reverse side respectively. The two solar longitudes are listed in the first two columns; the third column shows the maximum number of *ghaṭīs* marked in that scale; it is the half-duration of daylight when the sun's longitude corresponds to either of the two values mentioned in the first two columns.

Table T001-1 *Ghaṭī* Scales on the Obverse Side

Upper Left Quadrant			Upper Right Quadrant		
sū. 3;0	*sū.* 3;0	17;10	*sū.* 2;9	*sū.* 3;21	17
sū. 2;27	*sū.* 3;3	17;8	*sū.* 2;6	*sū.* 3;24	17
sū. 2;24	*sū.* 3;6	17;6	*sū.* 2;3	*sū.* 3;27	16;52
sū. 2;21	*sū.* 3;9	17;5	*sū.* 2;0	*sū.* 4;0	16;50
sū. 2;18	*sū.* 3;12	17;2	*sū.* 1;27	*sū.* 4;3	16;45
sū. 2;15	*sū.* 3;15	17;0	*sū.* 1;24	*sū.* 4;6	16;40
sū. 2;12	*sū.* 3;18	17	*sū.* 1;21	*sū.* 4;9	16;35
Lower Left Quadrant			Lower Right Quadrant		
sū. 0;27	*sū.* 5;3	15;55	*sū.* 1;18	*sū.* 4;12	16;30
sū. 0;24	*sū.* 5;6	15;49	*sū.* 1;15	*sū.* 4;15	16;25
sū. 0;21	*sū.* 5;9	15;43	*sū.* 1;12	*sū.* 4;18	16;20
sū. 0;18	*sū.* 5;12	15;37	*sū.* 1;9	*sū.* 4;21	16;15
sū. 0;15	*sū.* 5;15	15;30	*sū.* 1;6	*sū.* 4;24	16;11
sū. 0;12	*sū.* 5;18	15;24,14	*sū.* 1;3	*sū.* 4;27	16;6
sū. 0;9	*sū.* 5;21	15;18	*sū.* 1;0	*sū.* 5;0	16;1

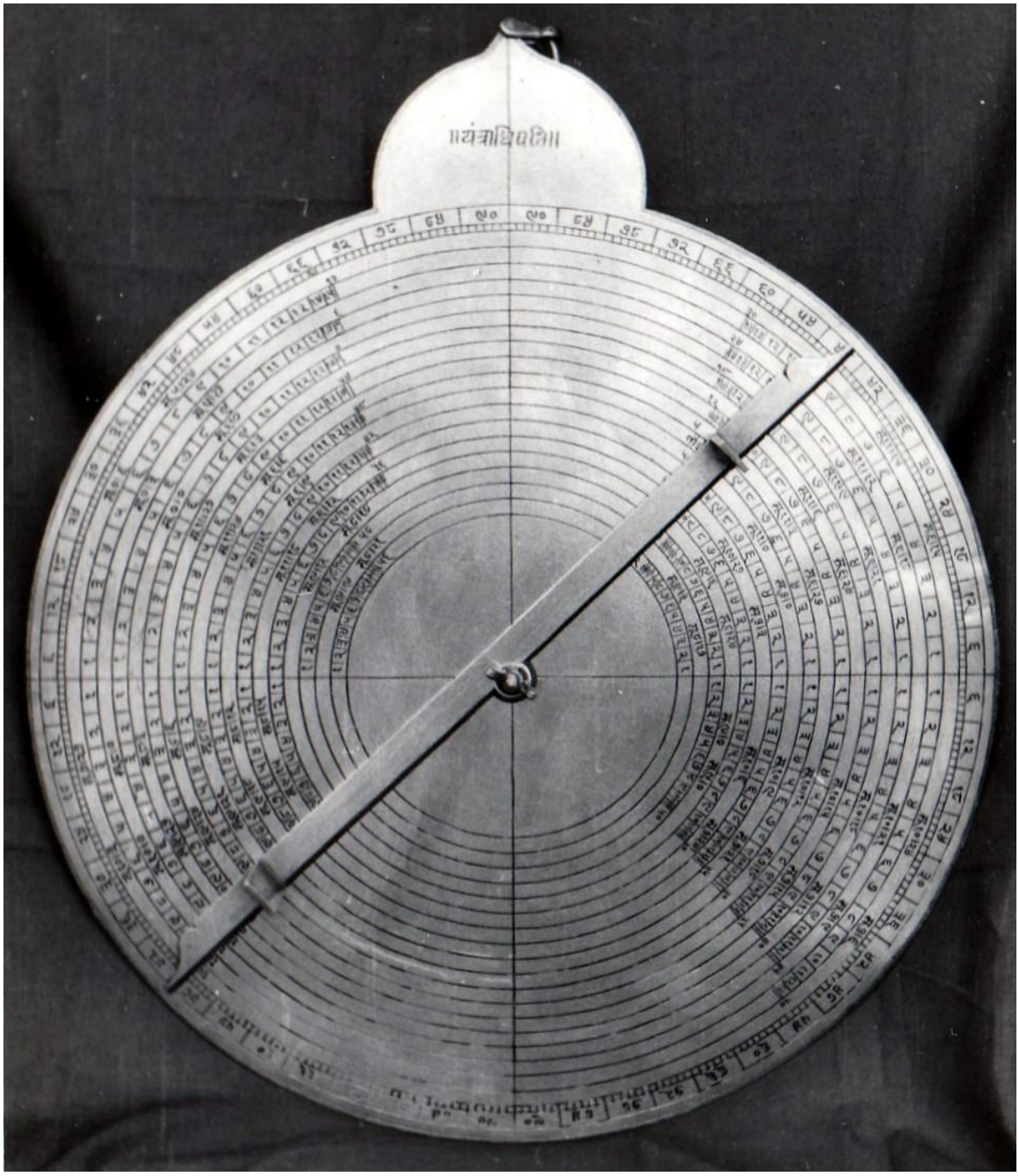


Figure T001.3 – Yantrādhipati, reverse side (photo by S. R. Sarma)

Table T001-2 *Ghaṭī* scales on the reverse side

Upper left Quadrant	Upper Right Quadrant
sū. 0;6 *sū.* 5;24 15;12	*sū.* 11;15 *sū.* 6;15 14;30
sū. 0;3 *sū.* 5;27 15;6	*sū.* 11;12 *sū.* 6;18 14;24
sū. 0;0 *sū.* 1;0 15;0	*sū.* 11;9 *sū.* 6;21 14;18
sū. 11;27 *sū.* 6;3 14;54	*sū.* 11;6 *sū.* 6;24 14;12
sū. 11;24 *sū.* 6;6 14;48	*sū.* 11;3 *sū.* 6;27 14;5

sū. 11;21	*sū.* 6;9	14;42	*sū.* 11;0	*sū.* 7;0	12;59
sū. 11;18	*sū.* 6;12	14;36	*sū.* 10;27	*sū.* 7;3	12;54
sū. 9;12	*sū.* 8;18	12;47	*sū.* 9;6	*sū.* 8;24	10;54
sū. 9;9	*sū.* 8;21	12;46	*sū.* 9;3	*sū.* 8;27	10;52
Lower Left Quadrant[1644]			Lower Right Quadrant		
sū. 7;27	*sū.* 10;3		*sū.* 10;24	*sū.* 7;6	13;50
sū. 8;0	*sū.* 10;0		*sū.* 10;21	*sū.* 7;9	13;45
sū. 8;3	*sū.* 9;27		*sū.* 10;18	*sū.* 7;12	13;40
sū. 8;6	*sū.* 9;24		*sū.* 10;15	*sū.* 7;15	13;35
sū. 8;9	*sū.* 9;21		*sū.* 10;12	*sū.* 7;18	13;30
sū. 8;12	*sū.* 9;18		*sū.* 10;9	*sū.* 7;21	13;25
sū. 8;15	*sū.* 9;15		*sū.* 10;6	*sū.* 7;20	13;20
			sū. 9;0	*sū.* 9;0	13;15 (?)

The maximum duration of the half-day recorded in these quadrants is 17;10 *ghaṭīs.* Accordingly the longest day at this latitude would be 34;20 *ghaṭīs* or 13;50 hours. The Indo-Persian astrolabes, in particular those by Ḍiyā' al-Dīn (e.g., Table A061-2), offer a more precise value of 13;43 hours for the latitude of 27°.

Use of the Yantrādhipati

For measuring the sun's altitude, one has to sight the sun through the alidade and read the degrees on the outermost scale where the alidade touches. For measuring time, one must first ascertain the solar longitude for the day of observation from an almanac and then choose the corresponding scale on the instrument. The place where the alidade touches the *ghaṭī* scale indicates the time elapsed since sunrise (*unnata-ghaṭīs*) if the observation is made in the forenoon, and the time remaining up to sunset if the

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[1644] I do not find the values of the maximum duration in my notes; I do not seem to have copied them when I examined the instrument. In the available photos, this part is blocked by the alidade.

observation is made in the afternoon. This, when subtracted from the duration of the sunlight hours on that day, yields the time elapsed since sunrise.

ALIDADES

On both sides, there are finely crafted alidades (length 337 mm) with sighting vanes (14 x 30 mm) in which there are two holes each.



Figure T001.4 – Inscription on the obverse (photo by S. R. Sarma)

INSCRIPTION

On the obverse side, in the empty space inside the last *ghaṭī* scale are engraved four Sanskrit verses in *Anuṣṭubh* metre, one in each quadrant, attributing the creation of this instrument to Madho Singh and concluding with the statement that with this instrument even a stupid person will know the time instantly:

śrīman-mādhavasiṃhasya paśyemāṃ yantranirmitiṃ |
paśyan prajñāti mūrkho ['']pi tatkālaṃ kālavid bhavet || [1]
jīyāc ciram ayaṃ yasya vāgvilāsaṃ pramādataḥ |
śrutvā mandaḥ kīdṛśo ['']pi sadyo ['']sau kṛtimān bhavet || [2]
yaḥ (yat?) kṛpākṣanimeṣeṇa durbhāgyo yasya lakṣitaḥ |

tatkṛpādṛṣṭikaṇikāṃ vāñchanti bhāgyaśālinaḥ ‖ [3]
sa jayaty asya kopāgnir yallavaḥ svavirodhinaṃ |
dṛptaṃ dahati saṃvṛddhasamudrajalam aurvavat ‖ [4]

‘Behold the creation (*nirmiti*) of this instrument of the glorious Mādhavasiṃha! Looking at this, even a fool will understand [time] and become at once a knower of time.

‘May he live long! After listening to the flourishes of his speech [even] by chance (*pramādataḥ,* lit. by mistake), one would become— howsoever dullard one might be— at once an accomplished person.

‘By the flutter of whose compassionate eyes, the misfortune of whosoever is seen [will be dispelled]; fortunate ones desire a fraction of his compassionate glance. (Difficult syntax; it probably means: a glance of his compassionate eye dispels the misfortune of anybody on whomsoever it falls; therefore fortunate people desire even a fraction of that glance to fall on themselves).

‘Victorious is that fire of his anger, a spark from which burns down his arrogant enemy, just as the marine fire burns down the abundant waters of the ocean.’

BIBLIOGRAPHY

Sarma 2010, s.v. Mādhava Siṃha

T002 ⊙ GHOṬĀ-YANTRA BY SAWAI MADHO SINGH

18th century, second half

Central column 206 x 39 mm; flaps 206 x 39 x 11 mm

Jaipur, Jai Singh's Observatory

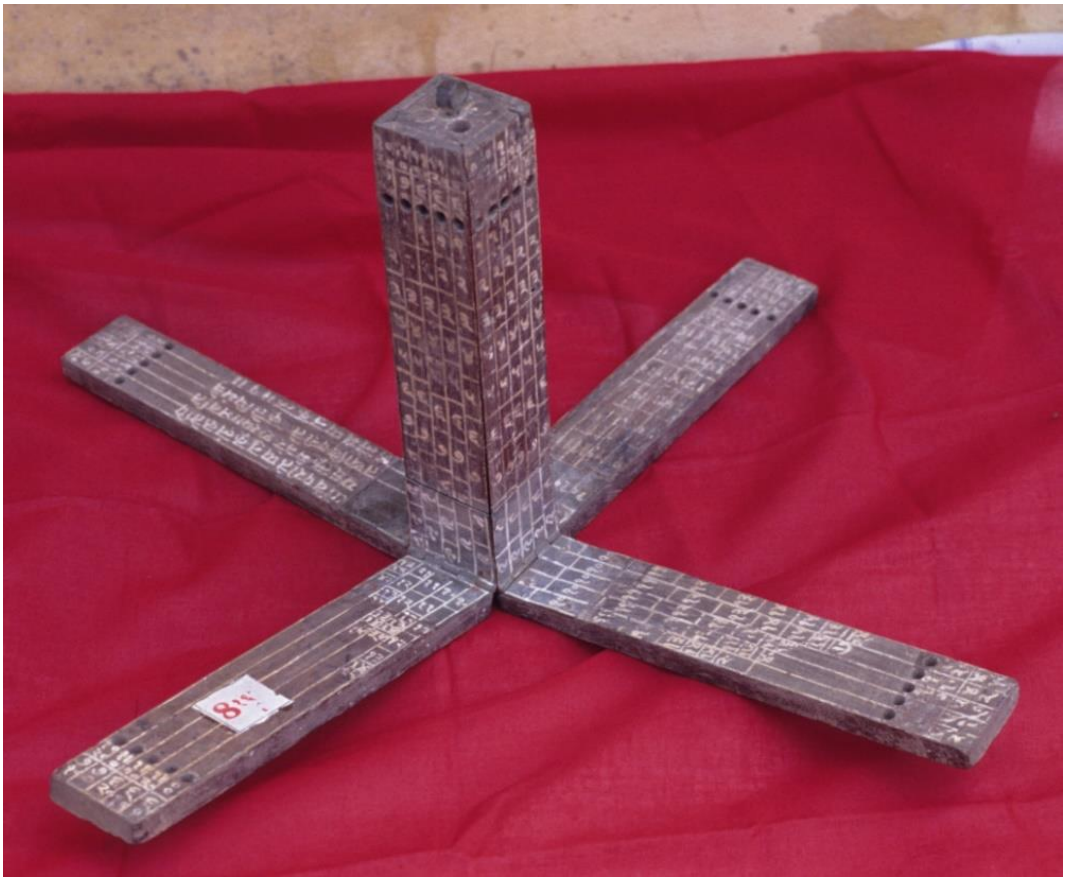


Figure T002.1 – Ghoṭā-yantra (photo by S. R. Sarma)

This device is made of wood on which the lines, numbers and inscriptions are painted in white. It is essentially a column dial with four sides of equal width. The upper half is a solid square pillar. On all the four sides at its bottom are hinged four flaps of the same length and width on which the scales continue. At the top and bottom of the four sides, there are holes, five on each side, into which the gnomon is inserted according to the season. When not in use, the gnomon can be deposited in the hollow space at the top of the solid pillar and the flaps folded back flush with its sides. For this purpose, each flap is endowed with a pin at the top and at the top of the central pillar there are flat metal hooks at each side which can be rotated. When the flaps are folded back, these hooks are moved to lock the pins at the ends of the flaps and thus securing them.

There is a cloth label with the name *Ghoṭā-yantra* written on it. In Hindi and presumably in Rajasthani, *ghoṭā* denotes the ankle. This name was chosen for this instrument apparently because the central sold pillar and the flaps at right angles to it resemble together the ankle and the foot in human anatomy.

At the top of the central vertical pillar, there are five holes on each side, below which that there *ghaṭī* scales which continue on the flaps below. These scales represent the half-duration of daylight in *ghaṭīs* in different periods of the year. On the four sides, there are altogether 20 scales, one for every 10° of solar longitude. A pair of solar longitudes in signs and degrees are written above the holes in the central vertical pillar; the holes and the pairs of solar longitudes also repeated at the end of the flaps.

Table T002-1 Pairs of solar longitudes on the four sides

Side 1		Side 2		Side 3		Side 4	
9;00	9;00	10;20	7;10	0;10	5;20	2;00	4;00
9;10	8;20	11;00	7;00	0;20	5;10	2;10	3;20
9;20	8;10	11;10	6;20	1;00	5;00	2;20	3;10
10;0	8;00	10;00	8;00	1;10	4;20	3;00	3;00
10;10	7;20	10;10	7;20	1;20	4;10	3;10	2;20

As in the *Yantrādhipati* (T001), here also the sum of the two values of the solar longitudes is 6 signs or 18 signs; the latter is, in effect, also equal to 6 signs. Since the *Yantrādhipati* is suspended freely, it does not require a compass. But for the present instrument, a compass is needed to see that the side of the central pillar and the flap which are in use are on the north-south line.

However, since the scales run from the top of the central pillar down to the flaps and not the other way, there is no need of the holes on the flaps, because the gnomon cannot be inserted in these holes.



Figure T002.2 – Inscription on the flap (photo by S. R. Sarma)

Inscription

On one of the flaps is a stanza which declares that the instrument will give the correct reading even when held upside down:

yad [v]iparīte [’]py anukūlaṃ kṛte [’]pi
yadvat karma nareśasya | bhavati
tathā viparīte kṛte [’]pi yantre
phalam apy anukūlam || [metre irregular]

‘Just as the king’s action, though adverse, turns out to be favourable, even so, when this
instrument is held upside down (*viparīte kṛte ’pi*), the result will be correct.’

The implication of the first half is that whatever the king does is for the good of the people, even if a particular act appears to be adverse. The import of the parallel is not so clear. The instrument is designed to be set upon the ground in the way shown in Figure T002.1, and the gnomon inserted in the appropriate hole at the top of the vertical column. Only then time can be measured. The gnomon cannot be inserted in the holes at the end of the flaps. Nor can the instrument be held upside down, by arranging a flap in the vertical position and the central column in a horizontal position after folding back the other three flaps. Therefore, the Sanskrit statement cannot be taken literally; probably it has to be understood in the manner as translated by Garrett & Guleri:

‘If the Maharaja does anything contrary to the wishes of the people, the result is always good; so, when the shadow moves in a contrary direction on the dial, the result is also good.’

Bibliography

Garrett & Guleri 1902, p. 62.
Sarma 2010, s.v. Mādhava Siṃha

T003 ⦿ ŚOṬĀ-YANTRA (1) BY SAWAI MADHO SINGH

18th century, second half

428 x 43 x 43 mm

Jaipur, Jai Singh's Observatory



Figure T003.1 – Three Śoṭā-yantras (photo by S. R. Sarma)

This is a set of three square column dials made of burnished brass, with lines and legends enamelled in black. Like the previous specimen (T002), these also have four sides of equal width, but are hollow inside. The small copper plaques attached to them inform that these are *śoṭā-yantras* (*śoṭā* in Rajasthani meaning 'staff'), the first two for measuring time in the day (*śoṭāyaṃtra 1 dinajñāna ko*; *śoṭāyaṃtra 2 dinajñāna ko*) and the third for measuring time at night (*śoṭāyaṃtra rātrijñāna ko*). On the first two is engraved an identical stanza proclaiming the authorship of Madho Singh.

These instruments are to be suspended sometimes vertically from either end and some other times horizontally from the middle. For this purpose, at both ends and also at the middle part, there are small knobs with holes in them.

Here will be described the first two specimens meant for use in the daytime. There are series of holes at the top and bottom of all the four sides of these instruments; below these holes can be seen the scales of *ghaṭīs.* As in T002, here also above each hole are mentioned two solar longitudes to which the hole and the scale that follows belong. The following table shows the pairs of solar longitudes in signs and degrees and the related maximum half-durations of daylight in *ghaṭīs.*

Table T003-1 *Ghaṭī* scales on the four sides

Column sides	scale no.	solar longitude 1	solar longitude 2	maximum half-duration
Side 1 top	1. scale	9;00	9;00	12;52
	2. scale	9.10	8;20	12;54
	3. scale	9;20	8;10	13
	4. scale	10;0	8;0	13
	5. scale	10;10	7;20	13;28
Side 1 bottom	6. scale	2;20	3;10	17;5
	7. scale	3;0	3;0	17;8
Side 2 top	8. scale	10;20	7;10	13;42
	9. scale	11;0	7;0	13;14
Side 2 bottom	10. scale	0;20	5;10	15

Column sides	scale no.	solar longitude 1	solar longitude 2	maximum half-duration
	11. scale	1;0	5;0	16
Side 3 top	12. scale	11;10	6;20	14;19
	13. scale	11;20	6;10	14;38
Side 3 bottom	14. scale	1;10	4;20	16;30
	15. scale	1;20	4;10	16;45
Side 4 top	16. scale	0;0	6;0	14;45
	17. scale	0;10	5;20	15;35
Side 4 bottom	18. scale	2;0	4;0	16;48
	19. scale	2;10	3;20	16;17

It can be seen that there are separate scales for every 10° of solar longitude as in T002. In the preceding two instruments (T001 and T002), the two solar longitudes for each scale are so chosen that their sum is equal to 6 signs; the same is the case here in T003 and T004.

For measuring time, one must first find out the solar longitude for the day of observation from an almanac, choose the appropriate scale on the instrument and insert the gnomon into the hole just above that scale.[1645] The top of the gnomon is so fashioned that it can be screwed into the hole. When not in use, the gnomon can be stored in the recess in the hollow of the instrument.

Then the instrument has to be suspended vertically from either end or horizontally from the middle part so that the shadow of the gnomon falls on the chosen scale; where the extremity of the shadow lies, is the measure of time in *ghaṭīs*. If the observation is made before noon, it is the time elapsed since sunrise; if the observation is made after noon, it is the time remaining up to sunset.

[1645] The gnomon is now missing in the present specimen. The one in the next specimen is extant (Figure T003.1).

However, the requirement that sometimes the instrument has to be suspended vertically from either end and sometimes suspended horizontally from the middle part, makes observation with this device extremely complicated. Thus this instrument does not offer any advantage over a simple column dial, or even over the modified column dial named *Ghoṭā-yantra* (T002).

Inscription

In the middle part of the column is engraved the following stanza in *Anuṣṭubh* meter, the engraving extending on all four sides.

prakāśaṃ mādhavavyāghra-
buddher niṣpakṣapātataḥ |
paśyānāyāsataḥ sūkṣmaṃ
svaprakāśaḥ prakāśitaḥ ||

‘Behold minutely, without bias, the light of the intellect of Mādhava, the tiger; it reveals its own brilliance without any effort.’

Bibliography

Garrett & Guleri 1902, pp. 61-62.
Sarma 2010, s. v. Mādhava Siṃha

T004 ⦿ ŚOṬĀ-YANTRA (2) BY SAWAI MADHO SINGH

18th century, second half

430 x 43 x 43 mm, gnomon 167 mm

Jaipur, Jai Singh's Observatory

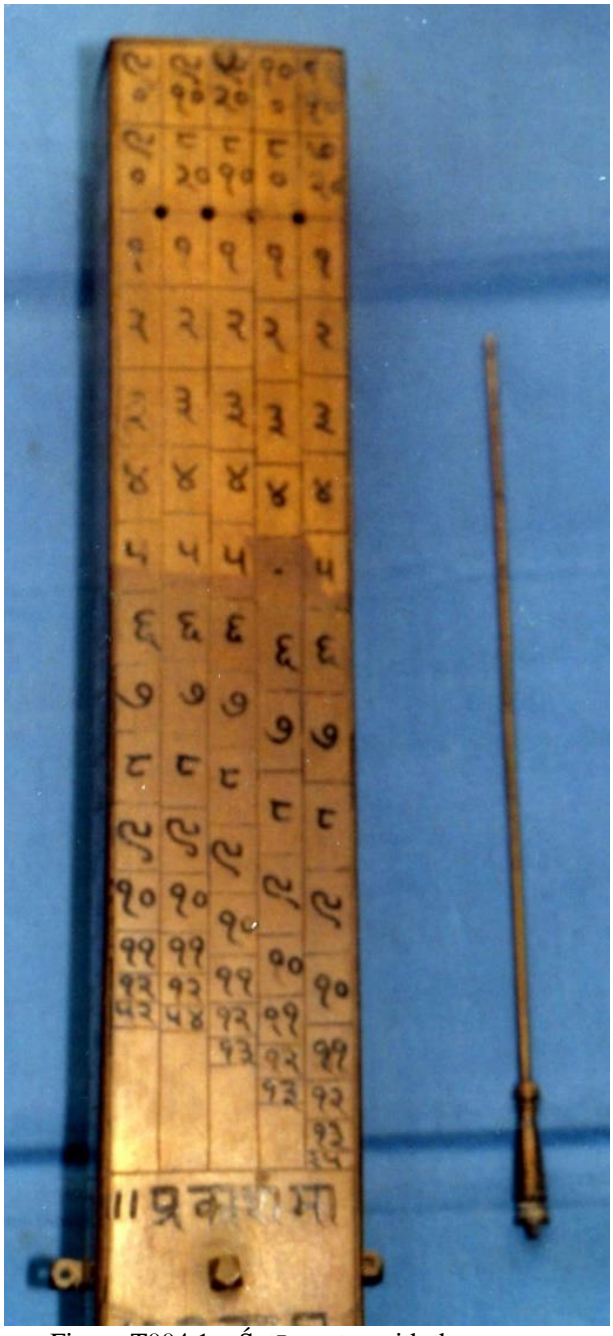


Figure T004.1 – Śoṭā-yantra with the gnomon
(photo by S. R. Sarma)

This specimen is exactly the same as the preceding one (T003), except that its gnomon is extant. Its full image can be seen in Figure T003.1; here it is shown with the gnomon.

T005 ⊙ ŚOṬĀ-YANTRA FOR THE NIGHT BY SAWAI MADHO SINGH

18th century, second half

426 x 41 x 41 mm;

Jaipur, Jai Singh's Observatory



Figure T005.1 – Śoṭā-yantra for the night;
below is the hollow column with four sides and above it
are the two bars with their sides 2 and 3 (photo by S. R. Sarma)

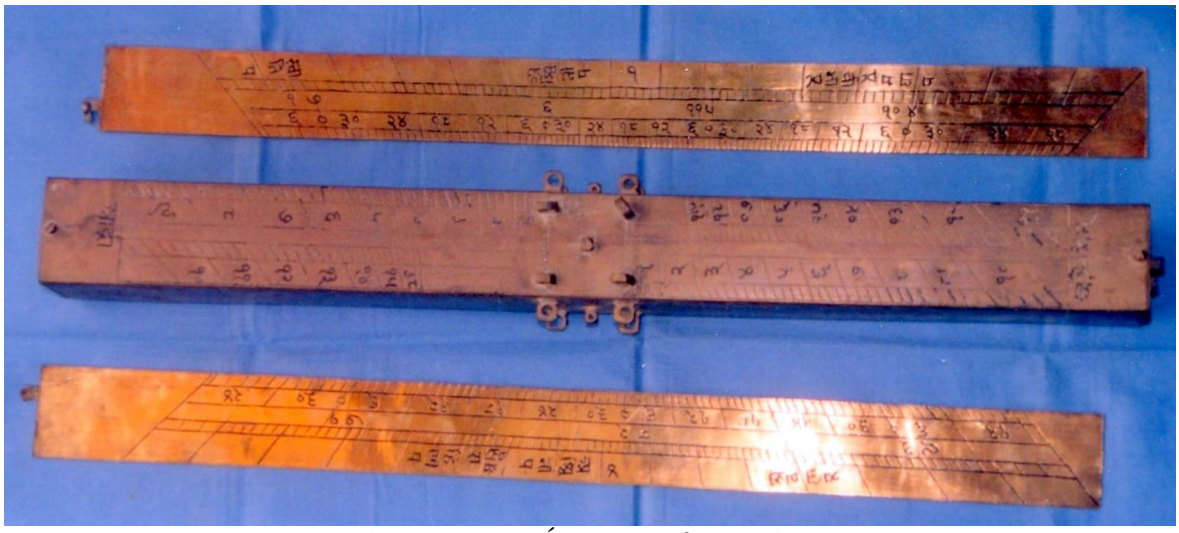


Figure T005.2 – Śoṭā-yantra for the night;
the hollow column is in the middle and the two bars
with their sides 1 and 4 are above and below (photo by S. R. Sarma)

The third *Śoṭā-yantra,* which is meant for the night, is slightly smaller with a length of 426 mm and width and thickness of 41 mm. A small copper plaque attached to it carries the label *śoṭāyaṃtra rātri jñāna ko* (*śoṭā-yantra* for the knowledge at night, i.e., for measuring time at night). With this device time is measured by observing any one of the eight junction stars of the lunar mansions: *Aśvinī* (β Arietis, lunar mansion 1),

Rohiṇī (α Tauri, lunar mansion 4), *Ārdrā* (α Orionis, 6), *Maghā* (α Leonis, 10), *Svāti* (α Bootis, 15), *Abhijit* (α Lyrae, 22), *Śravaṇa* (α Aquilae, 23) and *Pūrvā Bhādrapadā* (β Pegasi, 26). These eight stars cover the entire lunar orbit.

At the top and bottom of each side of this instrument are engraved one of the names of the above-mentioned stars, below which are added the related scales of *ghaṭīs*. The names of the stars and the maximum half-durations of the night in the related *ghaṭī* scales are shown in the table below.

Table T005-1 Stars on the column and the maximum half-durations

Side 1 top	*Svāti* (α Bootis)	17 *ghaṭīs*
Side 1 bottom	*Maghā* (α Leonis)	15;38 *ghaṭīs*
Side 2 top	*Pū*[*rvā*] *Bhā*[*drapadā*] (β Pegasi)	17;29 *ghaṭīs*
Side 2 bottom	*Aśvinī* (β Arietis)	16;44 *ghaṭīs*
Side 3 top	*Śravaṇa* (α Aquilae)	15;45 *ghaṭīs*
Side 3 bottom	*Rohiṇī* (α Tauri)	16;24 *ghaṭīs*
Side 4 top	*Abhijit* (α Lyrae)	19 *ghaṭīs*
Side 4 bottom	*Ārdrā* (α Orionis)	15;38 *ghaṭīs*

At the top of the instrument is a slit in which are stored two flat rectangular bars, each measuring 420 x 35 mm. These are engraved on both sides with scales and the names of the same eight stars which are engraved on the four sides of the main column. The two sides of the first bar are numbered 1 and 2 and the two sides of the second bar 3 and 4. On each side, there are the names of four stars, either with the suffix *pū[rva]* (east) or with the suffix *pa[ścima]* (west), indicating the eastern or the western hemisphere where the star is seen.[1646] The details of the stars are shown in the following table.

[1646] One would expect that each star is mentioned once in the east and once in the west, but that is not the case here: *Abhijit* is mentioned three times, always in the west; *Aśvinī* both times in the west; *Ārdrā* only in the east, and so on.

Table T005-2 Stars marked on the four sides of the bars

Side 1	*Pūrvā Bhā*[*drapadā*] *pū*[*rva*]	β Pegasi east
	Aśvinī pa[*ścima*]	β Arietis west
	Svāti pa[*ścima*]	α Bootis west
	Maghā pa[*ścima*]	α Leonis west
Side 2	*Rohiṇī pū*[*rva*]	α Tauri east
	Ārdrā pū[*rva*]	α Orionis east
	Śravaṇa pa[*ścima*]	α Aquilae west
	Abhi[*jit*] *pa*[*ścima*]	α Lyrae west
Side 3	*Maghā pū*[*rva*]	α Leonis east
	Svāti pū[*rva*]	α Bootis east
	Pūrvā Bhā[*drapadā*] *pa*[*ścima*]	β Pegasi west
	Abhiji[*t*] *pa*[*ścima*]	α Lyrae west
Side 4	*Śravaṇa pū*[*rva*]	α Aquilae east
	Aśvinī pa[*ścima*]	β Arietis west
	Rohiṇī pa[*ścima*]	α Tauri west
	Abhi[*jit*] *pa*[*ścima*]	α Lyrae west

This instrument is employed at night apparently in the following manner. Suppose one wishes to measure the time when the star *Svāti* is in the eastern hemisphere. Then one takes the second bar with the side numbered 3 on which is engraved *Svāti pū*[*rva*] and affixes its tip to that side of the hollow column on which the *ghaṭī* scale for *Svāti* is engraved. This should be done in such a manner that the column and the bar are at right angles. Suspending the hollow column in a vertical position, one sights the star along the point where *Svāti pū*[*rva*] is marked on the bar. Where the imaginary line joining the star and the mark on the bar touches the *ghaṭī* scale on the column indicates the time

in *ghaṭīs*. This is no doubt a novel design, but sighting a star with this ensemble would be far more difficult than with the alidade of an astrolabe.

T006 ⊙ STAR CHART BY SAWAI MADHO SINGH

18th century, second half

765 x 735 mm

Jaipur, City Palace, Maharaja Sawai Man Singh II Museum (# Khasmohor 1257)

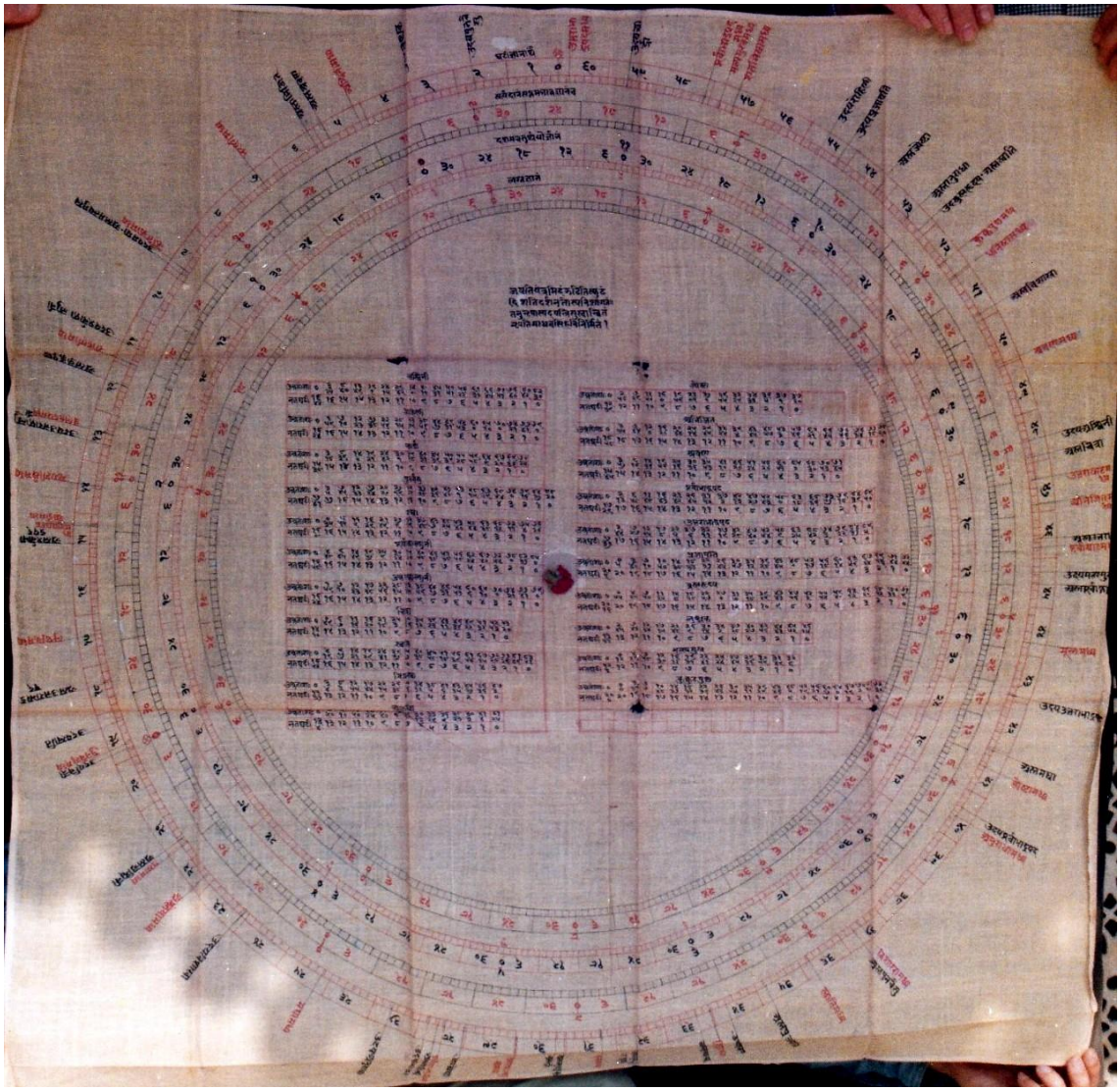


Figure T006.1 – Star Chart (photo by S. R. Sarma)

This star chart is copied on a large starched cloth. At the centre is a red silk thread with a red-and-blue pommel, which can be rotated along the circular scales like an index; (it cannot be seen in Figure T001.1, as it was pulled to the back during the photography). There are four concentric circular scales. The outermost one is labelled *ghaṭī-jñānārthaṃ* (for the knowledge of *ghaṭīs,* i.e., for measuring time in *ghaṭīs*). It is divided in 60 *ghaṭīs* and numbered anti-clockwise from 1 to 60, starting at the topmost point. In the inner band, each *ghaṭī* is subdivided into 6 units of 10 *palas* or 4 minutes each.

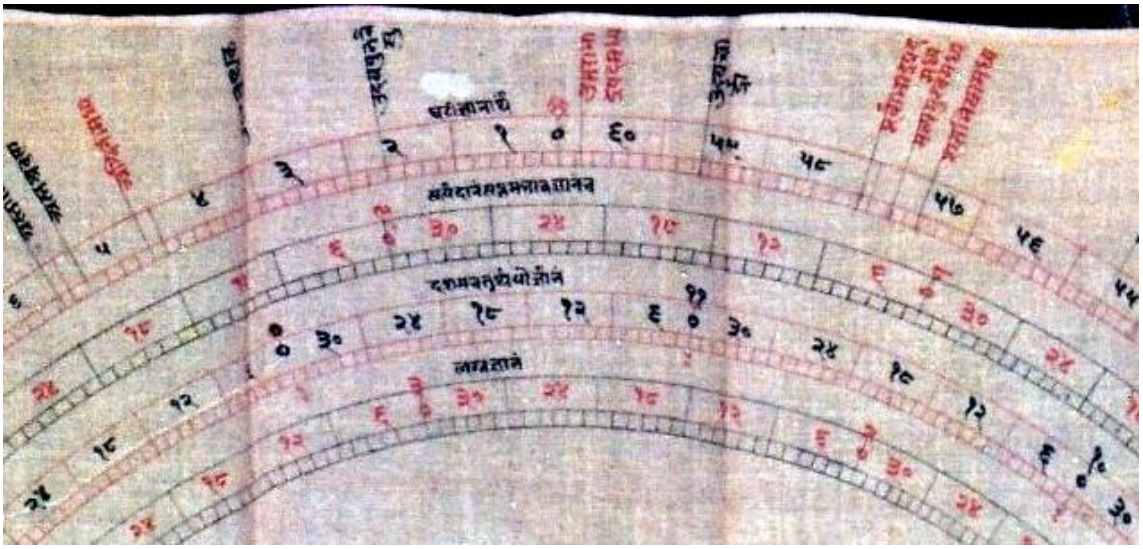


Figure T006.2 – Circular scales (photo by S. R. Sarma)

The second circle, labelled *sūryādīnāṃ saptamabhāvajñānārthaṃ* (for the knowledge of the descendant, i.e., for measuring the descendant), is divided in 12 zodiac signs, and numbered also anti-clockwise from zero to 11, with zero at 18;50 *ghaṭīs* (= 113 time-degrees). Each sign is divided in 6° and 1°; groups of 6° are numbered anti-clockwise 6, 12, 18, 24, 30, separately for each sign.

The third circle, labelled *daśama-caturthayor-jñānaṃ* (knowledge of the cusps of the tenth and fourth places, i.e., for measuring the cusps of the tenth and fourth places), is divided in signs, 6° and 1° and numbered as in the above circle. Here zero is at 3;10 *ghaṭīs* (= 19 time-degrees).

The innermost circle is labelled *lagna-jñānārthaṃ* (for knowing, i.e., measuring the ascendant). Here also the signs, 6° and 1° are marked and numbered as in the above circles, but the zero is at 47;30 *ghaṭīs* (= 285 time-degrees) and coincides with the label *Udaya-Aśvinī* (the rising of *Aśvinī*) written outside the circles.

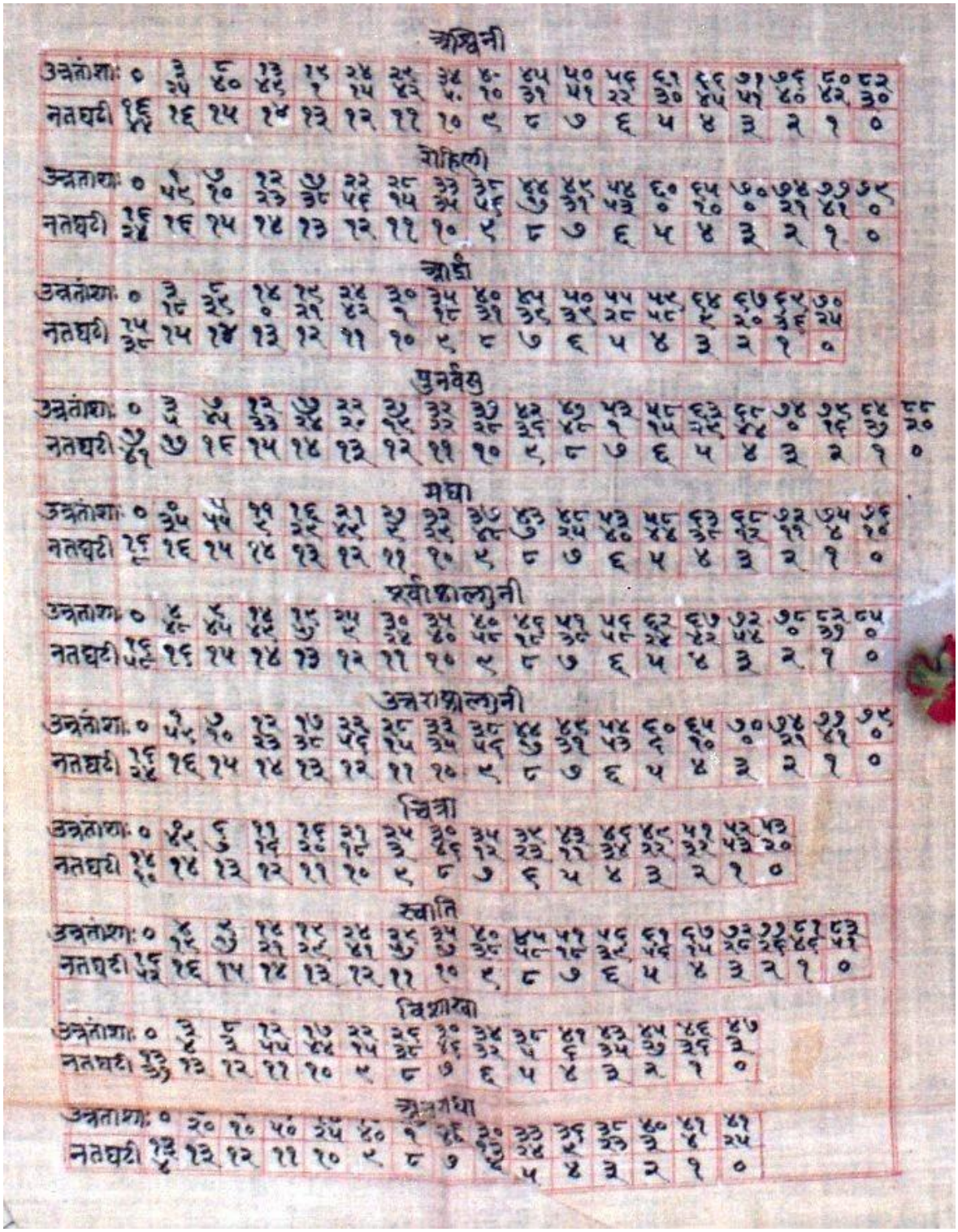


Figure T006.3 – Altitudes and Meridian Distances (photo by S. R. Sarma)

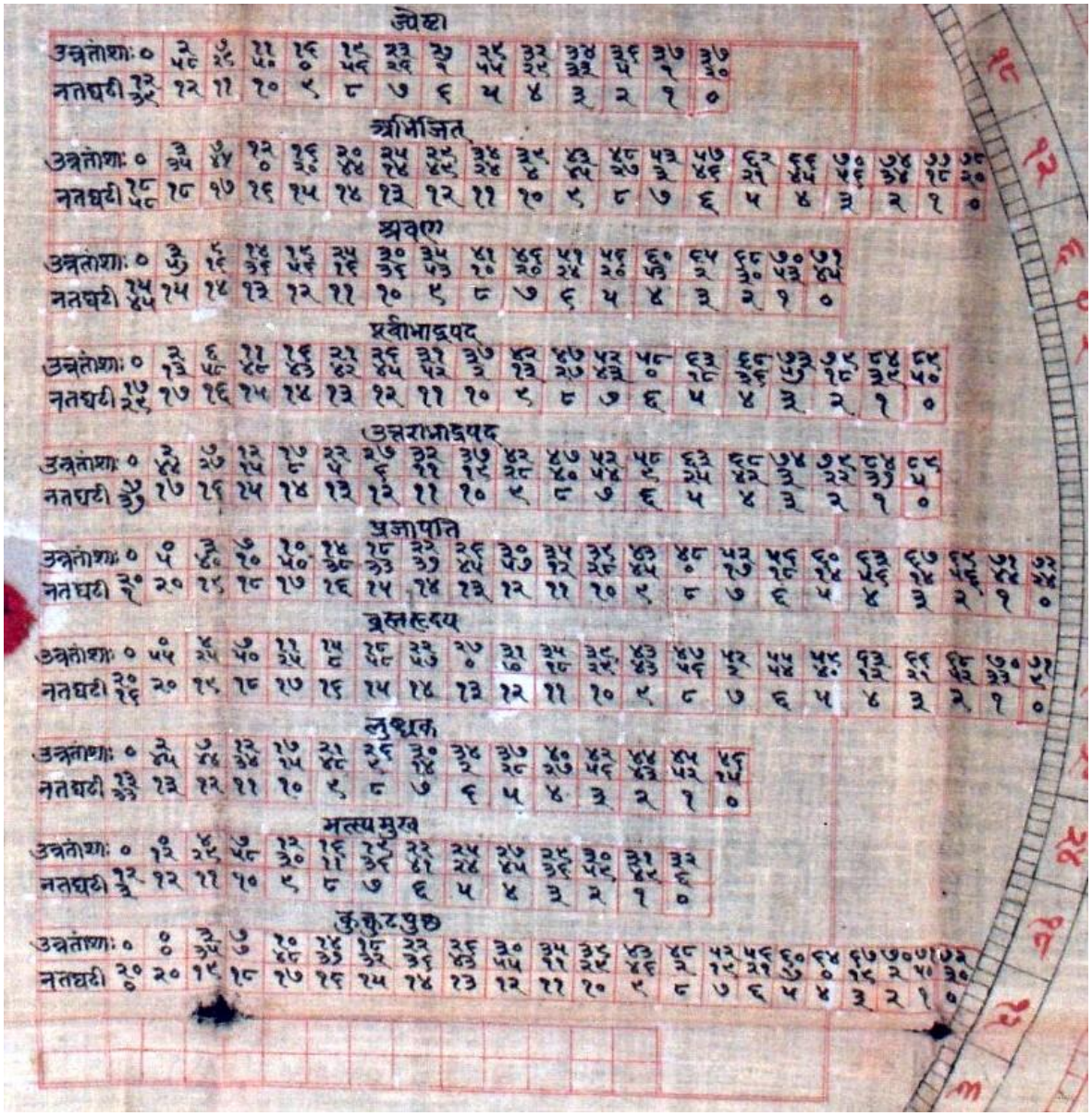


Figure T006.4 – Altitudes and Meridian Distances (photo by S. R. Sarma)

Inside these circular scales are two columns containing the meridian distances in *ghaṭīs* (*nata-ghaṭī*) of 21 stars, and their altitudes in degrees (*unnatāṃśa*) listed for each integer number of *ghaṭīs* of the meridian distance. For example, in the case of *Aśvinī,* the star is on the meridian when the meridian distance is 0; then its meridian altitude is 82;30°. On the other hand, when the star is on the horizon, its maximum meridian distance is 16;44 *ghaṭīs.* Of the 21 stars mentioned here, the first 16 are junction stars of the lunar mansions (*nakṣatra*) and the last 5 are derived from Islamic astrolabes.

Table T006-1 Meridian Altitudes and Meridian Distances

	Star Name in Sanskrit	Star Name modern	Meridian altitude in degrees	Max. Meridian distance in *ghaṭīs*
1	*Aśvinī*	β Arietis	82;30	16;44
2	*Rohiṇī*	α Tauri	79;0	16;24
3	*Ārdrā*	α Orionis	70;25	15;38
4	*Punarvasu*	β Geminorum	88;20	17;41
5	*Maghā*	α Leonis	76;10	16;8
6	*Pūrvā Phālgunī*	δ Leonis	85;0	16;58
7	*Uttarā Phālgunī*	β Leonis	79;0	16;24
8	*Citrā*	α Virginis	53;20	14;10
9	*Svāti*	α Bootis	83;41	18;52
10	*Viśākhā*	α Librae	47;3	13;37
11	*Anurādhā*	δ Scorpii	41;25	13;4
12	*Jyeṣṭhā*	α Scorpii	37;20	12;39
13	*Abhijit*	α Lyrae	78;20	18;58
14	*Śravaṇa*	α Aquilae	71;45	15;45
15	*Pūrvā Bhādrapadā*	β Pegasi	89;50	17;29
16	*Uttarā Bhādrapadā*	γ Pegasi	89;5	17;37
17	*Prajāpati*	δ Aurigae	72;24	20;1
18	*Brahmahṛdaya*	α Aurigae	71;9	20;16
19	*Lubdhaka*	α Ursae Majoris	46;15	13;33
20	*Matsyamukha*	α Piscium Austrini	32;6	12;3

	Star Name in Sanskrit	Star Name modern	Meridian altitude in degrees	Max. Meridian distance in *ghaṭīs*
21	*Kukkuṭapu[c]cha*	α Cygni	72;30	20;0

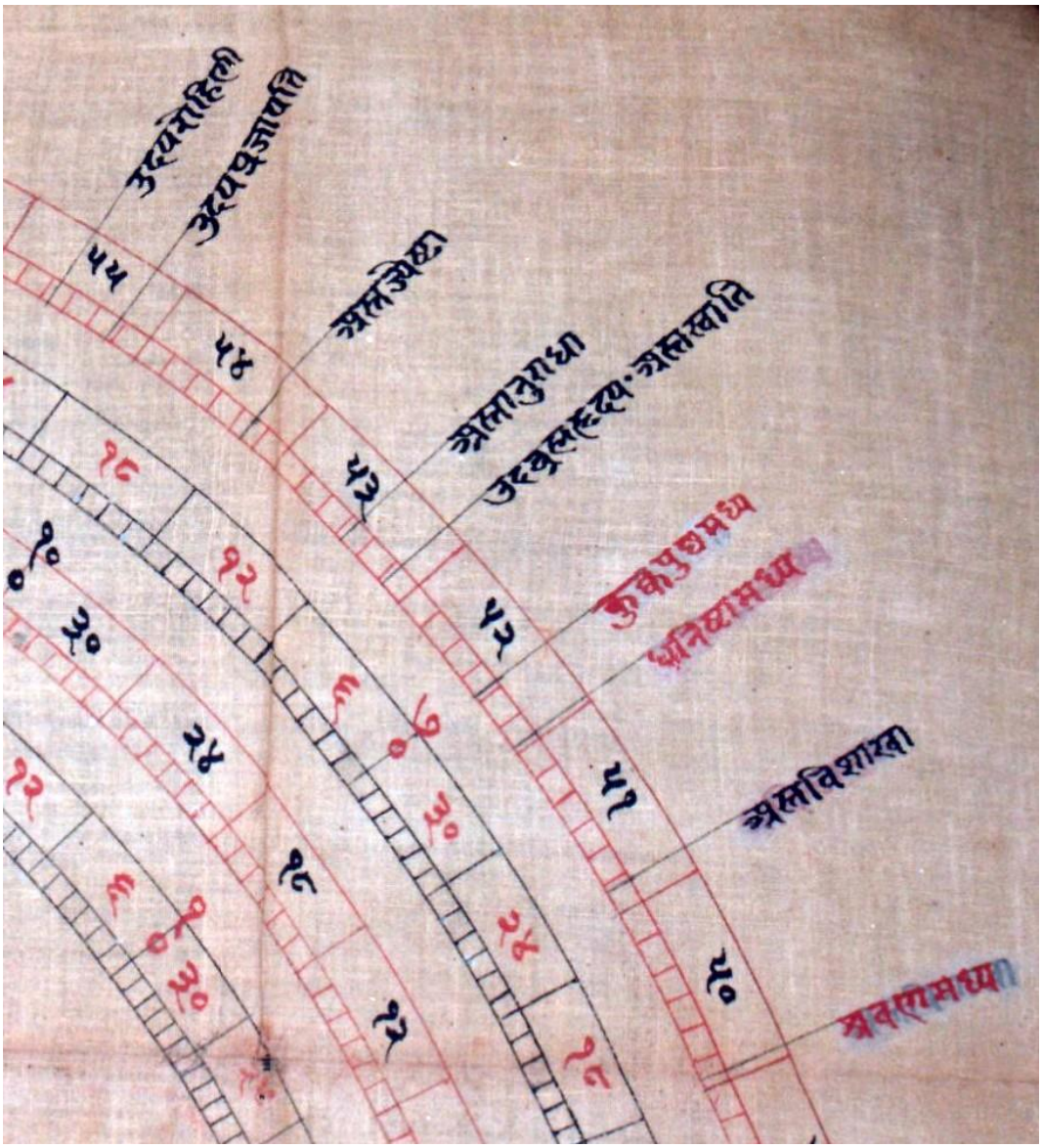


Figure T006.5 – Rising, culmination and setting of stars (detail of Figure T006.1)

Around the outer periphery of the outermost circle are marked the lines of the rising (*udaya*), culmination (*madhya*) and setting (*asta*) of 32 stars. *Udaya* and *asta* are written in black, *madhya* in red. Their respective times are indicated by straight lines that reach up to the scale of *palas.* These times are valid, presumably at the equinoxes. Read anti-clockwise, the times are as follows:

Table T006-2 Rising, Culmination and Setting around the clock

1;40	*udaya Punarvasu*	β Geminorum rising
2;52	*udaya Lubdhaka*	α Ursae Majoris rising
4;10	*Aśvinī Madhya*	β Arietis culmination
4;50	*asta Śravaṇa*	α Aquilae setting
5;08	*astābhijit*	α Lyrae setting
6;25	*Bharaṇī madhya*	41 Arietis culmination
8;46	*Kṛttikā madhya*	η Tauri culmination
8;52	*udaya Maghā* [and] *asta Matsyamukha*	α Leonis rising [and] α Piscium Austrini setting
10;34	*udaya Pūrvā phālgunī*	δ Leonis rising
10;55	*Rohiṇī madhyā*	α Tauri culmination
11;22	*asta Kukkuṭapuccha*	α Cygni setting
12;24	*Brahmahṛdaya madhya*	α Aurigae culmination
12;38	*udaya Uttarā Phālgunī*	β Leonis rising
13;24	*Mṛgaśīrṣa madhya*	γ Orionis culmination
14;11	*Ārdrā madhya*	α Orionis culmination
14;12	*Prajāpati madhya*	δ Aurigae culmination
14;36	*asta Pūrvā Bhādrapadā*	β Pegasi setting
16;24	*Lubdhaka madhya*	α Ursae Majoris culmination
17;22	*asta Uttarā Bhādrapadā*	γ Pegasi setting
18;14	*udaya Svāti*	α Bootis rising
18;42	*Punarvasu madhya*	α Geminorum culmination
18;48	*udaya Citrā*	α Virginis rising
21;52	*asta Aśvinī*	β Arietis setting
22;02	*Puṣya madhya*	δ Cancri culmination

22;48	*Aśleṣā madhya*	ζ Cancri culmination
23;52	*udaya Viśākhā*	α Librae rising
24;49	*Maghā madhya*	α Leonis culmination
26;24	*udaya Anurādhā*	δ Scorpii rising
27;12	*udaya Abhijit*	α Lyrae rising
27;24	*asta Rohiṇī*	α Tauri setting
27;32	*Pūrvā Phālgunī madhya*	δ Leonis culmination
27;58	*udaya Jyeṣṭhā*	α Scorpii rising
29;00	*Uttarā Phālgunī madhya*	β Leonis culmination
29;48	*astārdrā*	α Orionis setting
29;58	*asta Lubdhaka*	α Ursae Majoris setting
30;42	*Hasta madhya*	δ Corvi culmination
31;22	*udaya Kukkuṭapuccha*	α Cygni rising
32;40	*asta Brahmahṛdaya*	α Aurigae setting
32;58	*Citrā madhya*	α Virginis culmination
33;20	*udaya Śravaṇa*	α Aquilae rising
34;10	*asta Prajāpati*	δ Aurigae setting
35;12	*Svāti madhya*	α Bootis culmination
36;20	*asta Punarvasu*	β Geminorum setting
36;32	*Viśākhā madhya*	α Librae culmination
39;24	*Anurādhā madhya*	δ Scorpii culmination
39;38	*udaya Pūrvā Bhādrapadā*	β Pegasi rising
40;34	*Jyeṣṭhā madhya*	α Scorpii culmination
40;58	*asta Maghā*	α Leonis setting
42;08	*udaya Uttarā Bhādrapadā*	γ Pegasi rising
43;18	*Mūla madhya*	λ Scorpii culmination

44;28	*asta Pūrvā Phālgunī*	δ Leonis setting
44;42	*udaya Matsyamukha*	α Piscium Austrini rising
45;12	*Pūrvāṣāḍhā madhya*	δ Sagittarii culmination
45;22	*asta Uttarā Phālgunī*	β Leonis setting
46;10	*Abhijit madhya*	α Lyrae culmination
46;40	*Uttarāṣāḍhā madhya*	σ Sagittarii culmination
47;08	*asta Citrā*	α Virginis setting
47;28	*udaya Aśvinī*	β Arietis rising
49;04	*Śravaṇa madhya*	α Aquilae culmination
50;08	*asta Viśākhā*	α Librae setting
51;02	*Dhaniṣṭhā madhya*	β Delphini culmination
51;22	*Kukkuṭapuccha madhya*	α Cygni culmination
52;08	*udaya Brahmahṛdaya* [and] *asta Svāti*	α Aurigae rising [and] α Bootis setting
52;28	*astānurādhā*	δ Scorpii setting
53;14	*asta Jyeṣṭhā*	α Scorpii setting
54;12	*udaya Prajāpati*	δ Aurigae rising
54;38	*udaya Rohiṇī*	α Tauri setting
56;32	*Śatabhiṣā madhya*	λ Aquarii culmination
56;48	*Matsyamukha madhya*	α Piscium Austrini culmination
57;06	*Pūrvā Bhādrapadā madhya*	β Pegasi culmination
58;36	*udaya Ārdrā*	α Orionis rising
59;48	*Uttarā Bhādrapadā madhya*	γ Pegasi culmination

This data is rearranged star-wise in the following table.

Table T006-3 Culmination and Setting arranged star-wise

	Star Name	Identification	Rising	Culmination	Setting
1	*Aśvinī*	β Arietis	47;28	4;10	21;52
2	*Bharaṇī*	41 Arietis	---	6;25	---
3	*Kṛttikā*	η Tauri	---	8;46	---
4	*Rohiṇī*	α Tauri	54;38	10;55	27;24
5	*Mṛgaśīrṣa*	γ Orionis	---	13;24	---
6	*Ārdrā*	α Orionis	58;36	14:11	29;48
7	*Punarvasu*	β Geminorum	1:40	18;42	36;20
8	*Puṣya*	δ Cancri	---	22;02	---
9	*Aśleṣā*	ζ Cancri	---	22;48	---
10	*Maghā*	α Leonis	8;24	24;49	40;58
11	*Pūrvā Phālgunī*	δ Leonis	10;34	27;37	44;28
12	*Uttarā Phālgunī*	β Leonis	12;38	29;00	45;22
13	*Hasta*	δ Corvi	---	30;42	---
14	*Citrā*	α Virginis	18;48	32;58	47;08
15	*Svāti*	α Bootis	18;14	35;12	52;08
16	*Viśākhā*	α Librae	23;52	36;32	50;08
17	*Anurādhā*	δ Scorpii	26;24	39;24	52;28
18	*Jyeṣṭhā*	α Scorpii	27;58	40;34	53;14
19	*Mūla*	λ Scorpii	---	43;18	---
20	*Pūrvāṣāḍhā*	δ Sagittarii	---	45;12	---
21	*Uttarāṣāḍhā*	σ Sagittarii	---	46;40	---
22	*Abhijit*	α Lyrae	27;12	46;10	5;08
23	*Śravaṇa*	α Aquilae	33;20	49;04	4;50

	Star Name	Identification	Rising	Culmination	Setting
24	*Dhaniṣṭhā*	β Delphini	---	51;02	---
25	*Śatabhiśā*	λ Aquarii	---	56;32	---
26	*Pūrvā Bhādrapadā*	β Pegasi	39;38	57;04	14;36
27	*Uttarā Bhādrapadā*	γ Pegasi	42;08	59;48	17;22
28	*Prajāpati*	δ Aurigae	53;12	14;12	34;10
29	*Brahmahṛdaya*	α Aurigae	52;08	12;24	32;40
30	*Lubdhaka*	α Ursae Majoris	2;52	16;24	29;58
31	*Matsyamukha*	α Piscium Austrini	44;42	56;48	8;52
32	*Kukkuṭapuccha*	α Cygni	31;22	51;22	11;22

Rising, culmination and setting are given for those 21 stars for which the altitudes and meridian-distances are listed in the table in the middle of the circular scales. For the remaining 11 stars, only the culminations are given.

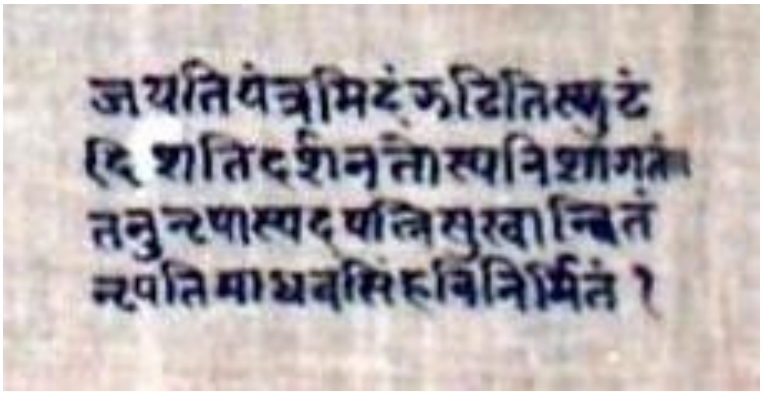


Figure T006.6 – Inscription (detail of Figure T006.1)

INSCRIPTION

Inside the circular scales is the following verse declaring that this star chart was created by Madho Singh:

jayati yaṃtram idam jhaṭiti sphuṭaṃ
diśati darśanato [’]sya niśāgataṃ |

tanunṛpāspadapatnisukhānvitaṃ
*nṛpati-mādhavasiṃha-vinirmitaṃ 1‖ [*metre*: Drutavilambita]*
'May this chart (*yantra*) designed by King Mādhavasiṃha be victorious. Just by looking at it, it shows instantly and clearly the nocturnal … (?).'

The third line scans alright but makes absolutely no sense in this context; it literally means 'endowed with the happiness of the wife, the abode of the slender king'!

BIBLIOGRAPHY

Pingree 2003, no. 221, pp.107-109
Sarma 2010

U. INSTRUMENTS DESIGNED BY BUHLOMAL AND HIS ASSOCIATES AT LAHORE

INTRODUCTION

LĀLAH BULHOMAL LĀHORĪ (*FL.* 1839-1851)

The various astrolabes, celestial globes, *Dhruvabhrama-yantras,* sine quadrants and horary quadrants made by the versatile instrument maker Bulhomal, with legends in Persian, or Sanskrit, or English, have been described in earlier sections. [1647] Bulhomal was indeed the true and the last representative of both the traditions of Indo-Persian and Sanskrit astronomical instrumentation. Besides producing some 24 well-crafted specimens of the above-mentioned traditional Islamic and Sanskrit instruments, he also tried his hand at designing some new ones. Most prominent of these is the *Jyotiḥsattā* of which three specimens are extant (U001, U002, U003).

Jyotiḥsattā

This new device was intended to measure the local time, the ascendant and the culmination in the daytime in the same manner as Padmanābha's *Dhruvabhrama-yantra* allows simultaneous measurement of these elements at night. These can, of course, be determined more easily both at night and in the daytime with the astrolabe, but it appears Bulhomal was interested in creating an alternative device.

The *Jotiḥsattā* is shaped like an astrolabe with a suspension bracket at the top. It carries on one side (let us call this the obverse side), a set of four horary quadrants together with an alidade as in the *Yantrādhipati* designed by Sawai Madho Singh of Jaipur in the second half of the eighteenth century (T001). The reverse side is engraved with a modified version of the *Dhruvabhrama-yantra* with scales for *ghaṭīs,* zodiac signs according to their right ascensions and zodiac signs with their oblique ascensions, together with an index pivoted to the centre.

We assume that the intended procedure would be that first one measures the local time with the alidade on the obverse side, by choosing the appropriate horary scale for

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[1647] Sarma 2015b; see also Apx.C, Index of Instrument Makers, s. v. Bulhomal.

the day in question. Then turning the disc to the reverse side, the index is placed on the local time just obtained. Where the ruler intersects the scale of the signs marked according to their oblique ascensions can be seen the ascendant and where the rule intersects the signs marked according to their right ascensions the culmination.

But there are several problems in this procedure. Bulhomal drew on the obverse side scales of hours to denote the lengths of the half-day in different periods of the year, but equipped the reverse side with scales in *ghaṭīs* in the outer periphery. This would necessitate conversion of hours and minutes into *ghaṭīs* and *palas* or vice versa in every operation.

More problematic are the hour scales themselves which are not properly defined. The obverse side of the *Jyotiḥsattā* is engraved with 19 scales to measure the half days in different periods of the year. These scales are divided into hours by radian lines and numbered from the horizontal diameter onwards. The durations of these 19 scales are as follows: 5;17 hours, 5;21 hours, 5;24 hours, 6;00 hours, 6;02 hours, 6;03 hours, 6;04 hours (twice), 6;06 hours (twice), 6;08 hours (twice), 6;10 hours, 6;12 hours, 7;10 hours, 7;12 hours, 7;17 hours, 7;21 hours and 7;24 hours. There is a large inexplicable gap between 6;12 hours and 7;10 hours. According to this arrangement, the half day-length at latitude 32° ranges between 5;17 hours and 7;24 hours.

But this arrangement does not conform to the generally accepted value of maximum daylight at 32° which is ca. 14;08 hours and according to which the length of the half-day at this latitude should range from 4;56 hours to 7;04 hours. Moreover, it is not known how one can determine which scale to use on which day.

There are problems on the reverse side as well which is fashioned somewhat like a *Dhruvabhrama-yantra,* with concentric scales of *ghaṭīs* and *palas,* zodiac signs according to their right ascensions and according to their oblique ascensions. Since this one is meant for use in the daytime, there is no slit for viewing the stars α and β Ursae Minoris, nor a four-armed index as in the *Dhruvabhrama-yantra.* Instead there is just an index, one end of which is pivoted to the centre of the circle. This has to be manipulated by hand.

While the obverse side in all the three specimens is identical, on the reverse side there are differences in the placement of the two scales of zodiac signs. In U001, the scale of the zodiac signs according to the right ascensions commences 90° ahead of the

ghaṭī scale, while the scale of the zodiac signs according to their oblique ascensions commences at the same point at the *ghaṭī* scale. In U002 and U003, however, all the three scales commence at the same point. Therefore, none of the three specimens of the *Jyotiḥsattā* can provide the desired results.

Jyotiḥsattā, the name which Bulhomal bestowed on this new device is also problematic, because it is not clear what is intended to be conveyed by this name; *jyotiḥ* means a 'light', 'luminary' or 'celestial body' and the term *sattā* denotes 'existence', 'being', or 'power'. If the term *Jyotiḥsattā* is intended to denote something like the 'power of planets', then it is not known where this power supposed to reside in this device.

The only successful innovation in this device seems to be the alidade. The alidades in the Lahore astrolabes have straight bars without any counter-change as in the astrolabes produced in the Middle East and Europe. Bulhomal also equipped his Indo-Persian and Sanskrit astrolabes with similar alidades with straight bars. But for the *Jyotiḥsattā* he devised an alidade with counter-change, by joining two narrow strips of metal in an ingenious manner so that the two sides of the alidade are equally balanced. Dharm Chand emulated this style in his horary quadrants X015 - X019.

JOSHI DHARM CHAND (*FL.* 1854-73)

Joshi Dharm Chand (*fl.* 1854-73) is a contemporary and an associate of Bulhomal.[1648] His title 'Jotishi' or 'Joshi' (from Sanskrit *Jyotiṣī)* indicates that he was a traditional Hindu astrologer, trained in Sanskrit astronomy and astrology; his surviving instruments show that he was at home in Persian as well. We do not know whether he was from Lahore, but it is certain that he was a resident of Panjab, for he uses the Panjabi phonetic forms of Sanskrit solar months (e.g. *hāṭ* for *āṣāḍha,* or *maggar* for *mārgaśirā*) on some of his instruments. Brahmin by birth, educated in Persian, trained in metal craft and in making traditional astronomical instruments, he was also open to new ideas from Europe. He seems to have been the first one to adapt European perpetual calendars for use in India, an attempt which he designates as *ikhtara*^{c} *naw* (a new invention). There

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[1648] Sarma 2003, pp. 78-84; Sarma 2010, pp. 88-89; see also Apx.C, Index of Instrument Makers, s. v. Dharm Chand.

survive five specimens made by him; three are engraved in Persian and two in English(X015 - X019). These are the earliest known prototypes of the brass perpetual calendars which are now mass-produced at Muradabad.

Āyīnah Falqī

Like Bulhomal, Dharm Chand was also interested in designing an instrument to determine the time, ascendant and culmination in the daytime. He used the reverse side of his perpetual calendars for this purpose. Unlike Bulhomal, Dharm Chand arranged here the scales of half-duration of daytime and the scales of the zodiac signs according to the right ascensions and the scales of the zodiac signs according to oblique ascensions on the same side of the plate and equipped this side with an alidade. Quite pragmatically, he drew just 7 *ghaṭī* scales for the half-duration of daylight and defined these precisely in terms of the Sanskrit-Panjabi solar months. (In the two English specimens, he has only six scales which he defined in terms of English months). He called this new device *Āyīnah Falqī* (mirror of the heavens). His attempt is more successful than Bulhomal's.

As regards the perpetual calendars on the obverse side, his first two attempts in X015 and X016 were not quite successful, because he did not include the years there. He achieved the objective in a third attempt in X017 which is engraved in Persian. He translated this device into English in X018 and X019. These five attempts will be described in section X under the heading 'Indian Adaptations of European instruments'.

In the present section the focus will be on another attempt by Dharm Chand at designing a new instrument by arranging the sine quadrant on one side of a rectangular plate and the plate of multiple horizons on the other side. Dharm Chand calls this creation a *taṣnīf* (invention). There exist two specimens (U006 and U007), but it is difficult to see any advantage in this juxtaposition.

U001⊙ JYOTIḤSATTĀ BY LĀLAH BULHOMAL LĀHORĪ, 1896 VS (AD 1839-40)

Diameter 88 mm; height 115 mm

London, Victoria & Albert Museum (# IM.10.1915)

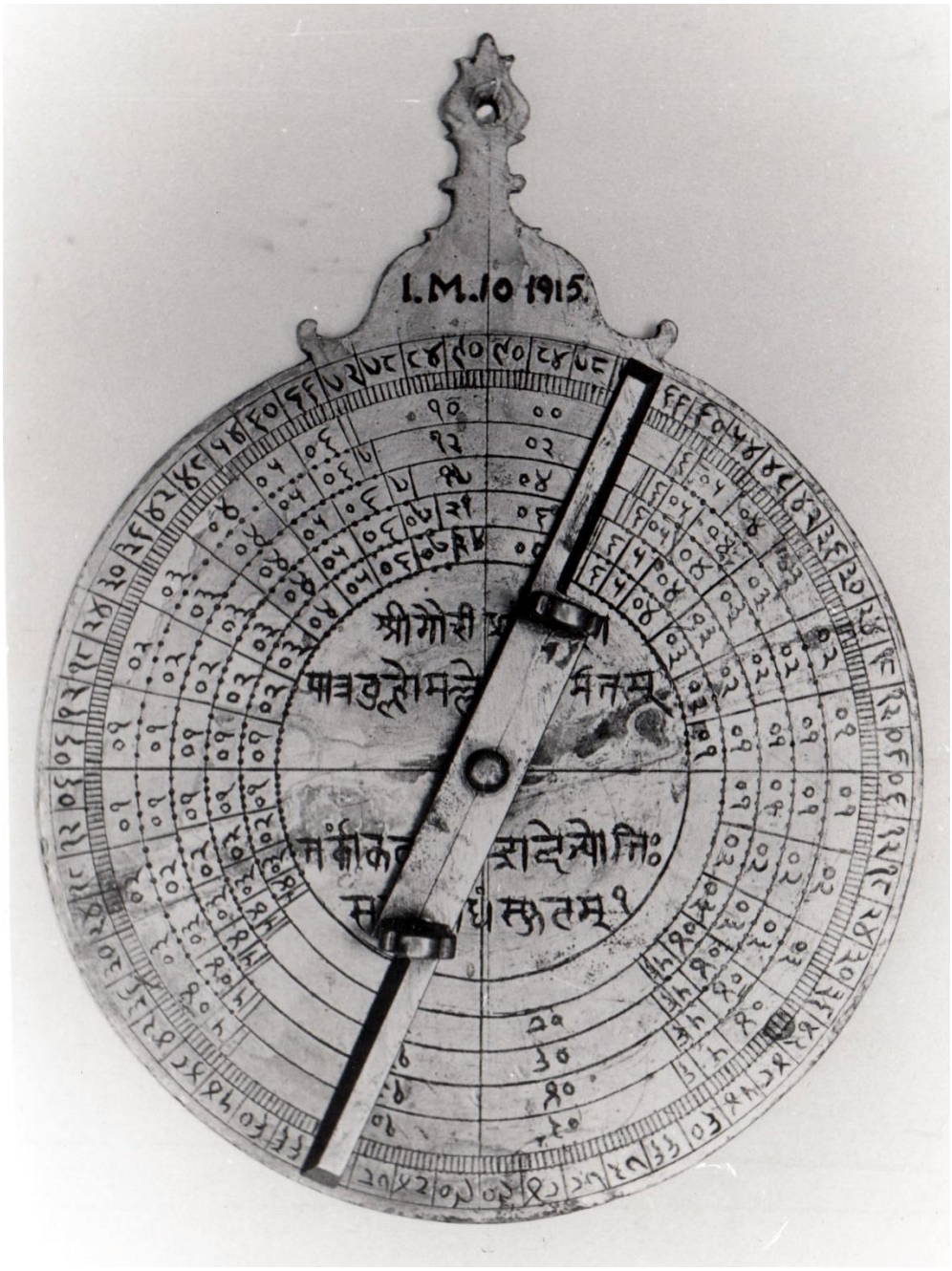


Figure U001.1 – Obverse side with horary quadrants
(photo from the archives of the Museum of the History of Science, Oxford)

OBVERSE SIDE

The instrument is shaped like an astrolabe with a high suspension bracket and an alidade pivoted to the centre of the main body. Vertical and horizontal diameters divide the main body into four quadrants. The rims of these four quadrants are engraved with

altitude scales as on the back of an astrolabe. The inner bands are calibrated for 1°; in the outer band groups of 6° are numbered from 6 to 90, starting at the two ends of the horizontal diameter and reaching the two ends of the vertical diameter.

Within these altitude scales are five annular rings, filled in each quadrant by different scales of half day-lengths in hours. There are altogether 19 such scales for different periods of the year. These scales are divided into hours by radian lines and numbered from the horizontal diameter onwards. Each cell is subdivided in 5 units (= 12 minutes) by means of the four dots placed in the line below.[1649] This style of division is characteristic of Bulhomal's work and can be seen in also his sine quadrants (L006 and L007) and it was emulated by his contemporary Dharm Chand in his sine quadrants (Figure U006.3 and Figure U007.2).

The durations of these 19 scales are as follows: 5;17 hours, 5;20 hours, 5;24 hours, 6;00 hours, 6;02 hours, 6;03 hours, 6;04 hours (twice), 6;06 hours (twice), 6;08 hours (twice), 6;10 hours, 6;12 hours, 7;10 hours, 7;17 hours, 7;21 hours and 7;24 hours. There is an inexplicable gap between 6;12 hours and 7;10 hours. According to this arrangement, the half day-length at latitude 32° ranges between 5;17 hours and 7;24 hours.

But this arrangement does not match with the generally accepted value of maximum daylight at 32° which is ca. 14;08 hours and according to which length of the half day at this latitude should range from 4;56 hours to 7;04 hours.

Reverse Side

The reverse side of the *Jyotiḥsattā* is fashioned somewhat like a *Dhruvabhrama-yantra* with three sets of concentric circular scales, separated from one another by double lines. The outermost set is divided in 1° and 6° with groups of 6° numbered serially from 1 to 60 clockwise. This can also be treated at a *ghaṭī* scale where *ghaṭīs* are numbered from 1 to 60 and each *ghaṭī* is divided in 6 units of 10 *palas* or 4 minutes each.

[1649] It is unusual to divide the hour into 5 parts of 12 minutes; more rational would be to divide it in 3 units of 20 minutes, 4 units of 15 minutes, or 6 units of 10 minutes each.

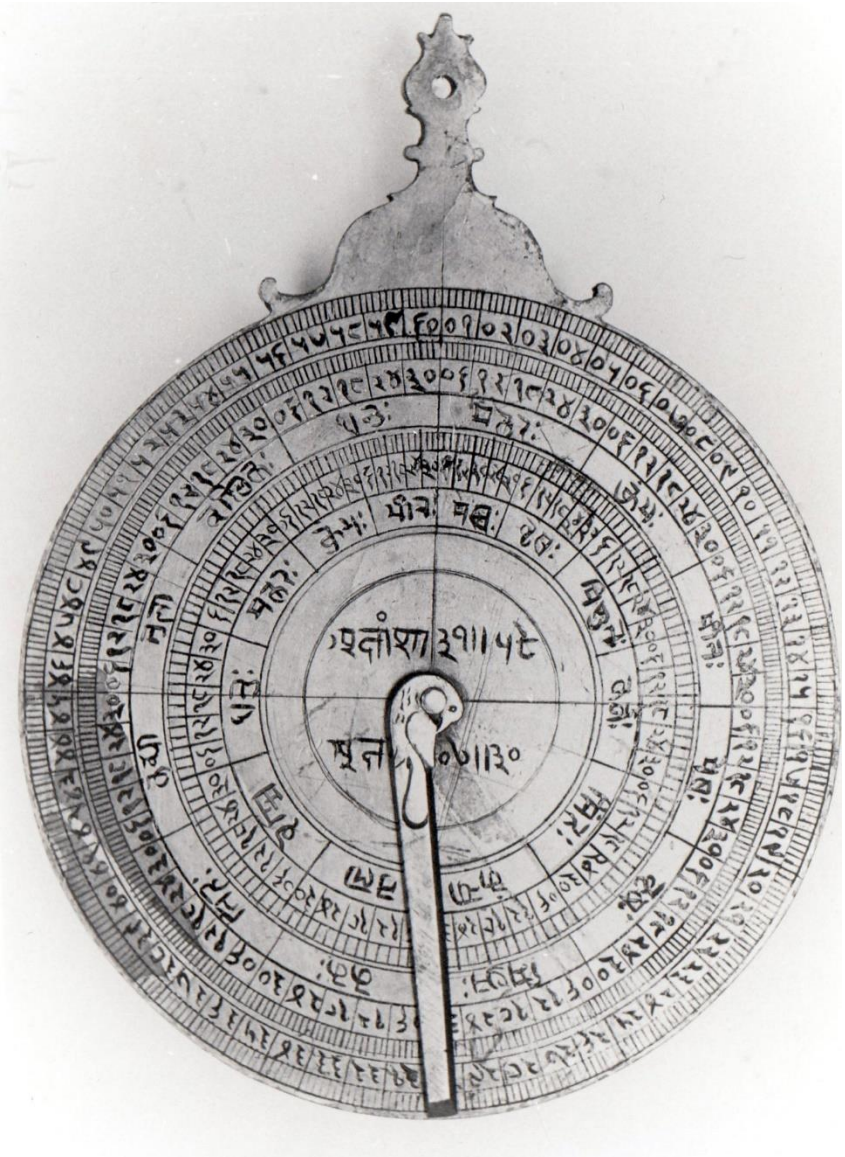


Figure U001.2 – Dhruvabhrama-yantra on the reverse side
(photo from the archives of the Museum of the History of Science, Oxford)

In the second set, the scales are divided in 12 zodiac signs, in proportion to their right ascensions, and labelled with their names, starting 90° ahead of the *ghaṭī* scale, i.e., at the beginning of the 16th *ghaṭī* and proceeding clockwise. The names of the signs are transcribed as *Meṣaḥ, Vṛṣaḥ, Mi*naḥ, Ka[r]kaḥ, Siṃhaḥ, Kaṃnyā, Tulā, Vṛścikaḥ, Dhanuḥ, Makaraḥ, Kuṃbhaḥ, Mīnaḥ.* Each sign is divided in 5 units and numbered clockwise as 06, 12, 18, 24, 30; each unit is further subdivided into 6 parts.

In the third set the scales are divided in 12 zodiac signs, in proportion to their oblique ascensions and labelled with their names, starting at the same point as the *ghaṭī* scale and proceeding clockwise. These signs are divided and subdivided in the same manner as in the above set of scales.

In the middle of the plate are given particulars of the locality for which the instrument is designed: *akṣāṃśa 31‖58* (latitude 31;58°) and *akṣabhā 07‖30* (equinoctial shadow at noon 7;30 units).

Alidade

The instrument is equipped with an alidade in the front and an index at the back. The alidade is made of two narrow strips, which are so joined that the two sides of the alidade are equally balanced. The sighting plates, like those in Bulhomal's astrolabes, are ornately fashioned with trifoliate outlines. The index on the back is a long strip with parallel sides; the top, which is pivoted to the centre, is beautifully fashioned like a bird turning its neck backwards and touching its wing with its beak.

Inscription

In the middle of the obverse side is engraved the maker's signature; it is composed in *Anuṣṭubh* metre and employs word numerals:

> *śrīgaurīśakaruṇāpātravulhomallena nirmitaṃ |*
> *tarkāṅkavasucandrābde jyotiḥsattābhidaṃ sphuṭaṃ ‖*
> 'This accurate [instrument] by name *jyotiḥsattā* was created by Bulhomal (*vulhomalla*), the receptacle of the grace of Gaurī and Śiva, in the [Vikrama] year [denoted by] the philosophical systems (*tarka* = 6), digits (*aṅka* = 9), the *vasus* (= 8) and the moon (*candra* = 1) (i.e. VS 1896 = AD 1839).'

Bibliography

Anderson 1982, no. 138, p. 36.
Sarma 2015b, no, 25, pp. 284-287.

U002⊙ JYOTIḤSATTĀ BY LĀLAH BULHOMAL LĀHORĪ, 1896 VS (AD 1839-40)

Diameter 92 mm

New Delhi, National Museum (# 56.155/7)



Figure U002.1 – Obverse side (photo courtesy National Museum)

In this specimen, only the circular main body is extant. Probably the suspension bracket was made separately and attached at the top, which got detached in course of time and is now lost. There is no alidade in front, nor an index at the back. The engraved lines and letters are filled with a white substance. In other respects, it is similar to U001.

OBVERSE SIDE

The obverse side is fashioned as a set of four horary quadrants. Vertical and horizontal diameters divide the main body into four quadrants. The rims of these quadrants are engraved with altitude scales as on the back of an astrolabe. The inner

bands of these scales are calibrated for 1°; in the outer band groups of 6° are numbered from 6 to 90, starting at the two ends of the horizontal diameter and reaching the two ends of the vertical diameter.

Within these altitude scales are five annular rings, which are filled in each quadrant by scales of half day-lengths in hours. Each scale is divided into single hours by radian lines and numbered. There are altogether 19 such scales, where the solar altitude of the sun can be converted into the local time. In U001, each cell indicating one hour is subdivided in 5 units by means of the four dots placed in the line below; here this is not done.



Figure U002.2 – Reverse side (photo courtesy National Museum)

REVERSE SIDE

The reverse side of the *Jyotiḥsattā* is fashioned somewhat like a *Dhruvabhrama-yantra,* with 11 annual rings. The first two are occupied by the degree/ *ghaṭī* scale. The next three rings carry the 12 zodiac signs according to their right ascensions; each sign is labelled with its Sanskrit name, divided in 5 units which are numbered clockwise as 6, 12, 18, 24 and 30, and each of these units is subdivided into single degrees. Rings 7,

8, 9 are divided into 12 signs according to their oblique ascensions; each sign is labelled with its Sanskrit name, divided in 5 units which are numbered clockwise as 6, 12, 18, 24 and 30, and each of these units is subdivided into single degrees. Unlike in U001, here all the three scales commence at the same point.

In the middle of the plate are engraved the latitude and the length of the equinoctial shadow at midday at this latitude thus: *akṣāṃśa 31‖58* ; *akṣabhā 07‖30* .

Inscription

In the middle of the obverse side is engraved the maker's signature composed in *Anuṣṭubh* metre:

> *śrīgaurīśakaruṇāpātravulhomallena nirmitaṃ |*
> *tarkāṅkavasucandrābde jyotiḥsattābhidaṃ sphuṭaṃ ‖*
> 'This accurate [instrument] by name *jyotiḥsattā* was created by Bulhomal (*vulhomalla*), the receptacle of the grace of Gaurī and Śiva, in the [Vikrama] year [denoted by] the philosophical systems (*tarka* = 6), digits (*aṅka* = 9), the *vasus* (= 8) and the moon (*candra* = 1) (i.e. VS 1896 = AD 1839).'

Bibliography

Sarma 2015b, no, 26, pp. 284-287.

U003⊙ JYOTIḤSATTĀ ATTRIBUTABLE TO LĀLAH BULHOMAL LĀHORĪ CA. 1840

Diameter 96 mm, height 112 mm

New York, Columbia University, Butler Library (# 27-258)

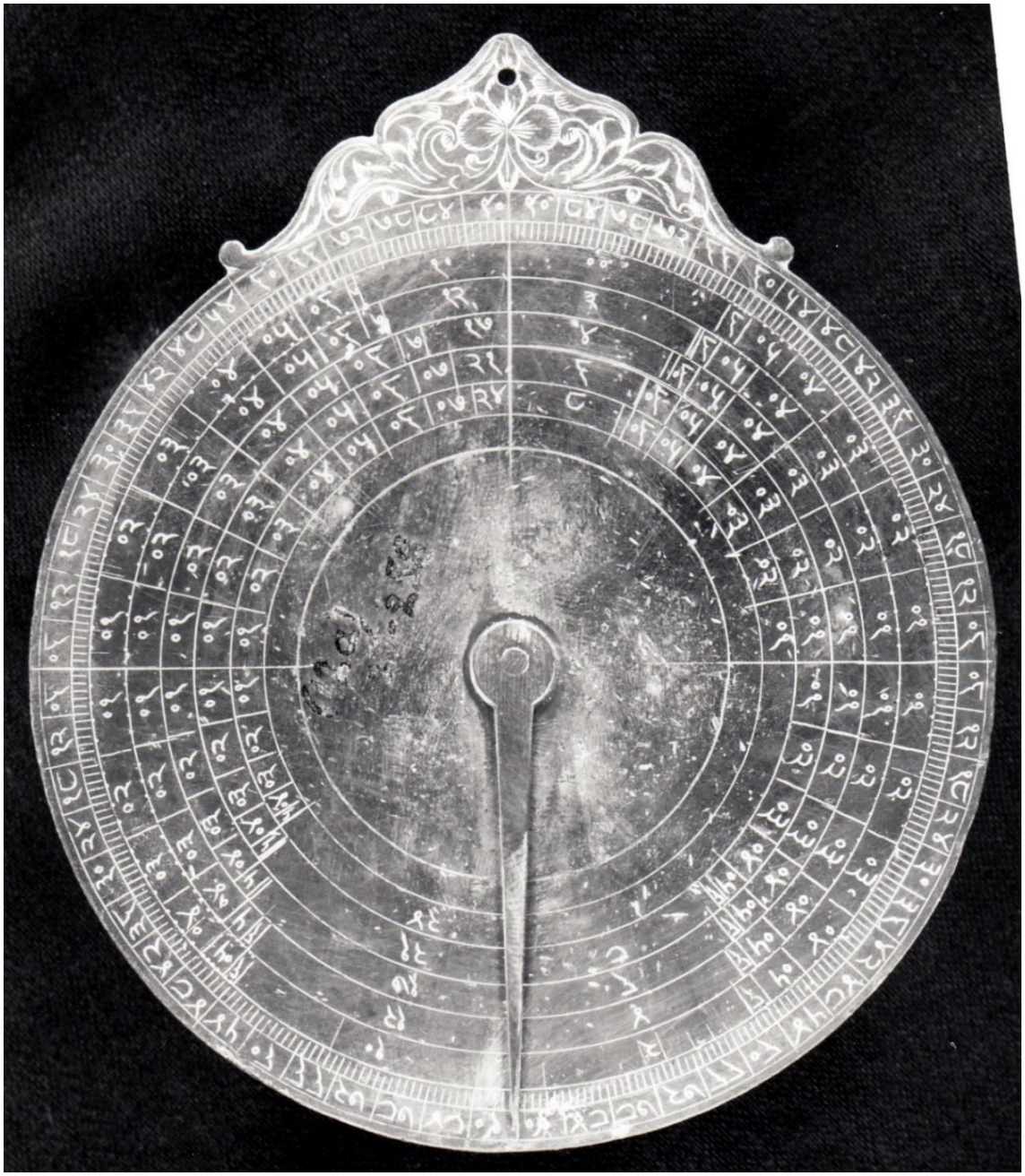


Figure U003.1 – Obverse side (photo courtesy Butler Library, Columbia University)

This specimen does not carry the signature in the middle of the obverse side, but is similar in other respects to the previous two specimens (U001 and U002). Therefore, it must have been made by Bulhomal himself at about the same time as the other two.

The low suspension bracket is elegantly shaped with two ogees in profile and filled with a highly ornate floral pattern on both sides. There is hole at the top, but the ring is missing. Engraving and calligraphy are much superior to those in the other two specimens, and the orthography correct. Obviously, this was done by Bulhomal himself, while his assistants did some engraving in the other two pieces.

The original alidade appears to have been lost. In its place, an index with a large circular top and tapering to sharp point at the other end is pivoted to the centre. The same kind of index is attached at the back as well. At present, these are firmly glued to the main body and cannot be rotated; therefore, the engravings beneath them cannot be seen.

Obverse Side

Vertical and horizontal diameters divide the main body into four quadrants and each quadrant is fashioned as a horary quadrant. The rims of these quadrants are engraved with altitude scales as on the back of an astrolabe. The inner bands of these scales are calibrated for 1°; in the outer band groups of 6° are numbered from 6 to 90, starting at the two ends of the horizontal diameter and reaching the two ends of the vertical diameter.

Within these altitude scales are five annular rings, which are filled by 19 different scales displaying half day-lengths in hours in different seasons. Each scale is divided in hours by radian lines and numbered, starting from the horizontal diameter. In U001, each cell indicating an hour is subdivided in 5 units by means of the four dots placed in the line below. Here this is done only in the first row and not in others.



Figure U003.2 – Reverse side (photo courtesy Butler Library, Columbia University)

REVERSE SIDE

The reverse side is fashioned somewhat like a *Dhruvabhrama-yantra* with 9 annual rings. The first two rings are divided in 60 *ghaṭīs,* numbered clockwise from 1 to 60, starting at the uppermost point. Each *ghaṭī* is subdivided in 6 units of 10 *palas* or 6 minutes each; these can also be treated as single degrees of arc.

Rings 3, 4 and 5 are divided in 12 zodiac signs according to their right ascensions and labelled with their Sanskrit names, starting at the upper radius: *Meṣaḥ, Vṛṣaḥ, Mithunaḥ, Karkaḥ, Siṃhaḥ, Kanyā, Tulā, Vṛścikaḥ, Dhanuḥ, Makaraḥ, Kuṃbhaḥ* and

Mīnaḥ. Each sign is subdivided in 5 units and numbered clockwise as 06, 12, 18, 24, 30. Each of these units is further subdivided in 6 parts.

Rings 6, 7 and 8 are divided in 12 zodiac signs according to their oblique ascensions and labelled with their Sanskrit names as above, starting at the upper radius; then these are subdivided in the same manner as above. The last annular ring is blank.

Thus all the three scales, of *ghaṭīs,* signs in right ascension and signs in oblique ascension, commence at the upper radius of the plate.

In the middle of the plate is engraved *akṣāṃśa 31‖58* (latitude 31;58°). The second line is partly blocked by the index; the beginning reads *pala,* the full word must be *palabhā,* another term for equinoctial shadow at midday. It is interesting that Bulhomal uses *akṣabhā* in U001 and U002, and its synonym *palabhā* here.

BIBLIOGRAPHY

Sarma 2015b, no, 26, pp. 284-287.

U004⊙ SINE QUADRANT & UNIDENTIFIED TABLE ATTRIBUTABLE TO LĀLAH BULHOMAL LĀHORĪ

Mid-19th century

274 x 250 mm

New York, Columbia University, Butler Library (# 27-253)

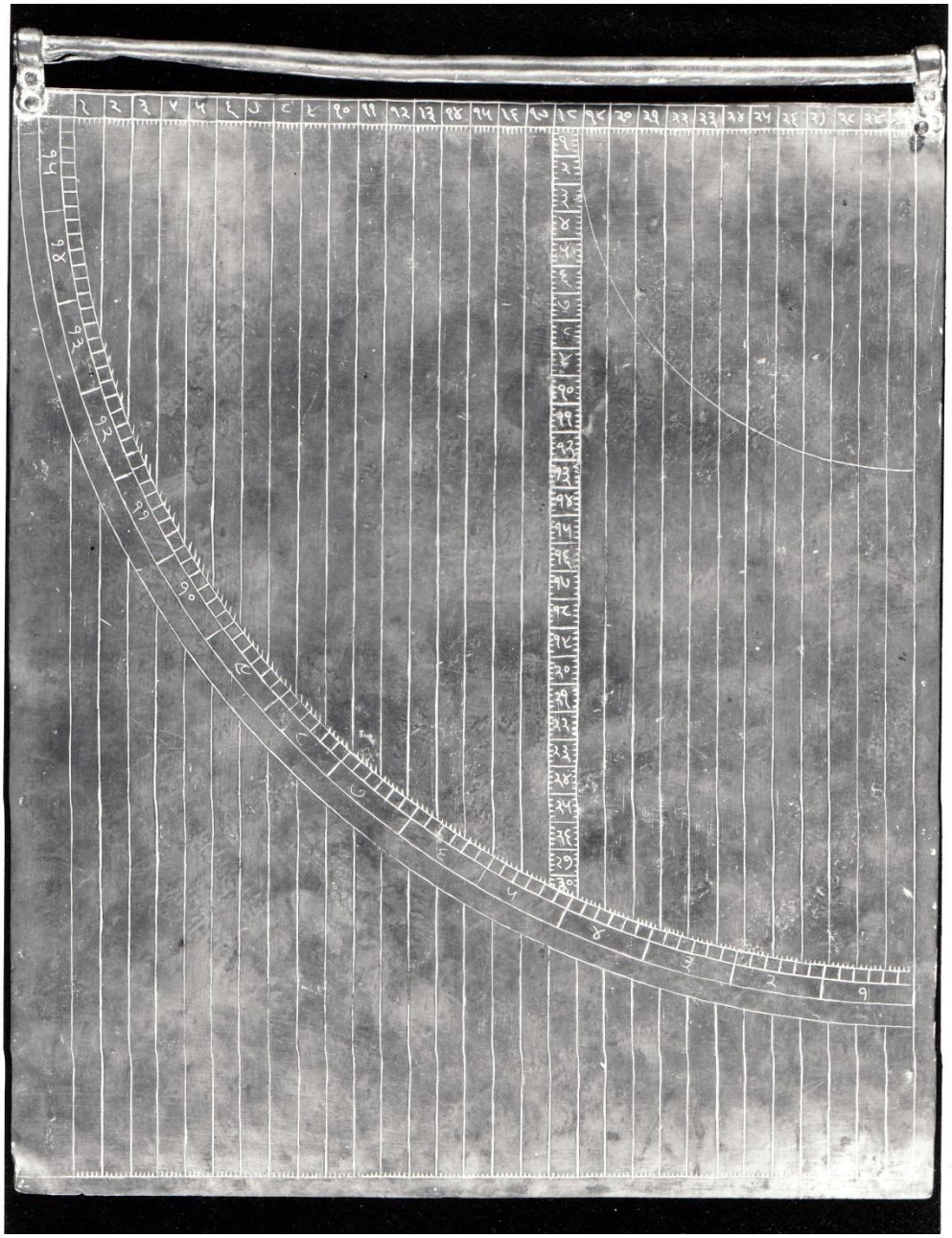


Figure U004.1 – Sine Quadrant (photo courtesy Butler Library, Columbia University)

This instrument is not signed, nor dated, but can be attributed to Bulhomal of Lahore on stylistic criteria. It is a rectangular plate of copper, on which the engravings are filled with some white substance.

OBVERSE SIDE

The obverse side is fashioned as a sine quadrant with a sighting tube (now slightly bent) inserted in two upright rings which are attached to one of the shorter sides of the plate. At the apex, there is a pin-like projection for pivoting the index which is now missing.

The upper horizontal side is divided in 30 equal parts, and from each mark of division, 30 vertical parallel lines are drawn over the entire plate, not just up to the arc of the quadrant. These are numbered from 1 to 30 from the arc to the apex. The 18th column is numbered from 1 to 28.[1650] The arc is marked with three concentric bands. The outer one is blank. The inner one is divided in 1°. In the middle band, groups of 6° are marked and numbered from 1 to 15, starting from the bottom of the vertical radius on the right and reaching up to the end of the horizontal radius on the left. At the top and bottom of the vertical columns, short strokes are made to divide the columns into 5 units. The graduated 18th column is also similarly marked. This is a characteristic feature of Bulhomal and can be seen in his sine quadrants L006 and L007, and also in his *Jyotiḥsattās* U001 and U002.

[1650] Cell 27 is correctly numbered, but the next one is numbered by mistake as 30 instead of 28.

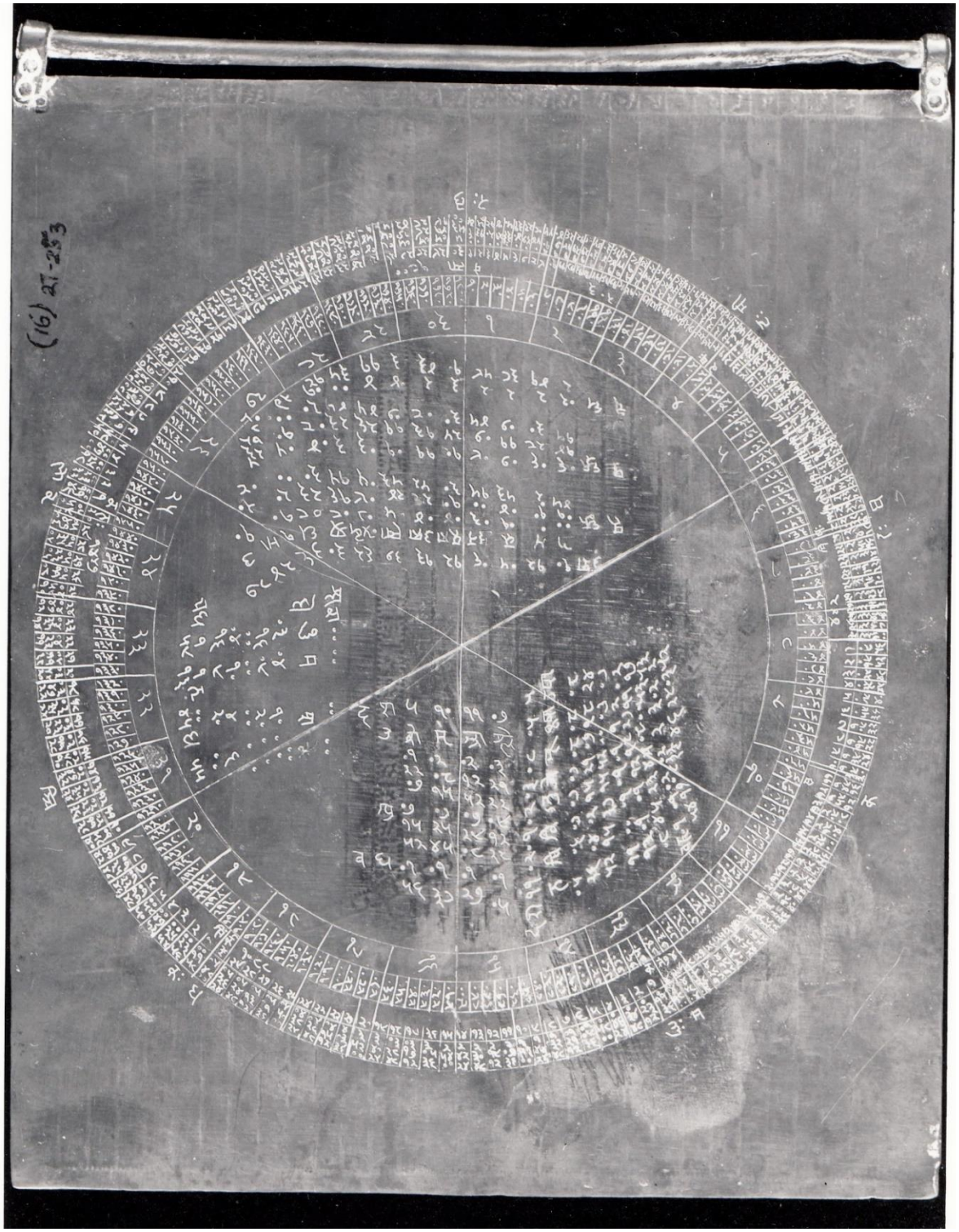


Figure U004.2 – Reverse side (photo courtesy Butler Library, Columbia University)

REVERSE SIDE

The reverse side is engraved with a circular table with a diameter of about 216 mm, which is divided into six equal segments by three diameters. There are four concentric rings. Starting from inside, these are as follows:

1. Divided in 30 units and numbered clockwise from 1 to 30, starting from the top.

2. Each unit above is sub-divided in six parts and numbered clockwise from 10 to 1800.

3. Names of the first six signs *Meṣaḥ* to *Kanyā* clockwise.

4. Oblique ascensions for each degree of the six zodiac signs *Meṣaḥ* to *Kanyā* clockwise; the same will pertain to the other six signs in the reverse order. Their names are written outside the annulus from *Mīnaḥ* to *Tulā.*

Inside these circular scales, there are haphazardly arranged tables related to the lunar mansions, with the initial syllables of their Sanskrit names.

U005⊙ SINE QUADRANT & UNIDENTIFIED TABLE ATTRIBUTABLE TO LĀLAH BULHOMAL LĀHORĪ

Ca. 1840

Diameter 97 mm; height 121

New York, Columbia University, Butler Library (# 27-199)

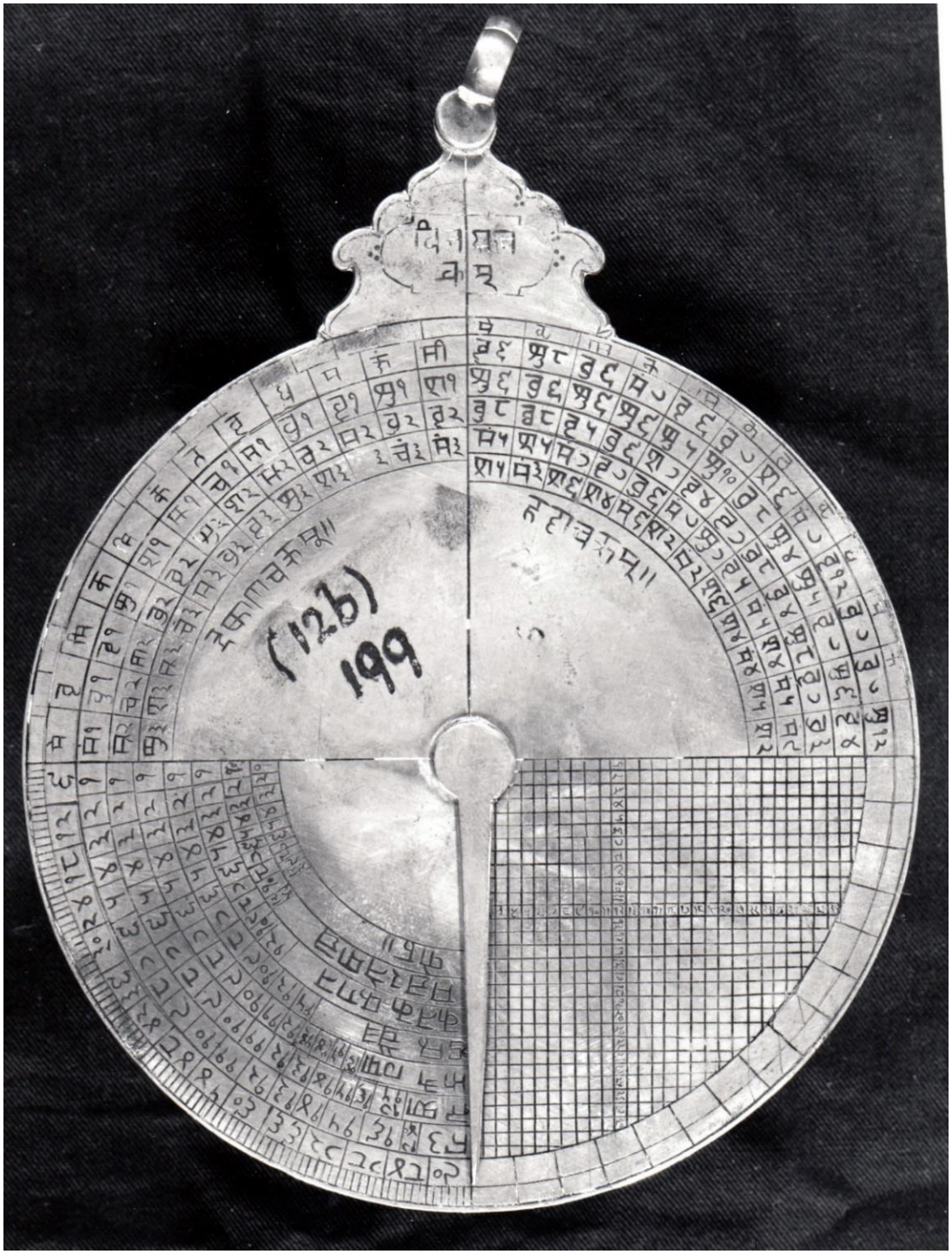


Figure U005.1 – Obverse side (photo courtesy Butler Library, Columbia University)

This device is neither signed, nor dated, but can be attributed to Bulhomal of Lahore on stylistic grounds. It has an outline like that of an astrolabe with a high suspension bracket and a shackle. But it is difficult to define the exact nature and purpose of this device which cannot be used for any observation. On the obverse side, the two upper quadrants are filled with astrological tables and the lower quadrants are designed as a horary quadrant and a sine quadrant. But there is no alidade to make use of these two lower quadrants in observation. Instead, there are indices on both sides with large circular tops and tapering to sharp points at the other end as in U003. On the reverse side, there is a large table the purpose of which is unknown.

OBVERSE SIDE

On the suspension bracket is written *vijaya-cakram* (table, diagram, or wheel of victory); its significance is not known. The circles are poorly drawn, esp. the quarter circles in the lower left quadrant. Some of the letters, esp. in the lower left quadrant, are engraved by one who is more at home with the Gurmukhi script rather than the Devanagari; therefore the legends are difficult to decipher.

The obverse side is divided by the vertical and horizontal diameters into four quadrants. In the upper left quadrant is engraved a table of decans in 12 columns and 4 rows with the title *Dreṣkāṇa-cakram.*[1651] Here the names of the zodiac signs and the related planets are written with the initial letters of their Sanskrit names.

A table of the terms of the signs occupies the upper right quadrant in 12 columns and 6 rows. It is entitled *Haddā-cakram,* which is the Sanskrit form of the Arabic term *ḥudūd.*[1652] Here also the names of the zodiac signs and those of the planets are written with the initial letters of their Sanskrit names.

A horary quadrant is engraved in the lower left quadrant; there are seven scales denoting the half durations, expressed in *ghaṭīs,* of the daylight in different solar months. These names of the months are in Sanskrit, as modified in the common usage in Panjab.

[1651] Cf. A. Introduction 2.6.4.3.

[1652] Cf. A. Introduction 2.6.4.2

Table U005-1 *Ghaṭī* Scales

Name	duration
Ḥāṭ (Āṣāḍha)	17;40 *ghaṭīs*
Sāwan-Jeṭh	17;15
Bhādon-Baisak	16
Assū-Caitra	15
Katak- Phagan	12
Māgh-Maghar	11;45 (written wrongly 12;45)
Poh	11;20 (written wrongly 12;20)

The lower right quadrant is filled with a sine-cosine graph with 30 horizontal and 30 vertical lines. The 12th horizontal row and the 12th vertical row (as counted from the respective radii) are numbered from 1 to 28 from the corresponding radius and up to the arc. The arc is covered by two concentric bands, both are divided in 15 parts, but not numbered.

REVERSE SIDE

On the reverse side, the suspension bracket bears a carelessly engraved legend *śī cakre nu śeṣaraḥ*; it is probably a miswriting for *śrī-cakrenduśekharaḥ* (glorious diagram which is like the moon-crested one, viz., Śiva). Its significance is not known.

There are three circular annuli, each with 72 cells which are filled with closely engraved digits.



Figure U005.2 – Reverse side (photo courtesy Butler Library, Columbia University)

In the outer annulus are written numbers from 00;33,50 to 60;00,00 at intervals of 00;35,50. If these assumed to be *ghaṭīs,* then the three items refer to *ghaṭīs, palas* and *vipalas.*

In the middle annulus, there are two rows one below the other, carrying the numbers 00;5 – 00;10 – 00; 15 – 00;20 – 00;25 – 01;00 – 01;05 … 11;05 – 11;10 – 11;15 – 11;20 – 11;25 – 00;00. These appear to be signs and degrees.

In the inner annulus, there are three numbers one below the other. The counting does not commence at the upper radius as in the other annuli, but immediately below 15;14,00 of the outer annulus and 3;15 of the middle annulus. The numbers range from 00;01,31 – 00;07,46 – 00;14,01 – 00;20, 17 … 11;16, 55 – 11;18,00 – 11;25,14.

The purpose of this elaborate table is not known.

U006⊙ PLATE OF HORIZONS & SINE QUADRANT BY JOSHI DHARM CHAND, 1911 VS (AD 1854-55)

212 x 165 x 3 mm

Stuttgart, Linden Museum (# A 36.124 L)



Figure U006.1 – Plate of Horizons on the Obverse (photo by S. R. Sarma)

This rectangular plate is engraved on one side with a plate of horizons as in an astrolabe and with a sine quadrant on the other side. In the astrolabe, the plate with the projections of horizons for several latitudes (*ṣafīha āfāqiya*) is used for determining the times of sunrise and sunset at latitudes other than one's own, or to determine the latitude

from the time of sunrise or sunset.[1653] Dharm Chand singled out this feature from the Islamic astrolabes to create a new device which he called an invention (*tasnīf*).

This instrument is made in the form of an oblong plate. From one of the shorter sides project two sighting plates, which are somewhat thicker than the rest of the plate. On the obverse side, at the top of the plate, there is the signature of the maker in Persian. The rest of the legends on this instrument are in Sanskrit and in Devanagari characters.



Figure U006.2 – Detail of the horizon plate (photo by S. R. Sarma)

PLATE OF HORIZONS

A little above the middle of the plate is engraved a circle with a diameter of 16 cm. Inside the circle, there are two concentric circular scales; the inner one is graduated into single degrees and the outer one into groups of 6° and numbered, starting from the centre at the top and proceeding clockwise, as 01, 02, 03 …58, 59, 60. Writing the single digits as 01, 02 etc. is clearly inspired by the European practice. Inside the circle are

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1653 Morrison 2007, pp. 63-65.

drawn the south-north and west-east lines, circles of Cancer, the equator and Capricorn, as in the astrolabe plates, but without any labels.

On this frame are engraved the families of horizons for 4 sets of latitudes, as is done on the astrolabe plate for multiple horizons. These are labelled where each horizon begins and where it ends. Unlike on the astrolabe plates, declination scales are not engraved here. The four sets of latitudes are as follows:

17	23	29	39	49	59
	20	30	40	50	60
	22	32	42	52	62
	25	35	45	55	65

To the centre of the circle is pivoted an ornate rete, which rotates on the circle eccentrically. The rete is tightly fixed with an iron nail, which is probably a later addition. The rete consists just of the circle of the ecliptic, which is connected to the central ring by two bars which are perpendicular to one another. Above the horizontal bar is an ornate triangle which is artistically perforated. The ecliptic is divided into the 12 zodiac signs and labelled with their Sanskrit names, each sign is again subdivided into groups of 6° and numbered as 06, 12, 18, 24, 30. The edge is cut at right angles to the surface of the plate and marked with the degrees of arc.

In an astrolabe, when one wishes to know the particulars of a latitude which is not represented in the plates, the plate of horizons is placed on top of the other plates and so rotated that the horizon of the desired latitude is aligned with the east. Then it can be used like any other latitude plate. But such an operation is not possible in the present case. It not clear what other purpose is served by this device which Dharm Chand proudly designates a *taṣnīf*.

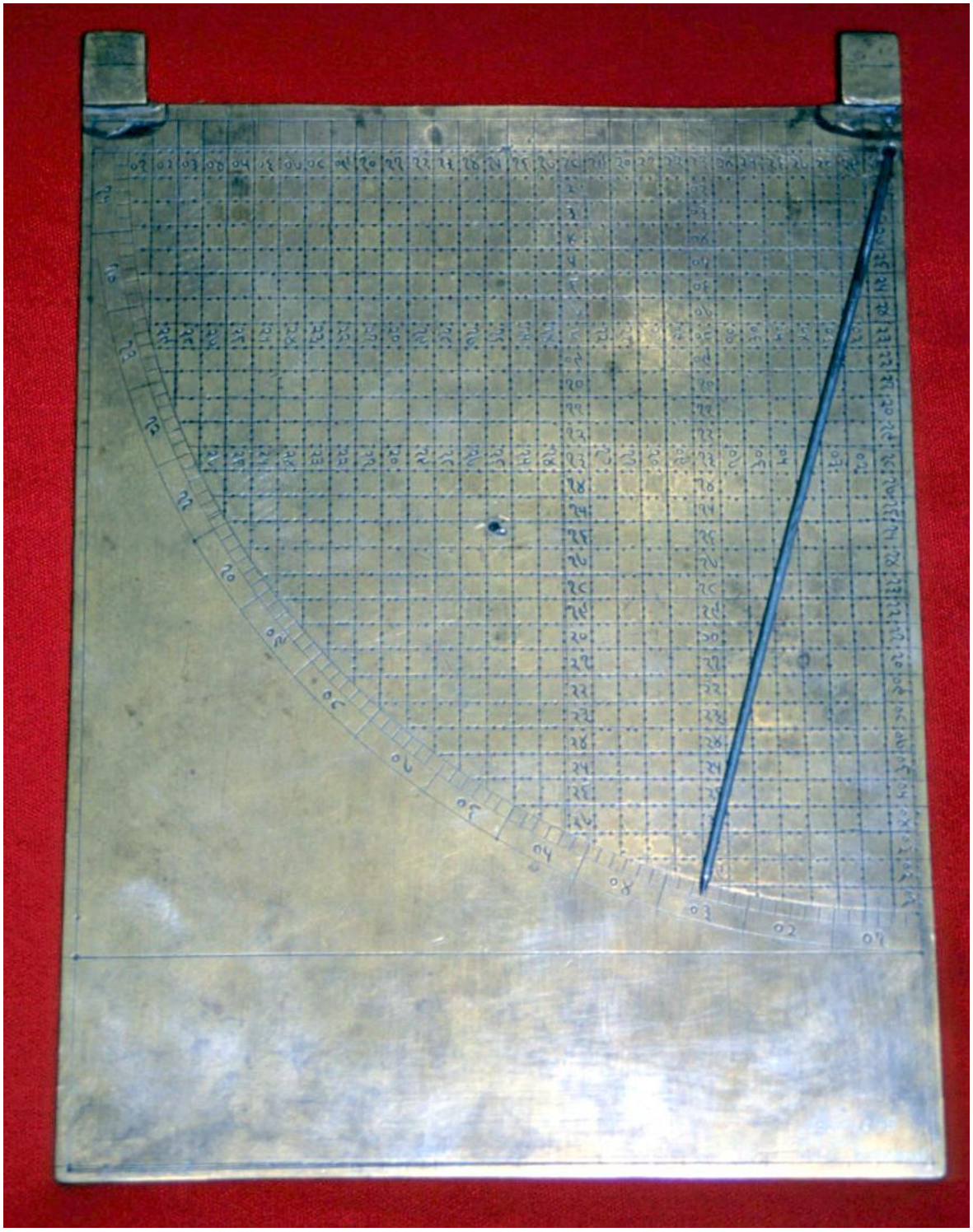


Figure U006.3 – Sine quadrant (photo by S. R. Sarma)

SINE QUADRANT

On the reverse side of the plate is engraved a sine quadrant. The iron index is probably a replacement like the central iron pin. The horizontal and vertical lines which form a grid of cells have dots on them. Thirty horizontal and thirty vertical parallels produce a grid of squares. Each square in the grid is sub-divided into 9 small sub-squares

by dots along the horizontal and vertical lines. Thus the vertical and horizontal lines are divided into 90 parts. The columns in the uppermost horizontal row are numbered from 1 to 30, starting from the arc and reaching up to the apex. Likewise in the first column on the right, the rows are numbered from 1 to 30, starting from the arc and reaching up to the apex. Furthermore, the cells in the 18th and the 23rd column and row are numbered likewise, but starting from the sides and proceeding towards the arc. (cf. L006).

Two concentric bands are engraved on the arc of the quadrant. The inner band is divided into single degrees and the outer band into groups of 6°; these are numbered as 01, 02, 03, … 13, 14, 15. Thus on this scale the degrees of altitude can be measured.



Figure U006.4 – Signature (detail of Figure U006.1)

INSCRIPTION

At the top of the obverse side is engraved the signature of the maker which reads as follows:

taṣnīf joshī dharm chand sambat 1911

‘Invention [of] Joshi Dharm Chand, Saṃvat 1911.

The year corresponds to AD 1854-55.

BIBLIOGRAPHY

Sarma 2008d, pp. 29-32

Sarma 2015b, no. 34, pp. 292-293.

U007 PLATE OF HORIZONS & SINE QUADRANT BY JOSHI DHARM CHAND, 1911 VS (AD 1854-55)

212 x 165 x 3 mm

PLU: ex-Skinner 2002.

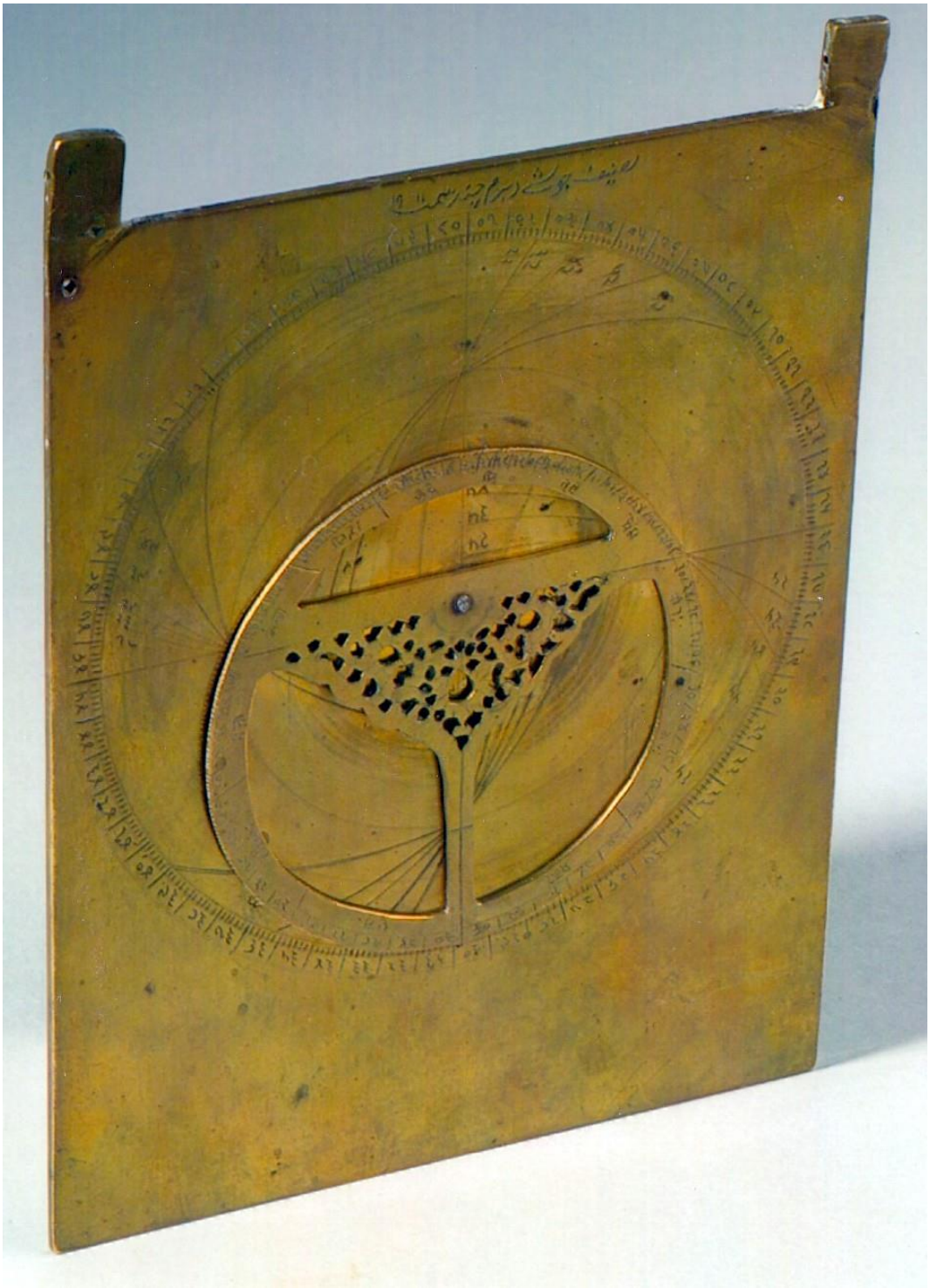


Figure U007.1 – Plate of Horizons (photo courtesy Prof. David Pingree)

This is an identical copy of the previous specimen (U005). It came up for auction at Skinners, Bolton, USA, on 23 April 2002 and its present location is unknown.

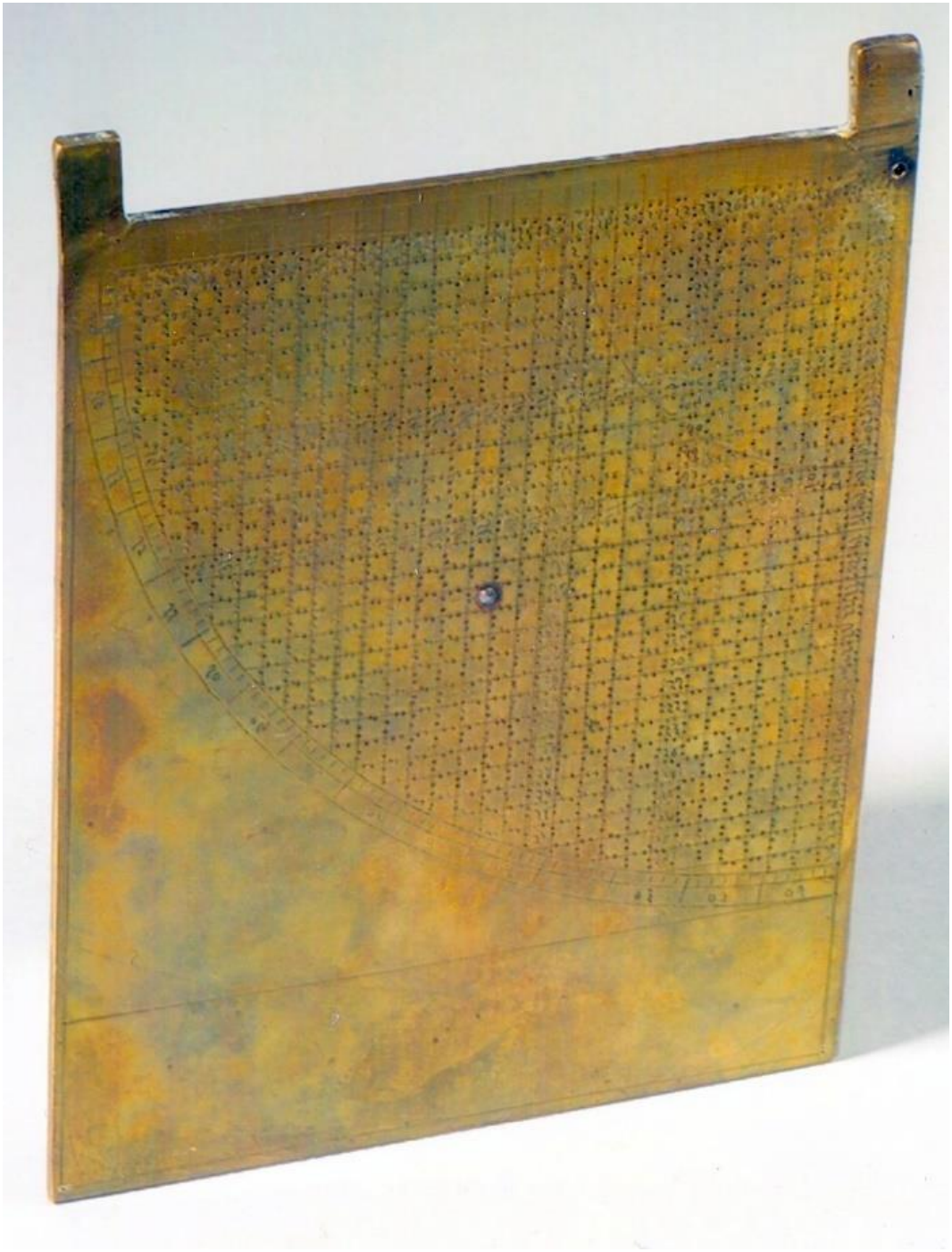


Figure U007.2 – Sine Quadrant (photo courtesy Prof. David Pingree)

BIBLIOGRAPHY

Skinner 2002, p. 36, lot 223.

Sarma 2015b, no. 35, p. 293.

V. ASTRONOMICAL COMPENDIA

INTRODUCTION

In the fifteen century, instrument makers in Germany began assembling together a variety of sundials like leaves in a book. Such an assemblage is called in German 'Büchsensonnenuhr', in English 'compendium' (pl. compendia). These were usually in miniature size to fit easily into one's pocket, yet accurate enough for actual observation, and made of gold- or silver-plated brass or copper for wealthy clients.[1654] Exquisitely crafted specimens can be seen in several European Museums.

In India, a few attempts were made in the nineteenth century to prepare compendia in which Sanskrit astronomical instruments were assembled. The first is a metal compendium in the form of a cylindrical casket (V001).

The second is a set of two wooden diptych sundials (V002 and V003) produced at Kuchaman during the reign of Maharaja Kesari Singh, ca. 1884. While the inner surfaces carried vertical and horizontal sundials as in the European diptych dials, the outer surfaces were designed as *Phalaka-yantras, Dhruvabhrama-yantras,* or sine quadrants.

The third example is a set of three rectangular wooden boards (V004, V005, V006) also produced at Kuchaman in 1896, during the reign of Maharaja Sher Singh. On these boards, the two sides were filled with the representations of *Phalaka-yantras* and *Dhruvabhrama-yantras.*

These wooden specimens were not fabricated by professional instrument makers, but by unskilled Brahmin astronomers; the workmanship is rather poor; the lines, circles, and the Devanagari letters and numerals were painted clumsily with thick brushes.

It is interesting that the instruments chosen for these compendia are the *Dhruvabhrama-yantra* and the *Phalaka-yantra*. The former, which was invented by Padmanābha around 1423, was a popular instrument and there are many extant

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[1654] Zinner 1979, pp. 98-102.

specimens of it; the instrument is described and the extant specimens are catalogued in the section L above.

In addition to these extant specimens, the *Dhruvabhrama-yantra* is represented also on the five wooden compendia (Figure Y002.4, Figure V003.5, Figure V004.3, Figure Y005.1, Figure Y006.1). However, these representations do not quite follow Padmanābha's instructions. In all the five cases, the *ghaṭī* scale on the outer periphery commences below the slit. The inner scales of the zodiac signs are divided in 12 equal parts and not according to the right or oblique ascensions. More strangely, while the *ghaṭī* scales run clockwise, the scales of the zodiac signs run anti-clockwise in three cases (Figure Y002.4, Figure V003.5, Figure Y005.1). The indexes are missing in three cases; there are indexes with just two arms in two examples (Figure V003.5 and Figure Y005.1), but these cannot function without a plumb. Slits are made in all examples, but these are too short and too narrow to view the stars α and β Ursae Minoris in one line. In two cases (Figure Y002.5 and Figure Y005.3), the *Dhruvabhrama-yantra* is accompanied by the same star table, but the connection between the two is not known.

The *Phalaka-yantra* is represented four times (Figure Y002.6, Figure V004.1, Figure Y005.4 and Figure Y006.4). It was invented by Bhāskara II in about 1150, but it was not so popular like the *Dhruvabhrama-yantra.* There are references to three actual specimens; in a fourth case, it was depicted on the back of an astrolabe (see section M above). Therefore, the four representations in these compendia here are of some importance. However, these too were not drawn exactly according to Bhāskara's specifications.

Bhāskara lays down that the 90 horizonal lines should be drawn on a rectangular board at equal distances and a circle with a radius of 30 units be described with the centre of the 30th horizonal line as the centre. But these four examples contain grids of rather haphazardly drawn horizontal and vertical lines with a graduated circle superimposed on them. According to Bhāskara, one end of an index should be pivoted at the centre of the circle. Here the middle of the index is pivoted to the circle in three cases (Figure V002.6, Figure V004.1 and Figure V006.4). Bhāskara envisages that the plate is suspended in a vertical plane; then there is no necessity of a compass; yet three specimens (Figure V002.4, Figure V004.1, Figure V005.4) are equipped with ready-made magnetic compasses.

For what purpose these compendia were fabricated must remain an enigma. If these were meant for demonstration in a class room, then there was no need to write long numerical tables on them. They appear to have been made more for amusement than for any practical use.

V001⊙ ASTRONOMICAL COMPENDIUM, NOT SIGNED, NOT DATED

19th century

Diameter 132 mm

London, Victoria & Albert Museum **(#** IM 471-1924) [1655]

The compendium is in the form of cylindrical casket. It is covered by a lid whose rim extends beyond the cylinder. Under the lid, there is a detachable marble disc which just fits into the cylinder. Below that a concave dial is permanently fixed to the cylinder. At the centre of the dial is a vertical gnomon. The lid as well as the marble disc are pierced with a hole at the centre so that the vertical gnomon can pass through the holes. There is a semi-circular plate with a ring at the centre of its diameter. Each of these parts is given a separate number, including the base.

The *Dhruvabhrama-yantra* (L018), which has been described above in the section L, is also given a number which is related to this compendium (IM 471.5-1924). It does not fit in the casket, but is stored along with it. The workmanship shows that it was fabricated by the same artisan who made the casket and the parts therein.

Lid (# IM 471.3-1924), d. 132 mm, is engraved with five concentric scales all starting from 234°. Counting from the outside, these are as follows:

1. Scale divided into 240 divisions, each representing ¼ *ghaṭī*
2. *Ghaṭī* scale, numbered from 1 to 60, with the 22nd *ghaṭī* commencing at 0°.
3. One-tenth parts of the zodiac signs shown in scale 6.
4. One-fifth parts of the zodiac signs, labelled 6, 12, …30, separately for each sign, in clockwise direction
5. Names of the zodiac signs; initials followed by the serial numbers: *me 1, vṛ 2* and so on.

These are the same scales which are engraved on the *Dhruvabhrama-yantra*. The only difference is that the outermost scale here shows ¼ *ghaṭīs,* while that in the *Dhruvabhrama-yantra* is marked for ½ *ghaṭīs.*

[1655] The Victoria and Albert Museum wrote to say that they do not permit the publication of private photography of their objects. Therefore, this entry regretfully does not contain my photos.

Marble disc (# IM 471.4-1924), d. 114, t. 4, also has a close resemblance to the *Dhruvabhrama-yantra.* There are 5 concentric scales; counting from the outside these are as follows:

1. *Ghaṭī* scale with 60 divisions which are not numbered.
2. Names of the lunar mansions (initials) marked at irregular intervals. Above each initial, there are some inlaid silver dots, which indicate the number of stars constituting that particular lunar mansion.
3. One-sixth parts of the zodiac signs in scale 5.
4. One-third parts of the zodiac signs labelled as 10, 20, 30, separately for each sign in clockwise direction
5. Names of the zodiac signs (initials followed by the serial number).

Concave Dial (# IM 471.1-1924) seems to be the main component of the compendium and is numbered accordingly. Four diameters, at intervals of 45° at the circumference, intersect at the centre. These are divided in 60 units and groups of 4 units are numbered serially from the periphery to the centre from 1 to 15. On the rim, these are numbered as 26 ½, 27, 28, 29, 30, 31, 32, 33 ½. At the centre of the dial is a vertical gnomon, 42 mm in length.

Semi-circular plate (# IM 471.6-1924) is equipped with a ring at the centre of diameter so that it can be pivoted to the gnomon of the concave dial. It can be moved along the surface of the concave dial so that it blocks half of the concave dial. The base is also given the number (# IM 471.2-1924) but it does not carry any engravings.

The compendium appears to have been made purely for demonstration and not for actual observation. The lid and the marble disc below it are equipped with scales as in a *Dhruvabhrama-yantra,* but these are non-functional without the horizontal slit and the index. The concave dial can be used to measure the solar altitude and azimuth, but only approximately. The semi-circular plate attached to it does not seem to serve any purpose.

BIBLIOGRAPHY

Anderson 1982, no. 134, p. 36.

V002 ASTRONOMICAL COMPENDIUM IN THE FORM OF A DIPTYCH BY JOŚĪ RĀMACANDRA, 1941 VS (AD 1884)

Kuchaman, Rajasthan
220 x 135 x 20 mm
Hastings-on-Hudson, NY, Tesseract

This diptych dial was apparently fabricated and painted by a Brahmin astronomer with his own unskilled hands and the surfaces were filled with diverse kinds of instruments and tables. The two wooden plates are crudely joined with a pair of hinges at one of the shorter sides. The surface is coated with a reddish pigment upon which the lines, circles and letters are written in yellow colour with a thick brush; a few times also in black colour. The legends are in Sanskrit and the script is Devanagari. Unfortunately much of the writing cannot be deciphered.

On the inner surfaces of the two plates, there are inscriptions to the effect that this diptych was made by Jośī Rāmacandra at the behest of Rao Bahadur Kesari Singh on some unspecified date in October or November 1884. Kesari Singh was the ruler of a minor princely state in Rajasthan, with its capital at Kuchaman which is roughly on the latitude of 27°. This town was an important centre of instrument production in Rajasthan. Several Sanskrit astrolabes produced here have been described in sections C and D (C034, D033 - D048). Kesari Singh is mentioned as the ruler of Kuchaman in astrolabe C034 which was completed on a date corresponding to 29 July 1883.

The diptych appears to have been designed to indicate time in *ghaṭīs* on the horizontal dial and in hours on the vertical dial, that too for four different localities, namely Kuchaman (27;10° N - 74;52° E), Kolkata (22;34° N - 88:22° E), Hyderabad (17;22° N - 78;28° E) and a fourth locality whose name is difficult to decipher. Therefore, four concentric *ghatī* scales are drawn on the inner sides of the lower plate and four different hour scales on the inner side of the upper plate. This seems to be a unique exemplar, for no other diptych dials are known which are designed for use at different latitudes.

When the two plates are spread apart so that they are perpendicular to one another, a string stretched between them functions as the gnomon. For this purpose, the string is so tied to the two plates that the angle between the string and the horizontal plate equals

the local latitude. In the present specimen, one end of a black string is attached to the centre of the inner surface of the upper plate and the other end to the lower part of the inner surface of the lower plate. On the upper plate, there are about 12 holes, so that the string can be attached at different points for different latitudes.

While the inner surfaces of the two plates are fashioned as the horizontal (A) and vertical (B) dials of the diptych sundial, the outer surfaces of the two plates are painted with the projections of the *Dhruvabhrama-yantra* (C) and *Phalaka-yantras* (D) respectively, thus making this diptych a compendium.

Besides the four projections, there are some tables and other writing on the surfaces. Much of this is undecipherable, in some places the colour has faded, at other places, grime has obscured the writing.



Figure V002.1 – Horizontal sundial on the inner surface of the lower plate
(photo courtesy Dr David Coffeen)

A. Horizontal Dial on the Inner Surface of the Lower Plate

Along the four edges of the plate are drawn four pairs of concentric scales for four different latitudes. All the scales are divided in *ghaṭīs* and numbered clockwise from 18 to 1 and from 1 to 18, so that they will indicate, in the forenoon, time in *ghaṭīs* to come until midday and, in the afternoon, time in *ghaṭīs* that have elapsed since midday. In parallel bands, each *ghaṭī* is subdivided into 6 units of 10 *palas* or 4 minutes each. The three outer pairs of scales are drawn in yellow while the innermost one is in black.

In the space within the scales is a concave brass cup, but without any markings on it; its purpose is not known. On the midday mark of the second scale as counted from the outside is embedded a magnetic compass.

Near the lower edge, there are four lines of writing, partly legible.

1. *vāraḥ* (weekday)
2. *palabhā* (equinoctial shadow).
3. *sa[ṃ]vat 1941 kā*
4. ?

One would expect to find here the value of the equinoctial shadow and/or the latitude for which the dial is prepared. If these are mentioned, they are not visible any more. The numbers in the third line refer to the year 1941 in Vikrama Saṃvat era (= AD 1884-85) and to the month is *kā[rtika]* = October / November. The fourth line may contain the number of the lunar day, but it is impossible to read. In any case, the instrument was manufactured sometime in October/ November 1884.

B. Vertical Sundial on the Inner Surface of the Upper Plate

On the inner surface of the upper plate is a partly oval dial with three pairs of concentric scales. A fourth pair is drawn somewhat lower than the three. All the scales are divided in modern hours of 60 minutes. On the left hand side they are numbered clockwise from 6 to 12 and indicate the hours from 6 am to 12 noon; on the right hand side from 1 to 7 to indicate the hours from 1 pm to 7 pm. In the parallel bands, each hour in the two outer scales is divided in 15 units of 4 minutes each; in the two inner scales into 6 units of 10 minutes each.



Figure V002.2 – Vertical sundial on the inner surface of the upper plate
(photo courtesy Dr David Coffeen)

At the top centre of the each scale is written the name of the place for the latitude of which this scale is intended. These legends are as follows. *kucāmaṇi ghaṃṭa 10, hadarāvāda ghaṃṭa 10, mamodū (?) ghaṃṭa 25* and *kalaka[ta] ghaṃṭa* ? (Kuchaman,

hours 10; Hyderabad, hours 10: Mamodi (?), hours 25; Kolkata, hours ?). It is difficult to identify the third locality. It is also difficult to explain what *ghaṃṭa 10* etc. mean; these '*ghaṃṭas*' are mentioned once again in the main inscription, but with different numerical values. Above the bottom of the fourth dial, there is one more short inscription in black: *kalakatā (?) 2250 vīkam*; its significance eludes us.

Inside the three pairs of scales, two clock hands are painted, one straight and another bent. Inside the fourth pair of scales there is another pair of similar clock hands. These painted hands naturally cannot move to show the actual time. They were probably added to indicate that the dials here show time in hours like the modern clocks.



Figure V002.3 – Inscription (photo courtesy Dr David Coffeen)

At the top of the plate, there are four lines of writing, which are difficult to decipher.

*(1) sūtra chāyā ghaṭi aṃkaḥ jñātanaṃ buddhi mā*pa*

(2) ṇāṃrtabha ghaṃṭakaṃ dṛṣṭvā majānāt pūrvato param |

*(3) kucāmaṇi 1 ghaṃ no ** kalakato 4 hadarābada 2*

(4) mahārājya-rāvabhādurajī śrī 108 śrī kesari siṃhajī kārājemaḥ josī rāmacaṃdraḥ varakārāḥ

Tentative Translation:

(1) string shadow *ghaṭī* number … …

(3) Kuchaman, 1 hour; Maṃmoi (?); Calcutta 4; Hyderabad 2

(4) Maharaja Rao Bahadur, the illustrious, 108 times illustrious, Kesari Singh-ji caused it to be made (?) [by] Jośī Rāmachandra Varakāra (?)

The first two lines appear to be a metrical verse, badly transcribed, which explains the function of the instrument. In the third line are the names of the four localities where the instrument can be used, viz. Kuchaman, Maṃoi (?), Calcutta and Hyderabad.



Figure V002.4 – Dhruvabhrama-yantra on the outer surface of the upper plate
(photo courtesy Dr David Coffeen)

C. Dhruvabhrama-yantra on the Outer Surface of the Upper Plate

The outer surface of the upper plate is designed as a *Dhruvabhrama-yantra*. A slit is cut through the two plates, close to and parallel to one of the shorter sides. Immediately next the slit are four graduated concentric circles. The outermost circle is divided into 60 *ghaṭīs*. These are numbered from 1 to 60, starting just below the slit and proceeding clockwise. Each *ghaṭī* is further subdivided into six units of 10 *palas* or 4 minutes each. The innermost circle is divided into 12 signs of the zodiac and numbered from 1 to 12, starting roughly at *ghaṭī* 45, but proceeding anti-clockwise. Each unit is divided into 5 divisions and again into 3 sub-divisions (= 2 degrees of arc). It is difficult to see the graduations on the two middle circles. There is a hole at the centre for the index, which is missing.

However, for a *Dhruvabhrama* the scales are not complete, nor are they correctly positioned. Since the slit is cut through the two plates, it will not be easy to view the two stars α and β Ursae Minoris through the slit.



Figure V002.5 – Unidentified table (photos courtesy Dr David Coffeen)

Just below the hinges, there is table occupying the entire width of the plate, in about 13 columns and 7 rows. Much of the table is effaced and cannot be deciphered. But it appears to be identical with the table written on compendium V005, where an attempt will be made to reproduce the table.



Figure V002.6 – Phalaka-yantra on the outer surface of the lower plate
(photo courtesy Dr David Coffeen)

D. PHALAKA-YANTRA ON THE OUTER SURFACE OF THE LOWER PLATE

The outer surface of the lower plate is designed as a *Phalaka-yantra.* Here a graduated circle is superimposed partly on a grid of horizontal and vertical parallels. The circle is divided into 60 divisions and numbered, not quite consecutively. One can see 26, 27, 28, 29, 30 followed by 6, 12, 18, 24, 30 and 36. In the outer band each of these groups is sub-divided into three parts. At the centre of the circle is pivoted a movable index, part of which is like a hollow tube and the rest a flat piece. A magnetic compass with lid is embedded on the left hand side.



Figure V002.7 – Numbers next to the graduated circle
(photo courtesy Dr David Coffeen)

In the upper corners, immediately close to the circumference of the circular scale are numerical tables on either side which are not clearly decipherable.

V003 ASTRONOMICAL COMPENDIUM IN THE FORM OF A DIPTYCH, ATTRIBUTABLE TO JOŚĪ RĀMACANDRA

Ca. 1884

170 x 110 x 20 mm

Hastings-on-Hudson, NY, Tesseract



Figure V003.1 – Diptych (photo courtesy Dr David Coffeen)

This wooden diptych sundial is not signed, nor dated, but the workmanship and the style of writing suggest that it must have made by the same Jośī Rāmacandra of Kuchaman who fabricated the previous specimen (V002). The two plates are joined at one of the shorter sides with a pair of hinges; there is a latch to lock the two plates together, when the diptych is not in use. The lines are drawn in yellow colour with a thick brush against a dark back ground; Devanagari numerals are also written in yellow colour with a thick brush.

This diptych is smaller in size and also less ambitious in the sense that there are no numerical tables or any other writings, except the projections of four different instruments. While the two inner surfaces carry vertical and horizontal sundials, the outer surface of the upper plate bears a *Dhruvabhrama-yantra* and the outer surface of the lower plate a sine quadrant.



Figure V003.2 – Horizontal sundial on the inner surface of the lower plate
(photo courtesy Dr David Coffeen)

A. Horizontal Sundial on the Inner Surface of the Lower Plate

The rectangular scale drawn along the four sides of the plate is divided in *ghaṭīs* and numbered clockwise from 18 to 1 and from 1 to 18, so that it will indicate, in the forenoon, time in *ghaṭīs* to come until midday and, in the afternoon, time in *ghaṭīs* that have elapsed since midday. In the parallel band, each *ghaṭī* is subdivided in 3 parts of 20 *palas* or 8 minutes each.

In the middle of the dial, an area in the form of the Roman letter U is excavated, for unknown reasons, and the space between the scale and the excavated area is painted red. A magnetic compass with a lid is embedded between the excavated part and the midday mark in the scale.



Figure V003.3 – Magnetic compass (detail of Figure V003.2)

B. Vertical Dial (?) on the Inner Surface of the Upper Plate

On the inner surface of the upper plate is painted an oval dial. It is divided in 24 units which are numbered anti-clockwise in large Devanagari numerals from 1 to 12 and again from 1 to 12 anti-clockwise. In the upper part, i.e. from 5 on the left to 8 on the right, each unit is divided into 6 parts, in the rest each unit is divided into 10 units. In the middle are painted two clock hands, one long and another short. One end of a black string, which functions as the gnomon, is attached to the centre of the dial; its

other end is tied to the lower part of the inner surface of the lower plate. This strange dial cannot serve as a vertical sundial like the one in V002.



Figure V003.4 – Vertical sundial on the inner surface of the upper plate
(photo courtesy Dr David Coffeen)



Figure V003.5 – Dhruvabhrama-yantra on the outer surface of the upper plate
(photo courtesy Dr David Coffeen)

C. DHRUVABHRAMA-YANTRA ON THE OUTER SURFACE OF THE UPPER PLATE

On the outer surface of the upper plate, an attempt is made to draw a *Dhruvabhrama-yantra* with two concentric circular scales and a slit close to and parallel

to one of the shorter sides of the plate. The outer scale is divided into 60 *ghaṭīs* and numbered from 1 to 60, starting below the slit and proceeding clockwise. Each *ghaṭī* is subdivided into 6 units of 10 *palas* or 4 minutes each. The inner scale is divided into the 12 zodiac signs and numbered from 1 to 12, starting roughly at *ghaṭī* no. 45, but proceeding anti-clockwise. Each sign is divided into 5 parts of 6° each and numbered clockwise as 6, 12, 18, 24, 30, and then further sub-divided into three parts of 2°. Pivoted to the centre is a crudely made index with two arms of unequal length. However, for a *Dhruvabhrama* the scales are not complete, nor are they correctly positioned. Since the slit is cut through the two plates, it will not be easy to view the two stars α and β Ursae Minoris through this slit. Moreover, without the plumb, the two-armed index will not move on its own to indicate the time or the related degree on the zodiac.



Figure V003.6 – Sine quadrant on the outer surface of the lower plate
(photo courtesy Dr David Coffeen)

D. Sine Quadrant on the Outer Surface of the Lower Plate

Leaving aside a border of about 30 mm at each of the shorter sides, the middle part of roughly 11 x 11 mm is carved in such a way that its surface is somewhat lower than the rest of the surface. On this low surface is drawn a sine quadrant with 30 horizontal and 30 vertical parallel lines at equal distances. The arc carries two scales, the inner one

is divided into 90 degrees and the outer scale into groups of 6° each and numbered serially from 1 to 15. A black string is tied to the apex of the quadrant with a plumb tied to the other end.

The horizontal dial on the inner surface of the lower plate and the sine quadrant on the outer surface are drawn rather correctly, but this cannot be said about the projections on the two surfaces of the upper plate, for the *Dhruvabhrama-yantra* on the outer surface and the dial on the inner surface are non-functional.

V004⦿ ASTRONOMICAL COMPENDIUM, NOT SIGNED

Saṃvat 1953 Vaiśākha sudi 3 (= 1896 May 15 Friday).

352 x 232 x 20 mm; weight 758 gm

Paris, PC

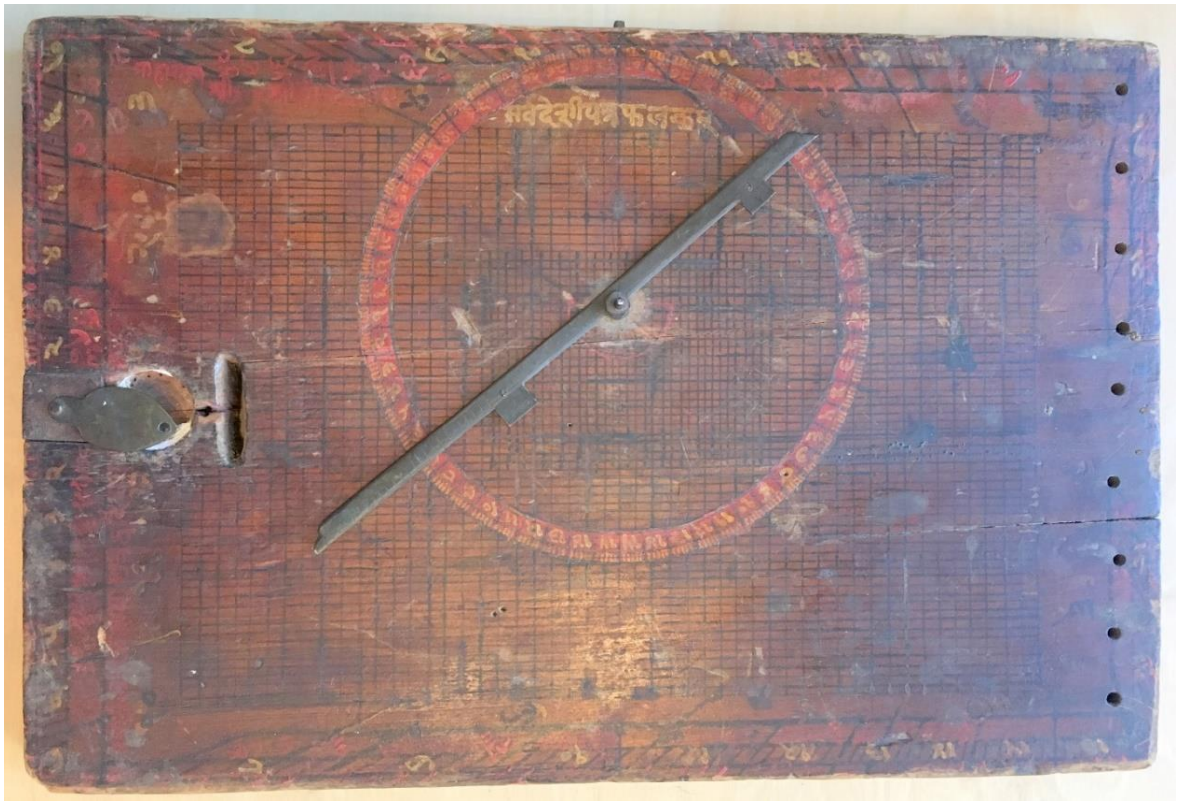


Figure V004.1 – Obverse side with the Phalaka-yantra (photo by Ananda Sarma)

This wooden rectangular board is made of some light timber; it is not well processed, even the surface and edges are not smoothened. A very small iron hook is affixed at the centre of one of the longer sides, obviously for suspending the board in a vertical plane. Holes are bored into the thick edge on all four sides. Nine holes are bored along the right rim at regular intervals; their purpose will be explained below in the description of the reverse side.

The board is given a brownish coating on which lines and letters are painted in black, red and white colours. Those in red have faded considerably and are particularly illegible. Lines are drawn mostly by hand without using any ruler and are not straight. Circles are drawn by a pair of compasses. On the reverse side, however, straight lines and circles are incised deeply in the timber. A large part of the writing got effaced in course of time and cannot be deciphered with certainty. The writing is Sanskrit in Devanagari script. Interestingly, both sides of the board display palimpsests.

OBVERSE SIDE

Originally the instrument maker intended to draw on this side a horizontal sundial as on Figure V003.2. For this purpose, he drew a *ghaṭī* scale with the centre of left side as the midday point, and numbered the *ghaṭīs* from this point onwards on both sides from 1 to 18 and divided each *ghaṭī* into 6 units of 10 *palas* or 4 minutes each. In the inner scale immediately adjacent to this *ghaṭī* scale, something else was written in red which is now indecipherable. Then he abandoned the idea of the horizontal sundial, and drew instead a *Phalaka-yantra*.

Inside this linear scale on the border, he drew a grid of 50 vertical lines and 66 horizontal lines upon which he traced a circle of 160 mm diameter in such a manner that it touches the upper edge. Inside the circle, there is a smaller grid in which the space between the horizontal and vertical lines is halved. The circle is divided in 1° and 6° and numbered in 6s in the following manner: in the lower half from 1 to 15, from the east and west points up to the south point at the bottom. In the upper half, from the east and west points up to the north point at the top as 6, 12, 18 … 90.

At the centre is pivoted an index; one arm has the same length as the radius of the circle (80 mm); the other arm is longer and measures 127 mm. At the top of the circle is the label *Sarvadeśīyantraphalakam*; it should actually read *Sarvadeśī-phalaka-yantram*. However, since the *Phalaka-yantra* is not latitude-specific and can be used at all latitudes, the epithet *sarvadeśī* (universal) is redundant.

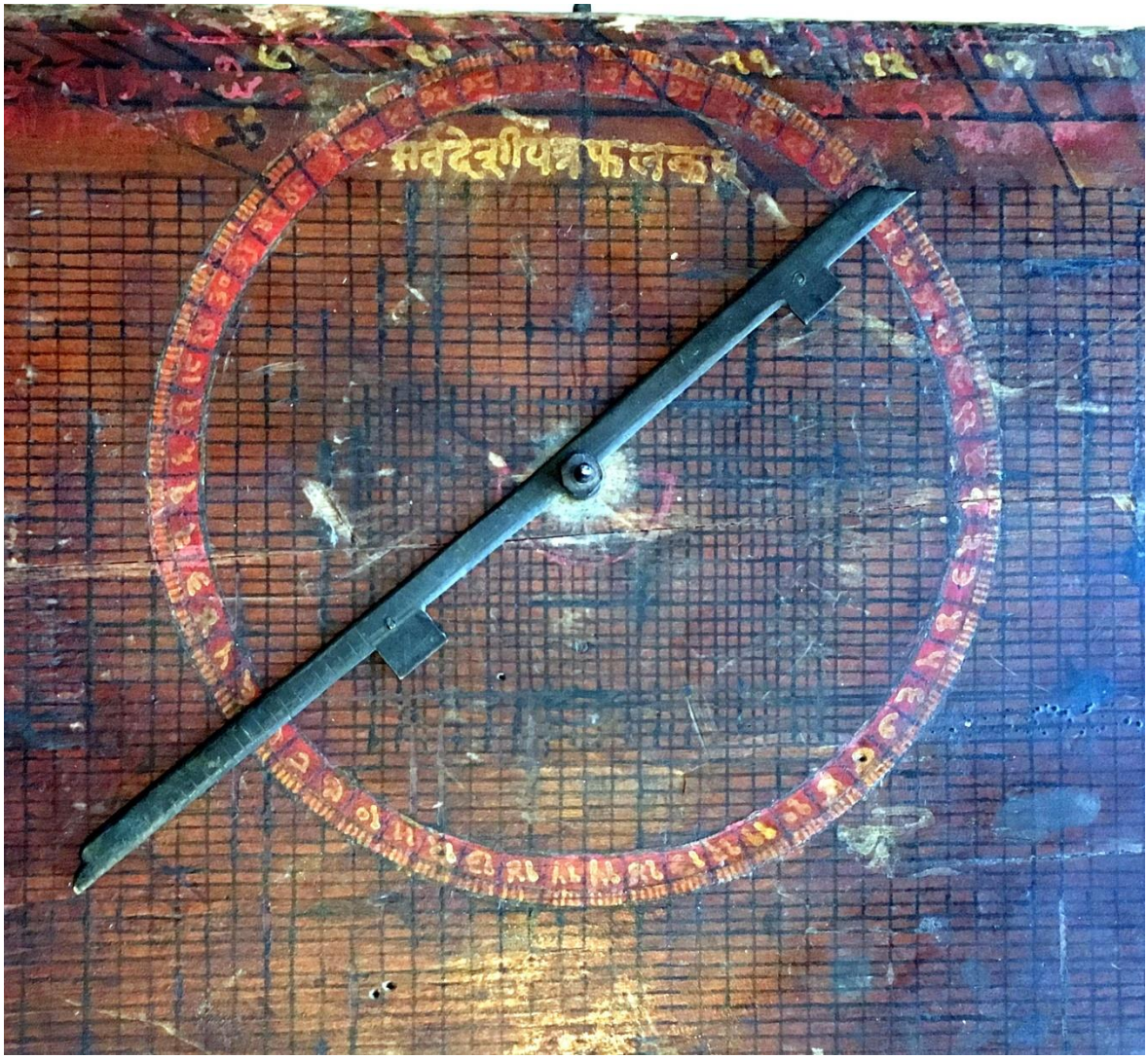


Figure V004.2 – Phalaka-yantra (detail of Figure V004.1)

Reverse Side

On the reverse side also, the instrument maker originally wished to draw the nine facets of a *Pratoda-yantra* or column dial, next to each other. For this purpose, he bored nine holes at regular intervals on the left hand side of the board for the insertion of the gnomon; below each of these holes, he drew *ghaṭī* scales for different solar months. He also added a label on the upper right corner *Pragopayantram* (sic! *Pratoda-yantram,* 'whip instrument' or column dial). The remnants of these scales can be seen in Figure V004.6.

Then he gave up the idea and drew instead a *Dhruvabhrama-yantra* with a slit parallel to the short side on the right.

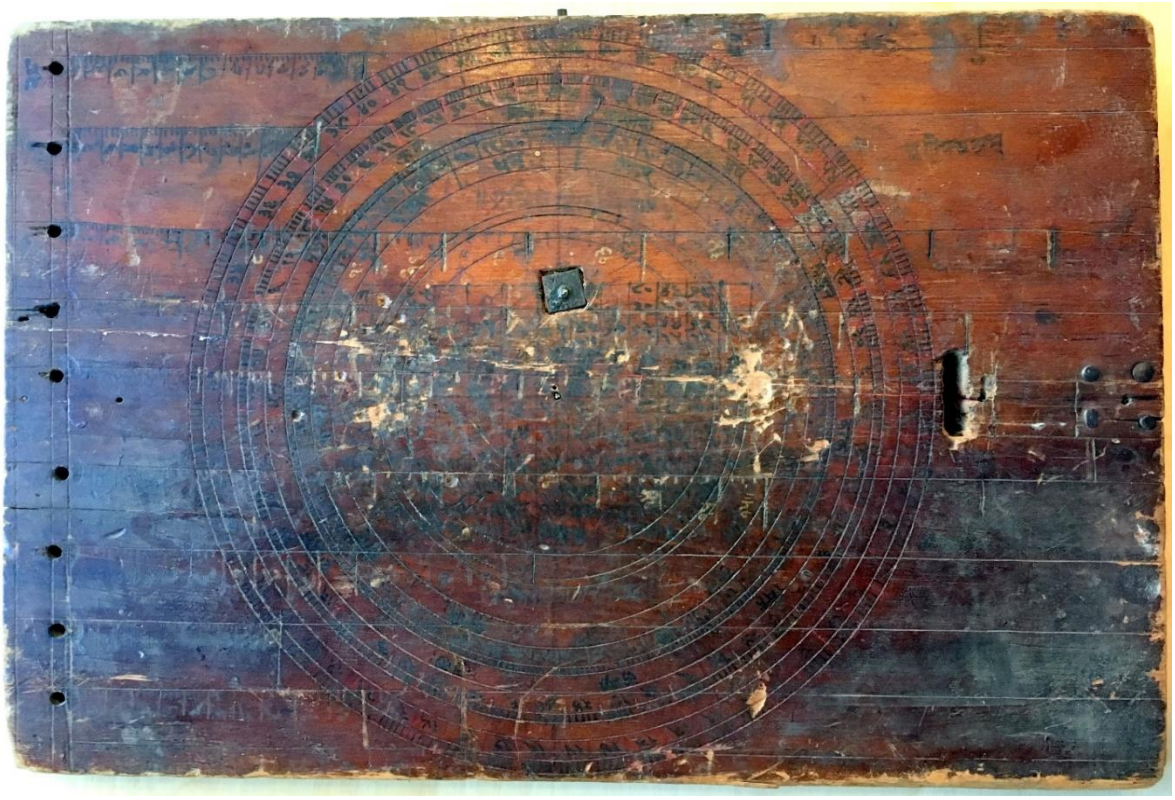


Figure V004.3 – Reverse side with the Dhruvabhrama-yantra (photo by Ananda Sarma)

The *Dhruvabhrama-yantra* is drawn with three sets of circular scales. The outer one is divided in 60 *ghaṭīs* and numbered clockwise from 1 to 60, starting at the slit. Each *ghaṭī* is divided in 6 units of 10 *palas* or 4 minutes each. The second set is divided in 12 zodiac signs and labelled with their names, starting at *ghaṭī* 46 and proceeding clockwise: *Lagna-meṣaḥ* (ascendant Aries), *Vraṣa* (! *Vṛṣa,* Taurus), *Mithuna* (Gemini), *Karka* (Cancer), *Siṃha* (Leo), *Kanyā* (Virgo), *Tulaḥ* (! *Tulā,* Libra), *Vraścika* (! *Vṛścika,* Scorpio), *Dhana* (!*Dhanuḥ,* Sagittarius), *Makara* (Capricorn), *Kuṃbha* (Aquarius) and *Mīna* (Pisces). Each sign is divided in 1° and 6° and groups 6° are numbered clockwise as 6, 12, 18, 24, 30, separately in each sign. The third set is divided similarly in signs, 6° and 1°, but the signs commence from *ghaṭī* 1 and proceed clockwise.

There should be a four-armed index at the centre of the circles, but it is missing. There is a broken nail at the centre, which is all that remains of the pivot.

Inside these circles can be seen faint traces of a numerical table. There is a heading of about 8 syllables; only the first two are legible *rātri* … (night …).



Figure V004.4 – Remnants of the column dial (photo by Ananda Sarma)



Figure V004.5 – Inscription on the left corner of the obverse side
(detail of Figure V004.1)



Figure V004.6 – Inscription on the right corner of the obverse side
(detail of Figure V004.1)

INSCRIPTIONS

On the upper left hand corner of the obverse side is written in red

mahārājya śrī 108 śrī serasiṃha-jī rā…

‘Mahārāja, the illustrious, the 108 times illustrious, Sher Singh-ji, …

On the upper right corner

kratāḥ (! kṛtaḥ) saṃvat 1953 vaiśākha sudi 3

‘Made [in] Vikrama Saṃvat 1953, on the third day of the bright half of the *Vaiśākha* [month] (= 1896 May 15, Friday).

V005⦿ ASTRONOMICAL COMPENDIUM, NOT SIGNED, NOT DATED

Ca. 1896

316 x 234 x 15 mm; weight 607 gm

Paris, PC



Figure V005.1 – Dhruvabhrama-yantra on the obverse side (photo by Ananda Sarma)

This wooden board is not signed, nor dated, but the workmanship and the writing are quite similar to those in the previous specimen (V004); therefore it must have been produced at Kuchaman by the same person and about the same time as the previous specimen.

Dhruvabhrama-yantra on the Obverse Side

The obverse side is fashioned almost like the outer surface of the upper plate in the diptych dial V002 with a *Dhruvabhrama-yantra* and a star table. The *Dhruvabhrama-yantra* consists of three sets of concentric circular scales drawn below the narrow horizontal slit. The outer set is divided into 60 *ghaṭīs* and numbered from 1 to 60, starting just below the slit; each *ghaṭī* is divided into 6 units of 10 *palas* or 4 minutes each. The middle set is divided in 12 zodiac signs and labelled with their names, starting at *ghaṭī* 46 and proceeding anti-clockwise; each sign is divided in 1° and 6° and groups of 6° are numbered also anti-clockwise from 6 to 30, separately in each sign. The third set of scales were drawn completely in red colour which has now faded and is illegible. It must have been marked with signs and their subdivisions, but with a different starting point.



Figure V005.2 – Detail of the scales in the Dhruvabhrama-yantra
(photo by Ananda Sarma)

There is a brass index; its two halves are of different length; the longer arm (115 mm) reaches up to the outer circle; the shorter arm (85 mm) reaches up to the second circle; there is a pointed tip inside this shorter arm which reaches up to the third circle.

At the top of the plate is a table in 8 rows and 13 columns, with the arguments in the last column. The table is reproduced below; for convenience, the columns are rearranged as rows and the rows as columns.[1656]

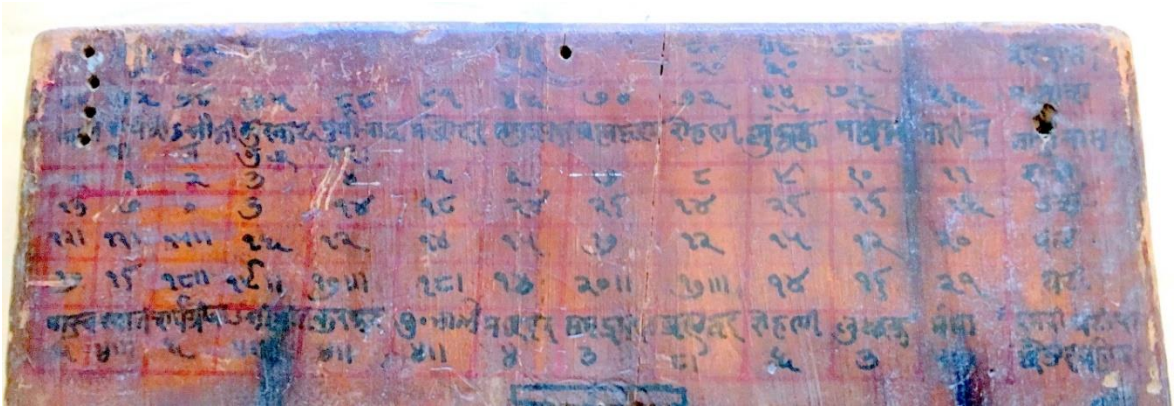


Figure V005.3 – Star Table (photo by Ananda Sarma)

Table V005-1 Star Table

?	**?**	**Star Name**		**sign**	**deg**	***pala***	***ghatī***			
-	-	---			17	12 ½	17	*Marīci*	η UMa	5
		Sarpagrīvā	α Ser	1	7	12 ½	19	*Svāt*	α Boo	4 ¾
	98	*Abhijīta*	α Lyr	2	0	15 ½	18 ½	*Sarpagrīvā*	α Ser	6
	195	*Kukkuṭa-puccha*	α Cyg	3	3	16	19 ½	*Abhijīta*	α Lyr	
	88	*Pūrvā Bhā-drapadaḥ*	α Peg	4	14	12	17 ¾	*Kurakuṭa*	α Cyg	4 ½
	81	*Machodara*	α And	5	18	14	18 ¼	*Pu.bhā*	α Peg	4 ½
?	46	*Samudra-pakṣa*	β Cet	6	24	15	14	*Machadara*	α And	2
	70	*Brahma-hṛdaya*	α Aur	7	29	17	20 ½	*Samudra-pakṣa*	β Cet	3
80 20	72	*Rohaṇī*	α Tau	8	14	12	17 ¾	*Brahma-hṛda*	α Aur	8 ¼
96 60	44 15	*Lubdhaka*	α CMa	9	29	15	14	*Rohaṇī*	α Aur	6
	72 ?	*Maghā*	α Leo	10	29	12	19	*Lubdhaka*	α Aur	3
	66	*Marīca*	η UMa	11	16	20	21	*Maghā*	α Leo	51

[1656] The Sanskrit star names are not correctly transcribed. These are reproduced as they are without making any attempt to correct them, but their modern names are added in adjacent columns.

It is difficult to say what this table is about. In V002 and here, the table is drawn next to the *Dhruvabhrama-yantra*, suggesting some connection between the two. The table contains the names of 12 astrolabe stars, and the related signs (in serial numbers), degrees, *palas* and *ghaṭīs*. It is not clear how *Sarpagrīva* (α Serpentis) is related to sign no. 1, i.e., Taurus, *Abhijit* (α Lyrae) to Gemini, *Kukkuṭa-puccha* (α Cygni) to Cancer and so on.

The star names are repeated in the penultimate column, but this time in a row below the one where they are mentioned first. The argument of this column states in Rajasthani dialect that 'at this *ghaṭī* there will be the rising [of the star?]'; this would imply that *Marīci* rises at 5 *ghaṭīs* (after sunset), *Svāti* after 4 ¾ *ghaṭīs, Sarpagrīvā* after 6 *ghaṭīs,* and so on.

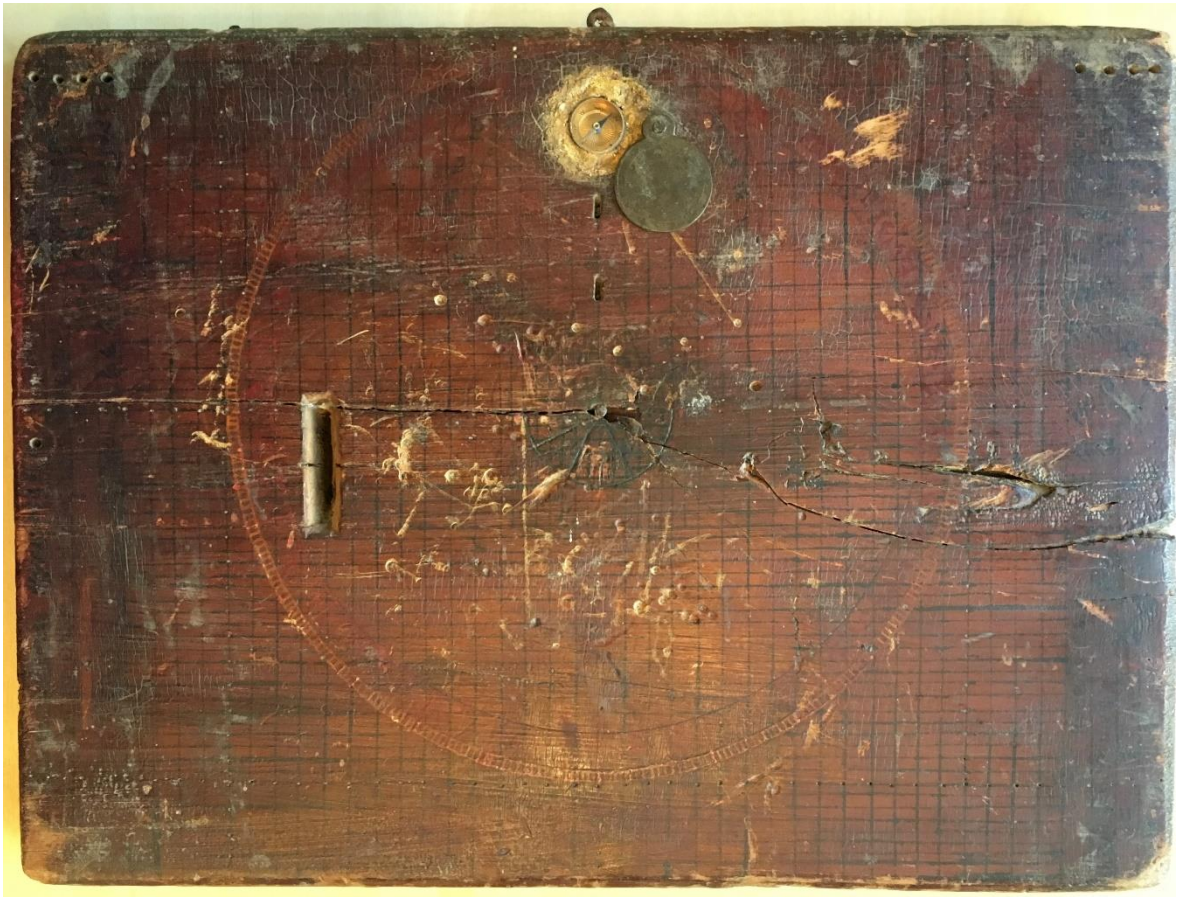


Figure V005.4 – Phalaka-yantra on the reverse side (photo by Ananda Sarma)

Phalaka-yantra on the Reverse Side

On the reverse side is drawn a *Phalaka-yantra* with a grid of 38 vertical lines and about 60 horizontal lines on which a circle of 200 m diameter is drawn. It is divided in single degrees. A smaller circle is drawn inside touching the upper point of the larger circle; it seems to have been divided in 1° and 6° and numbered in 6s. Another smaller

circle is drawn around the centre and divided into 8 segments. There must have been some kind of index at the centre; it is now missing.

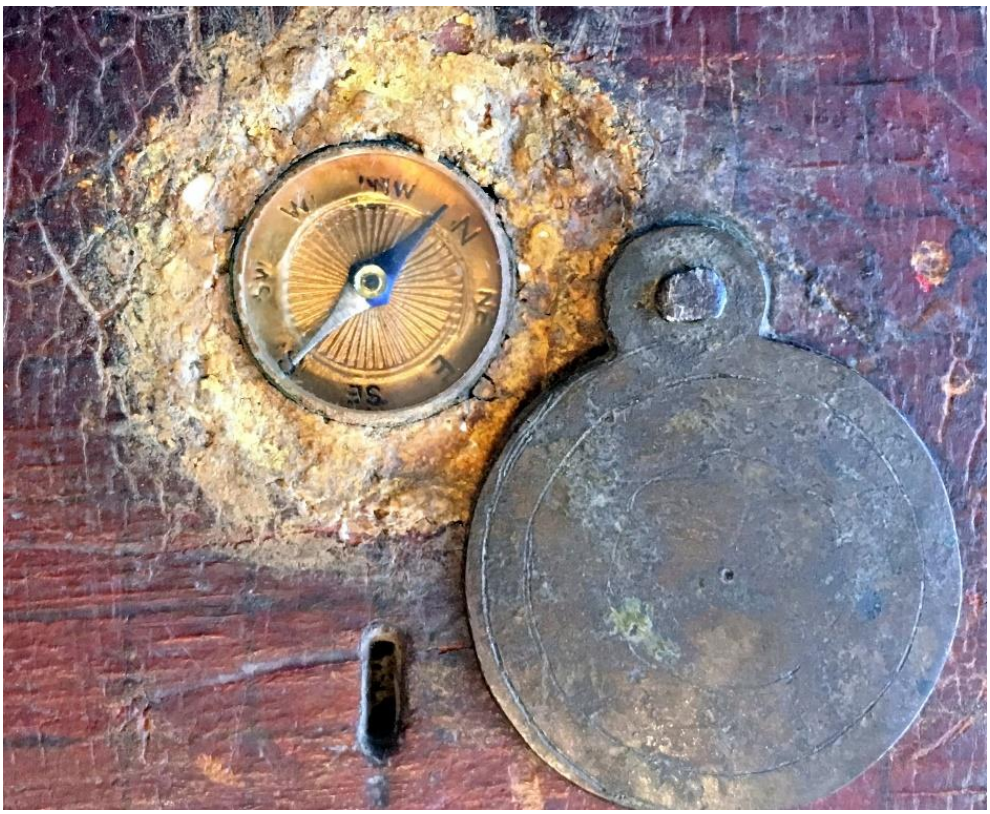


Figure V005.5 – Magnetic compass (photo by Ananda Sarma)

At the top of the circle, a modern magnetic compass is imbedded into the wood in a very crude manner. The four cardinal points and the four intermediate points are marked in Roman letters. It is placed in such a manner that NW is at the top. There is a sliding lid.

There are numerical tables on the left and right borders of the plate; but these are hardly visible.

V006⦿ ASTRONOMICAL COMPENDIUM, NOT SIGNED, NOT DATED

Ca. 1896

358 x 235 x 16 mm; weight 928 gm

Paris, PC



Figure V006.1 – Obverse side with a metal rete (photo by Ananda Sarma)

This wooden board is not signed, nor dated, but the workmanship and the writing suggest that it was produced at Kuchaman by the same person and about the same time as the two previous specimen (V004 and V005). As in V004, there is a small hook at the top for suspension. There are small holes all along the thickness in all the four sides.

OBVERSE SIDE

The obverse side is designed as a *Dhruvabhrama-yantra* with three sets of concentric circular scales below a longish slit and a star table as on Figure V002.4 and Figure V005.1. The outer set of scales are divided in *ghaṭīs* and numbered from 1 to 60, starting below the slit and proceeding clockwise; each *ghaṭī* is divided in 6 units of 10 *palas* or 4 minutes each. The middle set is divided in 12 zodiac signs and numbered serially from 1 to 12, starting at *ghaṭī* 46 and proceeding clockwise. Each sign is divided in 1° and 6°; groups of 6° are numbered clockwise as 6, 12, 18, 24, 30, separately for

each sign. Much of the inner ring is effaced; here also groups of 6° are numbered as above, but from a different starting point.



Figure V006.2 – Detail of the circular scales (photo by Ananda Sarma)

Strangely, instead attaching a four-armed index, a metal rete of an astrolabe is pivoted at the centre of the circles. The rete, which has a diameter of 168, displays a far superior workmanship than is seen on the wooden board. Here the three rings of Capricorn, ecliptic and equator are fully represented; these and a central ring are held together by the equinoctial bar which has a counter change at the centre; it is curved near the autumnal equinox to accommodate the star pointer of β Leonis. The equator ring has counter changes at the two equinoxes. In the northern part, it is connected to the Capricorn ring by three short bars. The ecliptic ring is not graduated; but endowed with a sharply pointed Capricorn index (*makarāsya*). From the rings and bars emanate 20 star pointers, which are elegantly shaped like curved daggers. These are not named, but can be identified from their positions. These are listed below in the order of increasing right ascension, starting from the vernal equinox and proceeding anticlockwise.

Table V006-1 Stars on the Rete

	Sanskrit Name	Arabic Name	Identification
1	*Samudra-pakṣī*	*Dhanab al-Qayṭus Janūbī*	β Ceti
2	*Matsyodara*	*Baṭn al-Ḥūt*	β Andromedae
3	*Pretaśira*	*Ra's al-Ghūl*	β Persei
4	*Rohiṇī*	*ᶜAyn al-Thawr*	α Tauri
5	*Mithuna-vāma-pāda*	*Rijl al-Jawzā' al-Yusrā*	β Orionis
6	*Brahma-hṛdaya*	*ᶜAyyūq*	α Aurigae
7	*Ārdrā*	*Yad al-Jawzā' al-Yumnā*	α Orionis
8	*Lubdhaka*	*Shiᶜrā Yamānī ya*	α Canis Majoris
9	*Lubdhaka-bandhu*	*Shiᶜrā Shāmīya*	α Canis Minoris
10	*Fard al-Shujāᶜ*	*Mahā-puruṣa*	α Hydrae
11	*Ẓahr al-Asad*	*Pūrva-phālgunī*	δ Leonis
12	*Uttara-phālgunī*	*Ṣarfah*	β Leonis
13	*Citrā*	*Simāk Aᶜzal*	α Virginis
14	*Pulaha* or *Vaśiṣṭha*	*Anwar al-farqadayn/ ᶜAnāq*	β / ζ Ursae Majoris
15	*Svāti*	*Simāk Rāmiḥ*	α Bootis
16	*Ra's al-Ḥawwā'*	*Dhanuḥkoṭi*	α Ophiuchi
17	*Abhijit*	*Nasr Wāqiᶜ*	α Lyrae
18	*Śravaṇa*	*Nasr Ṭā'ir*	α Aquilae
19	*Kukkuṭa-puccha*	*Dhanab al-Dajāja*	α Cygni
20	*Śatabhiṣā*	*?*	λ Aquarii

To the right of the rete, the entire board is filled with a large numerical table; it is very faint and cannot be deciphered.



Figure V006.3 – Faded numerical table (photo by Ananda Sarma)



Figure V006.4 – Phalaka-yantra (photo by Ananda Sarma)

REVERSE SIDE

The reverse side carries the projections for a *Phalaka-yantra,* with some 90 horizontal lines and 66 vertical lines in black. A circular scale is drawn so that its upper part touches the upper rim of the board. The scale is divided in 1° and 6°. Groups of 6° are numbered serially from 1 to 30 clockwise from the west point to the east point in the lower half. In the upper half, the scale is numbered as in the altitude scales on the back of astrolabes, i.e., in 6s from 6 to 90, starting from the east and west points and reaching up to the south point (6, 12, … 90; 90 … 12, 6).

To the centre of the circle is pivoted an iron bar, half of which is a tube; the other half is longer than the radius of the circle and is flat as in Figure V002.6.

W. MISCELLANEOUS INSTRUMENTS

INTRODUCTION

This section contains a few odd artefacts which cannot be placed in any other category. The first (W001) is an interesting lunar calendar in brass, engraved in Arabic/Persian, but of uncertain provenance. This is followed by a Sanskrit instrument named *Nalaka-yantra* also in brass. In 1915, when the Sanskrit Mahavidyalaya was established at the Maharaja Sarajirao University of Baroda to teach Sanskrit in traditional manner, some instruments were prepared as teaching aids for the classes of astronomy (*jyotiṣa*); this is one of those instruments; here the instrument maker gave a modern interpretation to the simple sighting tube.

Then follow three objects made in the shape of astrolabes. The first of these (W003) is carved in marble with an ornate *kursī* and engraved in Persian letters and *Abjad* numerals, displaying on one side the limb and a geographical gazetteer and on the other the usual configuration of tables to be found on the back of astrolabes. The other two (W004 and W005) are made of slate stone and engraved with circles and lines that are similar, but not identical, to those on astrolabes. These three stone items cannot be used either for observation, or for demonstration. They must have been made by some astrolabe makers or their apprentices to while away time

W001 ⊙ LUNAR CALENDAR, NOT SIGNED, NOT DATED

Diameters of three discs 86 mm, 66 mm, 48 mm

Oxford, Museum of the History of Science (# 25966)

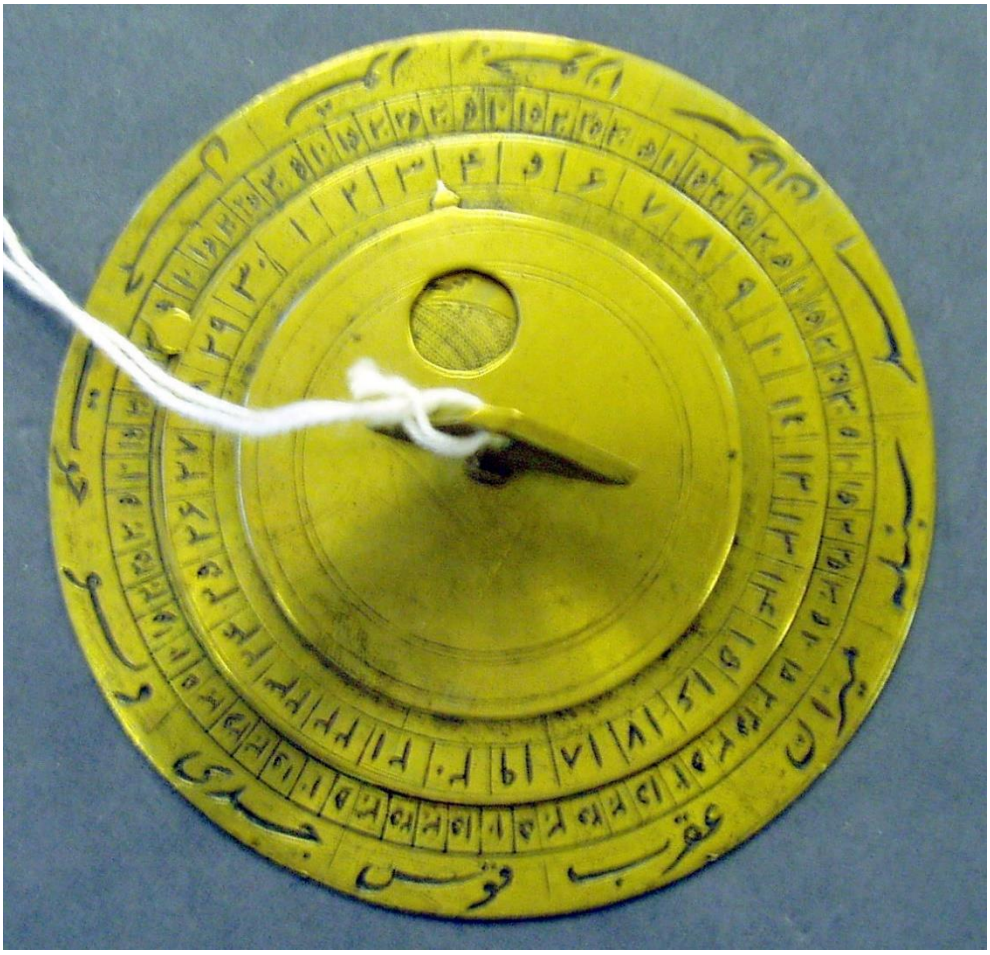


Figure W001.1 – Lunar calendar (photo by S. R. Sarma)

This lunar calendar displays the phases of the moon's orb on each day of the 30 days of the 12 solar months. It consists of three disc, each with a hole at the centre.

The rim of the lower and larger disc is divided into 12 parts and filled with the names of the zodiac signs arranged clockwise; in the inner band, each sign is divided in groups of 5° and numbered clockwise 5, 10, 15, 20, 25, 30 in common Arabic/Persian numerals.

The rim of the middle disc is divided in 30 parts and numbered from 1 to 30 clockwise in common Arabic/Persian numerals. At the division numbered 29 is an index with a sharp point to facilitate the rotation of this disc



Figure W001.2 – Middle disc (photo by S. R. Sarma)

A small circle is drawn around the central hole of this middle disc and a larger circle is placed eccentrically in such a way that the lower parts of the two circles touch at a point. The crescent-shaped portion between the two circles is hatched and embossed in the middle is the word *ijmāᶜ* (whole), meaning that at this point the full orb of the moon is visible. A diametrical line is drawn from 13 to 28 on the rim, which passes through the point where the two circles meet. On this line, towards 13 is written *muqābalah* (opposite point, where the lunar orb is not visible).

Another diametrical line is drawn at right angles to the previous one, on both sides of which are written the numerical figure 70 in *Abjad* notation, indicating that the visibility of the lunar orb at these points is 70%. Two other diametral lines are drawn from 3 to 18 and 8 to 23, on which 60 in *Abjad* is written towards 3 and 23, and an unidentified number towards 8 and 18.

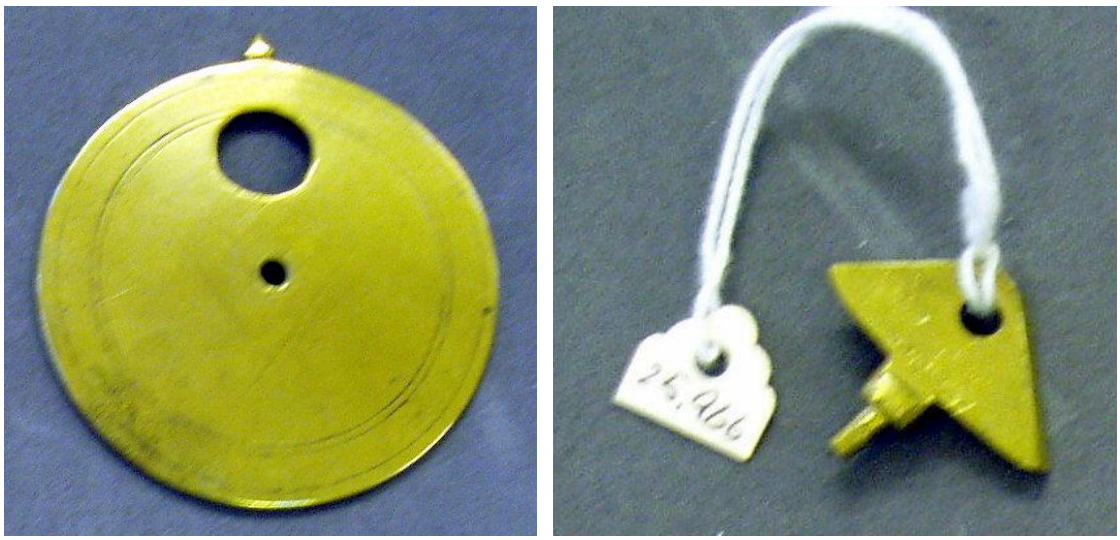


Figure W001.3 – Upper disc and handle (photo by S. R. Sarma)

The upper disc is endowed with the large hole through which the lunar phases are visible and an index to facilitate its rotation. Finally, at the top there is a triangular handle with a projecting pin below, which is inserted through the central of all the three discs to hold them fast.

Now, for viewing the phases of the moon on any given day, first the first middle disc is moved to the degree in the zodiac sign which is marked on the lower disk, where the sun is situated on that day; thereafter the upper disc is moved to the given day of the solar month marked on the rim of the middle disc. Then through the hole of the upper disc can be seen the phase of the lunar orb visible on that day.

The date and provenance of this device cannot be ascertained; it may have been made in north-western India, in Lahore or in its vicinity.

W002 ⊙ NALAKA-YANTRA, NOT SIGNED, NOT DATED[1657]

Early 20th century

Height 430 mm; base of the stand 427 x 290 mm; length of tube 398 mm

Vadodara, M. S. University of Baroda, Sanskrit Mahavidyalaya (# R.S.M.D. 100)

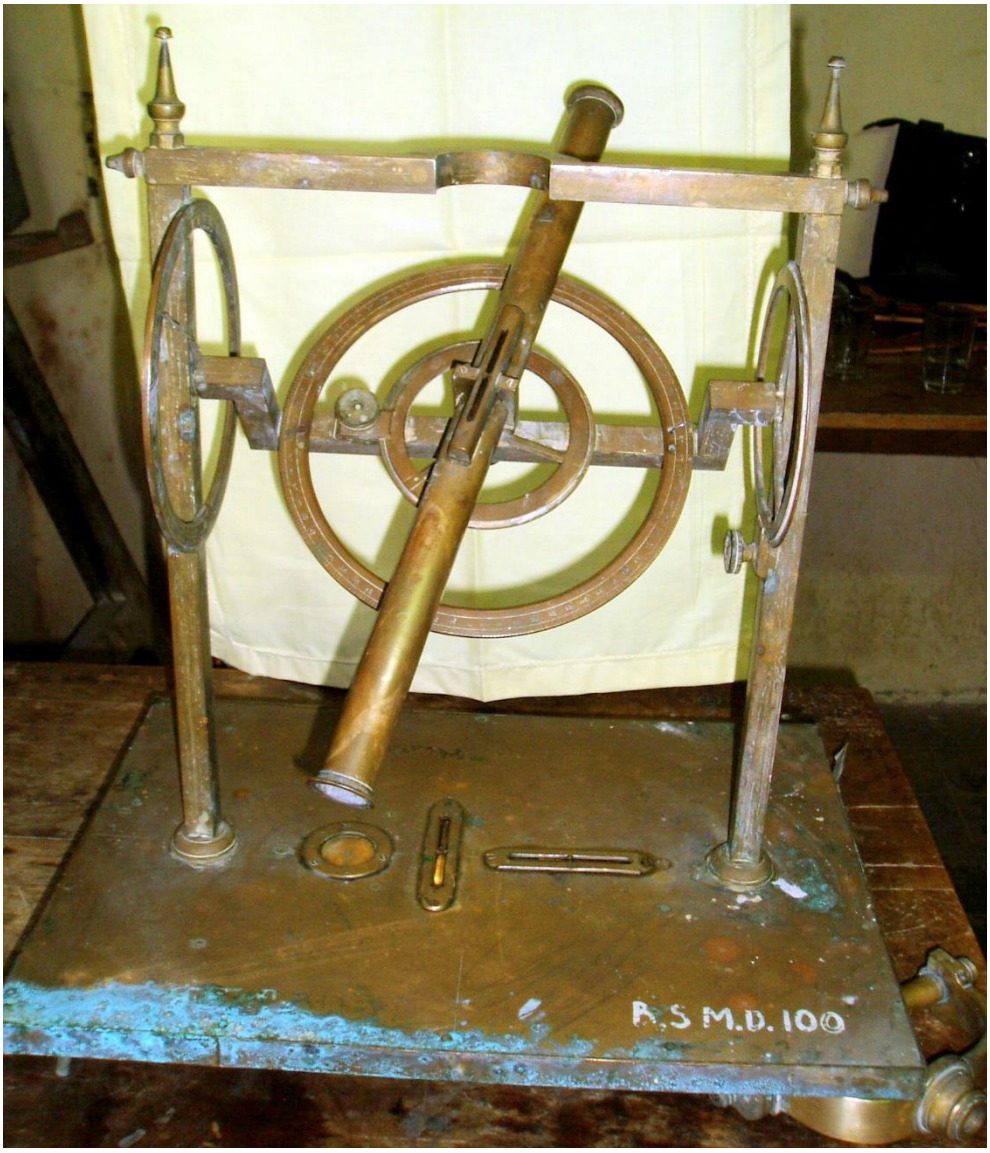


Figure W002.1 – Nalaka-yantra (photo by S. R. Sarma)

In Sanskrit astronomy *Nalaka-yantra,* also called *Nalikā-yantra,* is not an observational instrument but a tool for verifying computed planetary positions.[1658] That

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1657 This is an abridged and revised version of Sarma 2009a, pp. 16-18.

1658 Cf. Rai 1985, p. 333: 'Its use is only to verify the correctness of the computations of shadow and *bhuja.* If the computation is wrong, the planet will not be seen in the direction indicated by the values of the computed *bhuja* and *koṭi.*'

is why it is not discussed in the chapter on instruments (*Yantrādhyāya*) in the astronomical *siddhāntas*, but in the chapter dealing with three questions (*Tripraśna*). In the *Tripraśnādhikāra* of his *Śiṣyadhīvṛddhidatantra,* Lalla teaches how to verify the computed planetary positions by means of a hallow tube (*nalaka*) mounted upon two bamboo poles erected cross-wise in the ground so that the lower end of the tube is at the observer's eye-level. [1659] This procedure is adopted by Śrīpati in his *Siddhāntaśekhara* and by Bhāskarācārya in his *Siddhāntaśiromaṇi.* In the late medieval period, several small tracts were composed which deal with this *Nalaka-yantra.*

The present *Nalaka-yantra* is a modern version designed to measure the altitude (*unnatāṃśa*) and azimuth (*digaṃśa*). It works on the same principle as the modern theodolite, but is constructed differently.

The instrument contains a 398 mm long brass tube with a diameter of 20 mm, mounted on a stand consisting of a rectangular base (427 x 290 mm). In the base are incorporated two spirit levels at right angles to one another and a magnetic compass for the purpose of levelling and orientation. From the base rise two 430 mm high cylindrical pillars, which support a transverse horizontal bar on which the sighting tube is mounted. On the upper side of the tube is attached one more spirit level. Around the point where the tube is attached to the bar, a circular scale for measuring the azimuth is incorporated on the bar. The sighting tube can be rotated upon this circular scale (in the horizontal plane) by means of a screw. The scale is divided in single degrees, and groups of 5° are numbered in Devanagari, separately for each quadrant.

At the points where the transverse supporting bar touches the pillars, two graduated rings are attached to the pillars to measure the altitudes. The transverse bar can be rotated in a vertical plane by means of a screw attached to one of the pillars. When it is rotated, pins affixed to it move on the graduated rings and indicate the altitude. The altitude scales are graduated in single degrees, and groups of 5° are labelled as in the azimuth scale. Another transverse bar joins the tops of the pillars.

[1659] Lalla, part 1, pp. 80-83 (text), part 2, p. 99 (translation).

W003 ⊙ ASTROLABE-SHPAED MARBLE ARTEFACT, NOT SIGNED

Late 19th century

Diameter 206 mm, height 294 mm, thickness 24 mm

London, Nasser D. Khalili Collection of Islamic Art (# SCI 44)



Figure W003.1 – Marble astrolabe, gazetteer (photo by S. R. Sarma)

This object is fashioned out of marble like an astrolabe. It is not known whether the instrument maker had also made a rete, latitude plates and an alidade. What is extant is just the present piece comprising the *kursī,* limb, gazetteer and back. Engraved lines and letters are filled with some black pigment.

This specimen bears neither signature, nor a date. In the upper right quadrant on the back, there are curves for the midday solar altitude and for the times of the *ʿaṣr* prayers at the latitude of 30°. Therefore it is likely that this marble piece was produced in the vicinity of Multān, which city is situated roughly on this latitude. The mention of Calcutta in the geographical gazetteer would suggest late nineteenth century.

There remains the question why did the instrument maker choose marble instead of brass. It could not be a template or an object of demonstration prepared by a teacher who wished to show his apprentices how to make an astrolabe. The many faults in the gazetteer and in the shadow squares— attention to these will be drawn at the relevant places below— and the erratic use of the *Abjad* notation and the common Arabic/Persian numerals would indicate it to be the work of an apprentice astrolabe maker. But why did he not choose brass, which can be recycled if there are errors.

Front

The *kursī* is artistically shaped with a trifoliate finial. A small hole is bored in the finial for the suspension apparatus and around this hole is drawn a small circle. The south-north meridian line is extended upon the *kursī* up to the hole. Below the circle on the finial, on either side of the meridian line, are written the terms *khaṭṭ* (line), *ʿilāqaḥ* (cord) and *ʿurwah* (shackle). In the lower part of the *kursī* is an almost semi-circular pattern engraved from one side to the other. Inside the pattern is written the term *kursī.*

The limb is graduated for 1°, 3° and 6°. Groups of 6° are numbered clockwise from 6 to 90, separately in each quadrant.

Geographical Gazetteer

On the depressed part inside the limb is engraved a geographical gazetteer in two circles, each circle consisting of four circular columns carrying respectively the names of the localities (*bilād*), their longitudes (*ṭūl*), latitudes (*ʿarḍ*) and the names of the country or geographical area, together with the climate (*aqālīm*). There is no separate label for the country; the name of the country and the numerical value of the climate are mentioned together under *aqālīm.* While the terms *bilad, ṭūl* and *ʿarḍ* are in singular, the last term in the argument *aqālīm* is in plural. Moreover, this is perhaps the only geographical gazetteer where the country and the climate are mentioned in this manner.

Usually the arguments are written either to the left of the upper vertical radius or to the right of it, and the entries are added anti-clockwise so that they can be read from right to left. Strangely, in both the circles here, the arguments are written below the horizontal radius on the right. The localities are added at random without any meaningful sequence. In the table below where the gazetteer is reproduced, the localities are mentioned clockwise starting from the argument. The numerical values of the longitudes, latitudes and climates are often very incorrect; such cases are marked with an exclamation mark.

The letters are written in such a way that their tops are towards the centre of the disc. There is a large hole at the centre and a label *markaz al-ḥazrah* (centre of the limb).

Table W003-1 Geographical Gazetteer

	Place Name	L	φ	Country	Climate
	Outer circle				
1	Siyālkūt	108	32	Hind	3
2	Gujarāt	108;38	26	Hind	2
3	Kashmīr	107;8 !	43	Hind	3
4	Kalkatah	128	22;34	Hind	2
5	Kūfah	79	31!	ᶜIrāq	3
6	Lāhūr	109;30	31;50	Panjāb	3
7	Kowāliyār	114	28;36 !	Hind	2
8	Laknaū	114;40	36;30 !	Hind	3
9	Ludhiyānah	?;40	29;10	Hind	3
10	Madīnah	75;20	25;44	ᶜArab	4!
11	Madyan	33	23	ᶜArab	3

	Place Name	L	φ	Country	Climate
12	Miṣr	68;20	30;20	Miṣr	3
13	Makkah	77;10	21;40	ᶜArab	3
14	Munkīr	?	21	Hind	2
15	Harāt	94;22	34;30	Khurāsān	4
	Inner Circle				
16	Balkh	101;44	36;41	Khurāsān	4
17	Banāras	117;43	36 !	Hind	2
18	Bhūpāl	111	28 !	Dakan !	2
19	Pījāpūr	105;22	17;22	Dakan	2
20	Bayt al-Maqdis	66;30	31;55	Shām	3
21	Pashāwar	106;40	31	Hind	3
22	Tabrīz	102	34	Īrān	4

In the second row, the place name is given as ‘Gujarat’; it is not the name of a locality, but the name of a geographical region. In the penultimate column, Indian place names are marked with ‘Hind’, but Lahore is placed in Panjab, but not Ludhiana. Bijapur is correctly placed in the Deccan, but Bhopal’s placement there is not correct, nor is the high latitude assigned to this city. In row 12, the place name ‘Miṣr’ refers to Cairo or its earlier name Fustat ,while the country name ‘Miṣr’ indicates Egypt. The inclusion of Kolkata (formerly Calcutta) shows that the original source for the gazetteer is a fairly recent one.



Figure W003.2 – Back of the astrolabe (photo by S. R. Sarma)

BACK

The back is divided into four quadrants by the vertical and horizontal diameters. The vertical diameter is extended up to the hole in the finial of the *kursī.* Under the hole is engraved on either side of the vertical line the terms *khaṭṭ* (line), *ʿilāqaḥ* (cord) and *ʿurwah* (shackle). On the lower part of the *kursī* is an almost semi-circular pattern

engraved from one side to the other and inside the pattern is written the term *kursī,* as is done in the front.

The rim is divided in 1°, 3° and 6°. Groups of 6° are numbered from 6 to 90 in large *Abjad* symbols. In the two upper quadrants, the numbering starts from the horizontal diameter and reaches up to the vertical diameter; in the two lower quadrants, it starts from the vertical diameter and reaches up to the horizontal diameter. Inside the degree scale, each quadrant is halved by shorter diameters.

The upper left quadrant is fashioned as a trigonometric quadrant. The vertical radius to the right of the quadrant is divided in sixty parts; groups of three parts and groups of six parts are marked with longer lines. From the marks of the division into six parts of the radius, horizontal parallels are drawn up to the arc, dividing the quadrant into ten segments of six units each. These are numbered sometimes in *Abjad* notation and sometimes in common Arabic/ Persian numerals: 6, 24, 30, 36, 42, 54 and 60 are in *Abjad* notation, the rest in common numerals.

The upper right quadrant is designed as the zodiac quadrant, with six quarter circles dividing the upper part of the quadrant into as many segments, each representing a pair of zodiac signs, whose names are written to the right of the upper vertical radius and above the horizontal radius on the right. The names written to the right of the upper vertical radius are the following, read from top to the bottom: *Qaws* (Sagittarius)*, ᶜAqrab* (Scorpio)*, Mīzān* (Libra), *Sunbulah* (Virgo), *Asad* (Leo), *Sarṭān* (Cancer); above the horizonal radius are the following names, from right to left: *Jadī* (Capricorn), *Dalw* (Aquarius), *Ḥūt* (Pisces), *Ḥamal* (Aries), *Thawr* (Taurus), *Jawzā'* (Gemini).

Three curves are superimposed upon the quarter circles. The uppermost one indicates the solar altitude at midday throughout the year at the latitude of 30°; it is labelled *khaṭṭ niṣf al-nahār bi-ᶜarḍ 30* (line of the midday [altitude of the sun] at the latitude of 30°). The two lower curves are labelled respectively as *khaṭṭ ᶜaṣr sāmiᶜ bi-ᶜarḍ 30* and *khaṭṭ ᶜaṣr* …(?) *bi-ᶜarḍ 30*. They appear to have been drawn to indicate the times of the commencement and the conclusion of the afternoon prayer *ᶜaṣr* throughout the year at the same latitude. However, without a time scale, it is not clear how these would indicate the times.

In the lower half, immediately below the horizontal diameter, are the shadow squares. It is the usual practice to place the vertical and horizontal scales for the shadows

thrown by the gnomon of seven feet on one side of the vertical diameter and the scales for the gnomon of 12 digits on the other side. Here these four scales are mixed up.

On the left the vertical scale is for the gnomon on 12 digits; it has the label *ẓill aṣābiᶜ sullam maᶜkūs* (scale of the reverse shadows in digits); it is divided in 6 parts and numbered top to bottom 2, 4, 6, 8, 10, 12. The horizontal scale is for the gnomon of 7 feet; it carries the label *ẓill aqdām sullam mustawī* (scale of the direct shadows in feet); it is divided in 7 parts and numbered, from the vertical diameter leftwards 1, 2, 3, 4, 5, 6, 7.

On the right, the horizonal scale is for the gnomon of 12 digits; it carries the label *ẓill aṣābiᶜ sullam mustawī* (scale of the direct shadows in digits); it is divided in 6 parts which are numbered, from the vertical diameter towards the right as 2, 4, 6, 8, 10, 12. The vertical scale is for the gnomon of 7 feet; it is labelled as *ẓill aqdām sullum maᶜkūs* (scale of the reverse shadows in feet); it is divided in 7 parts which are numbered from the top as 1, 2, 3, 4, 5, 6, 7.

The horizontal scale on the left is projected on to the circular scale which is situated below the degree scale and the units are numbered as above. The horizontal scale on the right is also projected upon the same circular scale; this scale is divided in four parts which are numbered from the vertical diameter onwards as 2, 4, 6, 12 in common Arabic/Persian numerals.

The shadow squares are enclosed by two semi-circular scales, the inner one engraved with the names of the 12 zodiac signs from *Ḥamal* to *Ḥūt* and the outer one with the names of the 28 corresponding lunar mansions from *Sharṭān* to *Rishā'*.

BIBLIOGRAPHY

Maddison & Savage-Smith 1997, no. 135, pp. 236-238.

W004 ASTROLABE-SHAPED STONE ARTEFACT, NOT SIGNED

19th century

Diameter 218 mm, height 253 mm, thickness 12 mm

Chicago, Adler Planetarium & Astronomy Museum (# W-273)



Figure W004.1 – The front and back of the astrolabe (accession no. W-273)
Photograph by Stephen Pitkin, Pitkin Studio. Image © Adler Planetarium, Chicago, IL.

This and the next specimen are cut out of thin sheets of dark slate stone in the shape of an astrolabe with a circular body and a triangular *kursī* and engraved with scales and other circles which resemble those found on astrolabes. The *kursī* in the present specimen is nicely shaped with ogees in both profiles; the *kursī* in the next one is plain. The engravings on the front side of both pieces are nearly the same, but those on the back are totally different.

FRONT

In the present specimen, the rim of the circular body carries a scale graduated in 6°; it is numbered in the two upper quadrants from 6 to 90, starting at the horizontal radii on both sides and reaching up to the vertical radius. The numbers on the lower quadrants cannot be deciphered. This circle corresponds to the circle of Capricorn on regular astrolabes, and the numbering of the upper two quadrants is akin to that in the altitude scales on the back of astrolabes.

A horizontal diameter is drawn with parallel lines above and below it. Beneath this horizontal band, can be seen a semi-circular band which is concentric to the outer circle.

It is also divided like the outer circle, but not numbered. This corresponds to the equatorial circle on astrolabes.

In the upper half is a third circular scale, represented by three concentric circles. This would correspond to the ecliptic circle in astrolabes, with provision for the names of the zodiac signs and for the subdivisions of these signs. Inside this circle are a series of circles and arcs that resemble the almucantars in a regular astrolabe. Besides these, there are several other arcs which have no correspondence in regular astrolabes.

Three neat holes are bored on the upper surface, but not through the entire thickness, at the centre of the plate, at the centre of the circle in the upper half of the plate and at the point on the horizontal diameter where the semi-circular scale touches it on the left.

BACK

On the reverse side is a large circle in the upper half inside which are engraved a series smaller of circles. From the centre of the larger circle are drawn a series of arcs. In the lower half is a triangle with its vertex pointing downwards; this triangle is divided into four smaller triangles which are numbered from 1 to 4.

INSCRIPTIONS

On the *kursī* is engraved 1799 in Devanagari numerals and below it *a[ṃ]bara vedhaśālā.* Amber is the name of the original capital of the Jaipur state and *vedhaśālā* is Sanskrit means literally ‘hall of astronomical measurement’, that is to say, observatory. But this is a neologism and there is no evidence of this term being used by Jai Singh for any of his observatories. The year 1799 is presumably of the Vikrama era and corresponds to AD 1742-43. Sawai Jai Singh, it may be noted, died in 1743.

The *kursī* of the next item carries the date 1634 which translates to AD 1577-78; the writing below cannot be deciphered in the available photo; presumably it also reads *a[ṃ]bara vedhaśālā.*

From the mode of construction and the style of engravings and the shape of the numerals, it is quite obvious that these two pieces were made by the same artisan and about the same time in the nineteenth century, either at Jaipur or at Kuchaman which are the two main centres of astrolabe production in Rajasthan.

The artisan who made these appears to be a competent draftsman; the circles are very neatly drawn and the divisions in the scales are uniform. He appears to have chosen the dates and the name *Ambar Vedhaśālā* quite arbitrarily.

These cannot be called fake astrolabes prepared for the tourist market. It is more likely that an astrolabe maker made these stone objects for his personal amusement, in between his work on regular astrolabes.

BIBLIOGRAPHY

Pingree 2009, p. 242.

W005 ASTROLABE-SHAPED STONE ARTEFACT, NOT SIGNED

19th century

Diameter 203 mm

PLU, ex-Tesseract

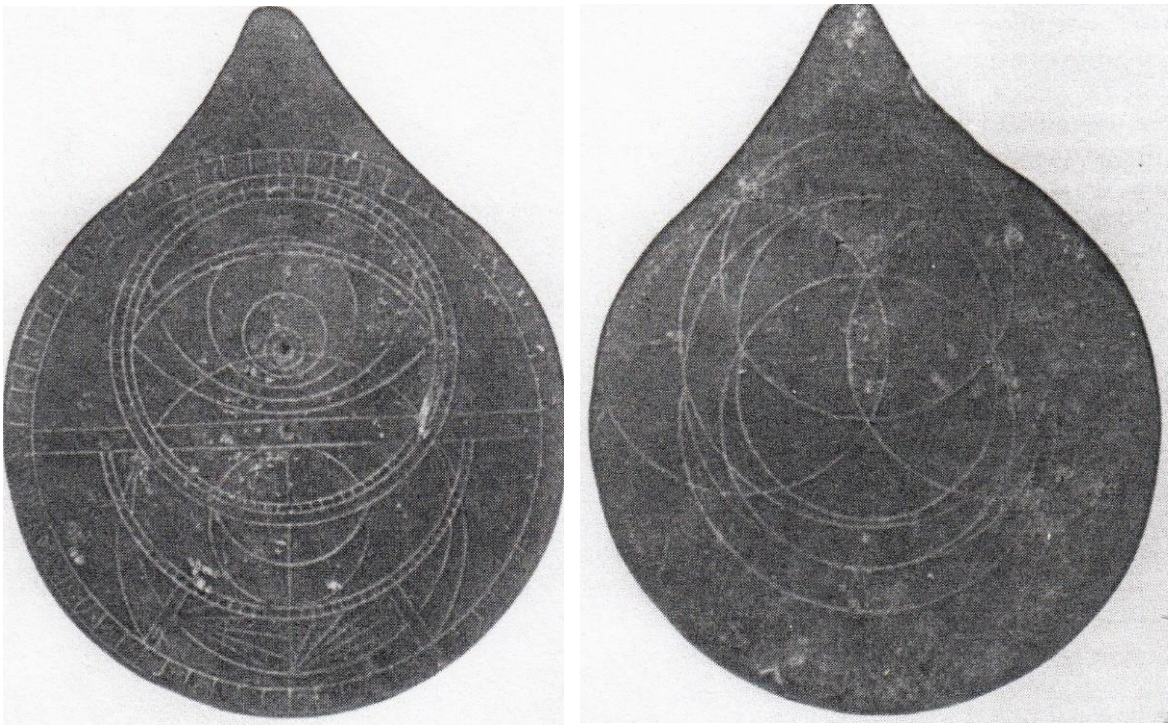


Figure W005.1 – The front and back of the astrolabe (from Tesseract Catalogue, C36)

This specimen has a plain conical *kursī.* The first side is engraved, like the front side of the previous specimen, with circular scales resembling the circles of Capricorn, equator and ecliptic, and with several other sundry curves. The outer circle is divided in 6° and the divisions of the two upper quadrants are numbered from 6 to 90, clockwise on the left and anti-clockwise on the right. The horizontal diameter is represented by two parallel lines. As in the previous specimens, here also three holes are bored in the upper surface at the centre of the plate, at the centre of the upper circle and on the horizontal diameter where the lower semi-circle meets it on the left.

The engravings on the back are different from those of the previous one. Here are drawn several intersecting circles.

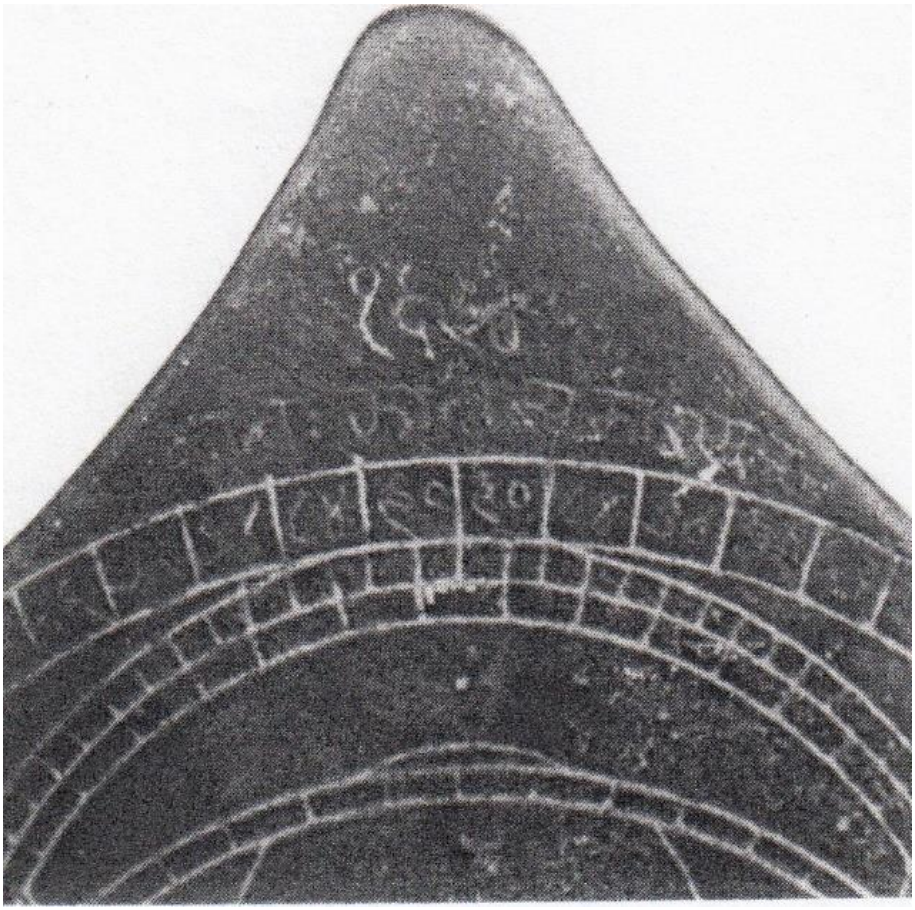


Figure W005.2 – The inscribed kursī
(from Tesseract catalogue, C36)

The *kursī* bears the date 1634 which would correspond to AD 1577-78; the writing below the date cannot deciphered. On the fictitious nature of this date, see the comments at the end of the preceding entry.

BIBLIOGRAPHY

Tesseract Catalogue, C36, no. 23

X. INDIAN ADAPTATIONS OF EUROPEAN INSTRUMENTS

INTRODUCTION

In the nineteenth century, as has been mentioned earlier, instrument makers continued to produce traditional Sanskrit and Islamic instruments. They also began copying, for reasons that are not completely clear, European models of some obsolete naked eye instruments and engraved on them legends in Sanskrit or Persian.

UNIVERSAL EQUINOCTIAL DOUBLE RING DIALS

This device consists of two rings placed one inside the other; the inner one is pivoted to the outer one in such a manner that the two can be stretched apart until they are at right angles to one another, or folded flat when not in use. The outer ring functions as the meridian ring and the inner one as the equatorial ring. The rim of the two upper quadrants of the meridian ring are graduated in degrees and numbered from 1 to 90, starting from the two points where the two rings are joined. These scales in the two quadrants allow the use of this instrument at the northern as well as the southern latitudes.

The lower part of the equator ring is marked with a symmetrical pair of hour-scales.

A horizontal bridge is attached to the meridian ring at the two points of 90° in such a manner that it can be rotated on its sides. This bridge is a flat rectangular piece of metal with a long slit running through its length. The bridge carries a calendar scale on one side and a declination scale on the other. Inside this slit is a sliding plate containing a small hole through which a ray of sunlight passes and a small knob which assists in moving the plate inside the slit.

The meridian ring carries a groove all around on its rim. The suspension bracket clasps the meridian ring in the groove; the two legs of the clasp can be tightened with a screw. By turning this screw the clasp can be loosened and moved to the desired degree of latitude and then tightened. To the bracket is attached a large ring for suspension.

For measuring time, the suspension bracket is fixed at the latitude of the place of observation and the two rings are stretched apart until they are at right angles. The sliding plate is moved so that the pinhole is at the solar longitude corresponding to the

day of observation. Then the dial is suspended by the ring and slowly turned around until a ray of sunlight passes through the pinhole and falls on time scale on the equatorial ring, and thus indicates time.

The invention of this universal double ring dial is generally attributed to the English mathematician William Oughtred (1574-1660) who published a description of it in 1652. He is credited with the invention of the slide rule and the introduction of the symbol ‘x’ for multiplication and the abbreviations ‘sin’ and ‘cos’ for sine and cosine functions. However, it is not quite certain that he was the real inventor of the universal double ring, because it was described or illustrated in European documents which are earlier than the alleged invention by Oughtred.

This universal equinoctial double ring dial can be used at all latitudes without the aid of compass, can be folded flat and carried easily. However, suspending it steadily until a ray of sunlight passes through the tiny pinhole is not an easy job. Even so, it was quite popular in Europe and specimens of various sizes can be found in all the European museums. Even now one can buy small pocket models, such as the one below, which has an outer diameter of just 46 mm.



Obverse side with the latitude scale on the outer meridian ring and time scale on the inner equatorial ring. Note that the mark on the suspension bracket is pointing to 51°, the latitude of Düsseldorf.



Reverse side; on both rings are engraved the names of various cities in Europe with their latitudes.

Figure X1 – Modern pocket double ring dial (photos by S. R. Sarma)

Some specimens brought to India by the British colonial officers must have aroused the interest of local astronomers and metal-smiths and several Sanskrit versions were produced in the nineteenth century. All the extant specimens are reasonably well made and the labels are correctly engraved. In the time scale, instead of hours, the traditional Indian units of *ghaṭīs* (of 24 minutes) are employed, with a range of 17 *ghaṭīs* before and after noon; in X001, however, the range is 20 *ghaṭīs*.

One side of the bridge is engraved with the Sanskrit names of zodiac signs, from solstice to solstice, on the panels above and below the long slit, in the following manner.

On the upper panel above the slit are engraved the names of the six signs from the winter solstice to the summer solstice, which constitute the *Uttarāyaṇa,* the northern course of the sun, namely Capricorn, Aquarius, Pisces, Aries, Taurus and Gemini.

On the lower panel below the slit are engraved the names of the six signs from the summer solstice to the winter solstice, which constitute the *Dakṣiṇāyana* (southern course of the sun), namely Cancer, Leo, Virgo, Libra, Scorpio and Sagittarius; these are written in the reverse order, that is, from right to left. Quite often, instead of the full names of the signs, only the first syllables of the names are engraved.

The reverse side of the bridge is engraved with pairs of declination scales, which are marked in single degrees and numbered in sixes thus: 24, 18, 12, 6, 6, 12, 18, 24.

It is not known when and where these Sanskrit ring dials were produced. Only one of the extant specimens (X005) carries what appears to be a personal name and a date. The name, however, cannot be deciphered, except the last syllable *sya*; it is genitive singular particle used in the sense of ‘of’ or ‘belonging to’. Therefore, the name must be the name of the owner, that is, the person for whom it was made. The date reads *Saṃvat* 1922 which corresponds to 1865-85. It is reasonable to assume that the other specimens were also produced about the same time, roughly in the second half of the nineteenth century. The workmanship and particularly the form of the numerals indicate that all these specimens were produced in Rajasthan, and probably in Jaipur itself. In fact, one of the specimens (X003) was said to have been purchased from the astrologer of the Maharaja of Jaipur.

At present, we know of 10 specimens; six of these must have been produced in Rajasthan in the second half of the nineteenth century. There are two specimens in

silver; these must have been produced by the jewellers of Jaipur in the twentieth century for foreign tourists, the same jewellers who produced silver astrolabes (D028 to D032).

There are also two Indo-Persian ring dials. One of these (X009) is a large specimen with scales numbered in *Abjad* system and the bridge engraved with the Arabic names of the zodiac signs. Interestingly, the equatorial ring carries a pair of time scales numbered from 1 to 17; therefore, the units must be *ghaṭīs* and not hours. Thus this scale is similar to the time scales on the Sanskrit ring dials. Therefore, this ring dial must also have been produced in India and in the same milieu as the Sanskrit dials.

In the second Indo-Persian ring dial (X010), the meridian ring is engraved with common Arabic/Persian numerals on one side and with modern 'English' numerals on the other side. The equatorial ring carries an hour scale, numbered in Roman numerals on both sides.

Even though these Sanskrit ring dials are endowed with *ghaṭī* scales, they do not quite conform to the time-measuring practices of the Hindu astronomers or astrologers, because they measure time in *ghaṭīs,* but starting from the local sunrise. Therefore, instruments which measure *ghaṭīs* from the midday backwards or forwards do not serve their purpose. These were produced merely as curiosities.

Universal Equinoctial Sundials made by Mangaran

Mangaran of Patna, who claims to be a worthy pupil (*shāgird-i rashīd*) of Lālā Makhan Lāl, produced several nearly identical copies of the same type of an unusual universal equinoctial sundial between the years 1275/ 1858-59 and 1303/ 1885-86. The dial is unusual because it is engraved on a rectangular brass sheet which was bent to form a semi-cylindrical trough. A gnomon set perpendicular to the axis of the dial on one side of the trough throws its shadow on the scales engraved on the inner side the trough. Time can be measured on these scales both in hours of 60 minutes and *ghaṭīs* of 24 minutes. The trough is mounted on a stand at the back of which there is an arc graduated in single degrees which are numbered from 10° to 50°. By sliding the trough along the arc up to the desired degree, the sundial can be adjusted according to the local latitude. A magnetic compass is attached to the base of the stand so that the sundial can be correctly positioned on the north-south axis.

This was obviously copied or adapted from a European model. The Time Museum, Rockford, owned a French sundial in which the dial was engraved also on a bent

rectangular metal sheet. It was sold in an auction by Christie's of London on 14 April 1988; the catalogue of that auction describes the sundial thus:

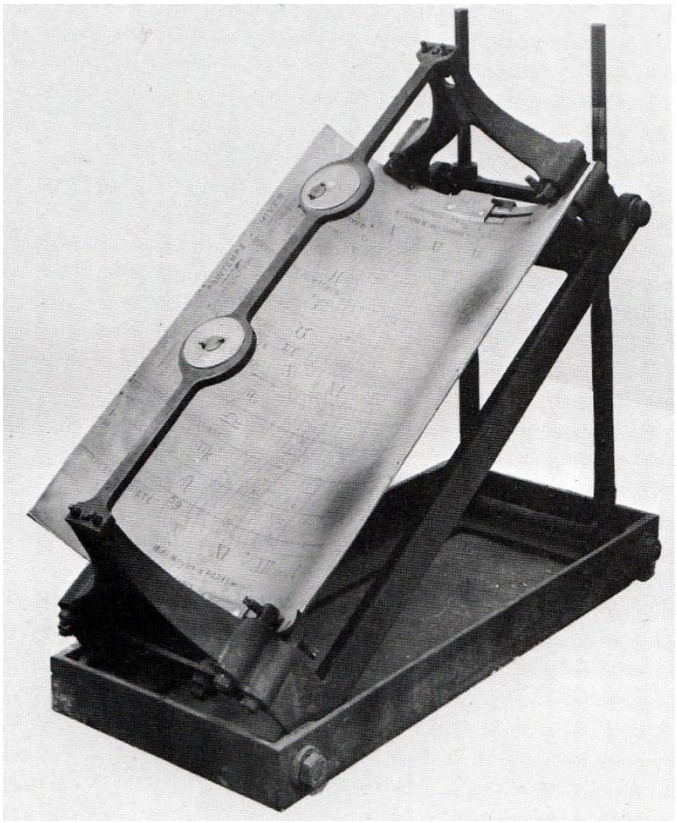


Figure X2 – Sundial by Louis Alphonse Decohorne (from Christie's catalogue)

> 'A French iron and brass meantime sundial, the frame on the base with scroll supports and adjustable for declination via hinged screw thread supports, the crossbar with twin apertures, the concave plate engraved with hours, the meridian of Paris, adjustable vernier for latitude East and West, the season's equinoxes and zodiac calendar scale, and with descriptive plaque for the *Régleur Solaire, Système Decohorne Breveté S. G. D. G.,* the stand — 46 ½ in (118 cm).'[1660]

However, the prototype of this device was designed by Louis Alphonse Decohorne in 1891, i.e., much later than the dates of the known pieces by Mangaran. Therefore, both Mangaran's and Decohorne's sundials must be based on an earlier European model, which is not known.

[1660] Christie's, London, *Time-Measuring Instruments from the Time Museum,* auction catalogue of 14 April 1988, lot 116, p. 61.

A dealer in Lucknow told me in 2001 that he had a dozen specimens of this sundial by Mangaran and that he had sold off all but one.

At least, six of these came to light. Khuda Bakhsh Oriental Public Library of Patna owns a specimen dated 1275/1859 (X011); Victoria and Albert Museum, London, has one of 1284/1868 (X012); another dated 1295/ 1878 came up for auction at Sotheby's, London, on 24 October 2007 (X013). Moreover the French catalogues of a dealer named 'Tazan', whom I cannot identify, carry photos and brief descriptions of two more copies dated 1293/1876-77 and 1303/1885-86 respectively. Just now came to light a silver specimen made jointly by Mangaran and his pupil Ram Charan in 1292/1875 (X014); this was commissioned by a zamindar of Patna and was presented on 4 January 1876 to the Prince of Wales during the latter's tour of India.[1661]

Mangaran seems to have specialised only in making copies of the same device, for no other instrument made by him came to light, nor any instrument made by his teacher Lālā Makhan Lāl. All the specimens made by Mangaran display excellent workmanship. It is not known how the European prototype reached him at Patna.

All the specimens carry an almost identical inscription in Persian. The inscription on the specimen at Patna reads: 'The maker of this compass is Mangaran, worthy pupil of Lālā Makhan Lāl, resident of the locality Mainpura in the city of Patna.' Other copies do not mention the residence; they merely state: 'The maker of this compass is Mangaran, worthy pupil of Lālā Makhan Lāl.'

Mangaran's teacher Lālā Makhan Lāl and his pupil Rām Charan have Hindu names; Mangaran must also be a Hindu. In nineteenth century India, it was not unusual that many Hindus used Persian as their professional or academic language. In two specimens, which are in the Khuda Bakhsh Library of Patna and in the Victoria & Albert Museum in London, Sanskrit names of the twelve zodiac signs are engraved on the outer surface of the dial in Devanagari script. The various scales are numbered in what were

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[1661] Some of the gifts received by the Prince of Wales during his tour of India are the subject of a special exhibition entitled 'Splendours of the Subcontinent: A Prince's Tour of India 1875-6' being held at several places in the UK in 2017-18; there is a catalogue of the exhibition with the same title, viz. Meghani 2017.

called in nineteenth century India ‘English numerals’; these are now variously designated as ‘Hindu-Arabic numerals’ or ‘Arabic numerals’.

However, certain features of these sundials are quite intriguing.

(i) Sanskrit names of the zodiac signs are engraved on the outer surface of two copies, the one at Patna and the other at London, for no practical purpose.

(ii) The upper parts of the gnomons are engraved with a numbered scale, the purpose of which remains unknown.

(iii) All the specimens carry an inscription in Persian which begins with the words ‘the maker of this compass is Mangaran’. The specimens are, no doubt, equipped with a magnetic compass, but these universal equinoctial sundials are much more than mere compasses. Why did Mangaran then call them compasses?

(ii) Besides the magnetic compass for the correct placement of the sundial in the north-south axis, the sundials are equipped with a mechanism which enables the use of the sundial at different terrestrial latitudes. At each latitude, the gnomon must point towards the celestial north pole; for this purpose, it must subtend an angle equal to the latitude of the place above the horizontal plane. Therefore, the trough carrying the dial must be tilted so that the angle between it and the horizontal plane is the complement of the terrestrial latitude, i.e., the co-latitude. The curved bar at the back of the stand is engraved with a scale of co-latitude from 0° to 50°. The trough must be tilted along this scale and the screw tightened at the desired degree of co-latitude.

However, since the scale is marked only up to the colatitude of 50°, the sundial can be adjusted only for the terrestrial latitudes of 40° or more. Thus it cannot be used any latitude in India. For example, if the sundial is to be used at Patna which has a latitude of at 25.6°, then the gnomon should be elevated from the horizontal base by an angle of 25.6°; this can be done only when the trough carrying the dial is raised by an angle equal to the co-latitude of the place, which in this case is (90° – 25.6° =) 64.4°. This is not possible with this curved scale which is marked only up to 50°.

In the silver specimen made for the Prince of Wales, the scale of co-latitude is marked up to 60°; therefore it can be used at places with the latitude of 30° or more. This cannot be used at Patna, but could be used in Lahore, and definitely in London if the Prince of Wales was inclined to do so.

It is highly intriguing why Mangaran produced so many specimens with unsuitable scales of co-latitudes, which cannot be used anywhere in the Indian subcontinent. Did he not understand the simple principle of latitudes and colatitudes? Or did he make these exclusively for the British clients who could use them in England?

Perpetual Calendar & Horary Quadrat by Joshi Dharm Chand

European months of 28/29, 30, or 31 days do not synchronise with the weeks of seven days. Therefore, perpetual calendars are designed to provide the matching weekday for any date in the European calendar. The idea is said to have originated with Samuel Moorland (1625-95) of England, who arranged the dates in cycles of seven with appropriate instructions for locating the weekday for the desired date. Small copper or silver discs, carrying such information, were produced in good numbers and were known as 'coin calendars'.[1662]

In India, perpetual calendars for 3, 30, or 100 years are among the souvenirs offered for sale. Made in the shape of an astrolabe at Muradabad, a north Indian town famous for its production of brassware, these perpetual calendars consist of a circular disc with enamelled decorations in the border. A smaller circular disc with windows cut in it is pivoted at the centre of the main disc, so that the smaller disc rotates above the surface of the main disc, partly blocking and partly revealing the engraved numerical data on the main disc. The design of this perpetual calendar is clearly of European origin, but the path of its transmission from Europe to India has not been mapped so far.

[1662] Turner 1993-94.



Figure X3 – Perpetual Calendar for 2001-2100 made in Muradabad;
here it is set for October 2017 (photo by S. R. Sarma)

Joshi Dharm Chand of Lahore (*fl.* 1854-73) appears to be one of the intermediaries in the transmission of perpendicular calendars to India. In 1860s and 1870s he produced some devices with perpetual calendars on one side and horary quadrants on the other. At present, we know of five specimens made by him; three of these are engraved in Persian letters and numerals and two with English letters and numerals.

The earliest of these (X015) is dated 1918 VS (AD 1861-62); here Dharm Chand calls this device a 'new invention' (*ikhtirāᶜ naw*). It consists of a main plate which is shaped like an astrolabe with a *kursī* and two volvelles. It provides the weekday for any date in the European calendar, but in order to use this, one should find out from another source on which weekday the first of the month in question falls or at least the first of January in that year falls. This is the same case with the chronologically second extant specimen (X016) which is dated 1929 VS (AD 1872-73).

The third extant specimen (X017) inscribed in Persian represents an advanced version. It is not dated, but it must have been produced some time after 1873. It is engraved with the years 1 to 100, i.e., 1801 to 1900. Its construction is also simplified in that it contains just a single volvelle, instead of the two in the earlier versions. Here one can easily find out the weekday for any date of any month in any year from 1801 to 1900. The two other extant specimens (X018 and X019) are basically English versions of this X017. Between this specimen and the modern products of Muradabad, there lie some more stages of development . We would not know about these stages until more specimens of the intermediary stages are discovered.

Besides providing the weekday corresponding to the given date in the English calendar, all the five specimens provide a table of equivalence between the first date of each English and the corresponding day in the Hindu solar months. This is necessary for Hindu *Jyotiṣīs* who were freshly exposed to the English calendar. They needed to understand the new English months in terms of the familiar Hindu solar months. Otherwise, this data does not serve any calendrical purpose. This data is absent in the modern perpetual calendars of Muradabad.

Horary Quadrant on the reverse

The reverse side of these five specimens are designed as horary quadrants. Here *ghaṭī* scales for different solar months are engraved in all the four quadrants of the circular disc in the same manner as in the *Yantrādhipati* designed by Sawai Madho Singh of Jaipur (T001). Here also the five specimens represent two stages of development. With X015 and X016, one can measure the ascendant also, in addition to the time of the day. The other three (X017, X018 and X019) contain three additional scales for finding out the culmination. Thus these specimens combine Madho Singh's *Yantrādhipati* and Padmanābha's *Dhruvabhrama-yantra.* Dharm Chand designated this new creation as the 'Mirror of Heavens' (*āyinah-i falqī*) in X017.

In the Persian specimens, Dharm Chand employs common Arabic/Persian numerals and not *Abjad* notation; his dates are in the Vikrama era; for the Hindu solar months, he uses the names current in Panjab.

Circumferentor by Joshi Dharm Chand

Circumferentor is a surveying instrument widely used in Europe, UK and in the British colonies before it was superseded by the theodolite. Dharm Chand prepared two Indian versions (X020 and X021) of which only parts are extant.

Mechanical Clocks adapted for India

I have noticed four cases of mechanical clocks which were adapted to show Indian astronomical parameters.[1663] The first (X022) is set up in the Saraswati Bhavan Library of the Sanskrit University at Banaras. The dial carries scales for hours, *ghatis*, *palas* (with labels to the effect) and three hands for pointing these three time units. On the dial face is written 'Synchronome'.

The second (X023) is a highly elaborate astronomical clock in the Ramnagar Palace of the Maharaja of Banaras. It was made in 1872 by the state clockmaker named Mulchand. 'It shows not only the correct time of the day but also the position of the sun and the phases of the moon together with the signs of the zodiac and the date of the month and year.' A smaller version of this astronomical clock (X024) was presented to the Prince of Wales when he visited the Maharaja on 5 January 1876.

Finally, a private collector in Leeds owns several dials and plaques (X025) which were once part of an astronomical clock which is now dismantled.

[1663] I did not search for these systematically. I noticed these four purely by chance. There may be many others in Indian Royal palaces or in the Salar Jung Museum of Hyderabad which has a large collection of clocks.

X001 SANSKRIT UNIVERSAL EQUINOCTIAL DOUBLE RING DIAL

Not signed, not dated, 19th century

Diameter 140 mm

PLU, ex-Tesseract

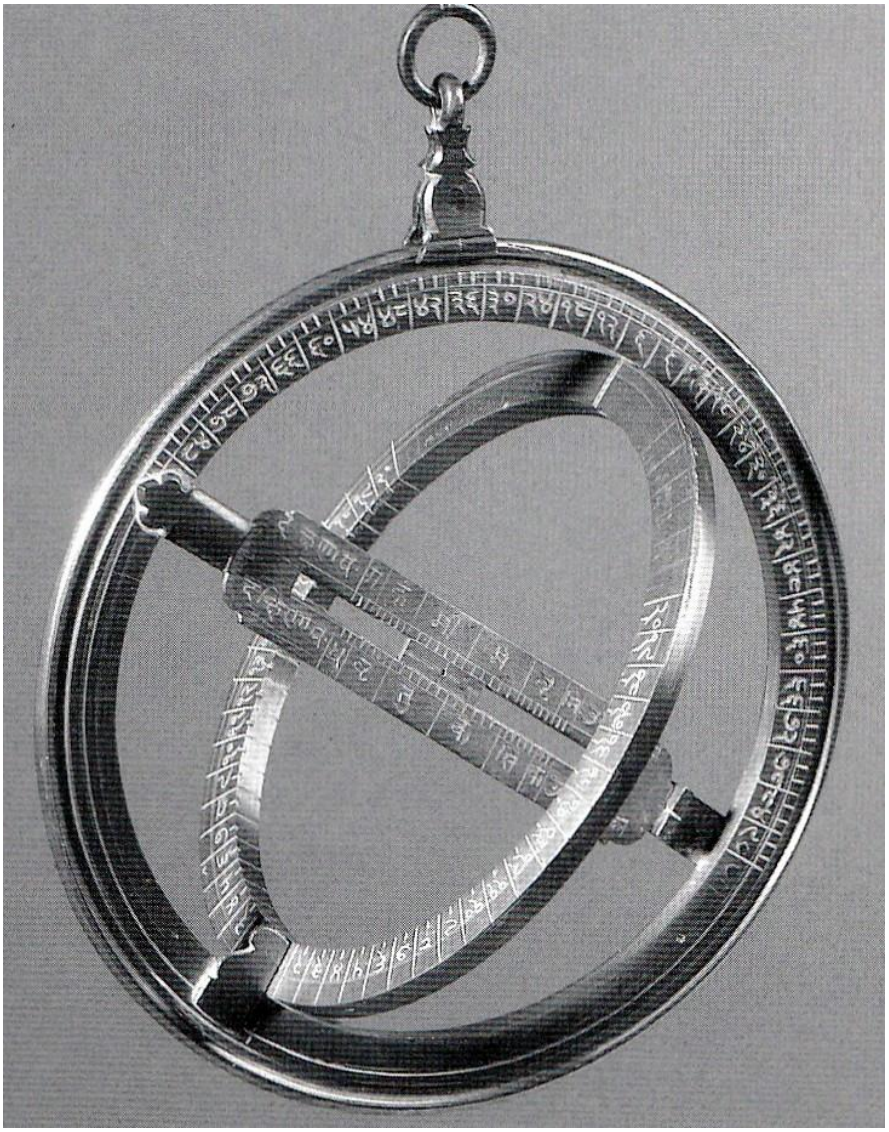


Figure X001.1 – Ring Dial (from Skinner Catalogue)

This is a well-crafted specimen with an ornate suspension bracket and ornate mounting plates at either end of the bridge. The Devanagari numerals and letters display good orthography. The divisions and the subdivisions in the scales are accurately drawn; the marks of these divisions as well as the numerals and letters are filled with a white substance.

In the meridian ring, the two upper quadrants are divided in 2° and 6°; groups of 6° are numbered from 6 to 90. There is a groove running all around the meridian ring

in which the suspension bracket can be made to slide to the desired degree of latitude pertaining to the place of observation. The lower part of the equatorial ring is marked in *ghaṭīs* and numbered from 1 to 20 on either side, for measuring time 20 *ghaṭīs* (= 8 hours) before and after midday. Each *ghaṭī* is subdivided into two halves. The *ghaṭī* divisions are extended on the inner thickness of the ring as well.

The bridge is attached to the meridian ring by means of ornate mounts; there is a long slit in the middle of the bridge within which the plate with pinhole slides. The bridge is engraved with the names of the zodiac signs in the following manner.

Upper panel above the slit:

Dakṣiṇā[yana], Ma[kara], Kuṃ[bha], Mī[na] | Me[ṣa], Vṛ[ṣa], Mi[thuna], Uttarāyaṇa

(southern course, Capricorn, Aquarius, Pisces, Aries, Taurus, Gemini, northern course)

Lower Panel below the slit:

Dakṣiṇā[yana], Dha[nuḥ], Vṛ[ścika], Tu[lā] | Ka[nyā], Siṃ[ha], Ka[rkaṭa], Uttarāyaṇa.

(southern course, Sagittarius, Scorpio, Libra, Virgo, Leo, Cancer, northern course).

Strictly speaking, the six signs in the upper panel, viz., Capricorn, Aquarius, Pisces, Aries, Taurus and Gemini constitute the northern course of the sun (*Uttarāyaṇa*), from the winter solstice to the summer solstice. The six signs in the lower panel, in the reverse order, namely, Cancer, Leo, Virgo, Libra, Scorpio and Sagittarius constitute the southern course of the sun (*Dakṣiṇyana*), from the summer solstice to the winter solstice. Therefore, the labels *Dakṣiṇyana* and *Uttarāyaṇa* are not correctly placed.

Each sign is subdivided in 6 units of 5° each, so that the pinhole can be adjusted according to the solar longitude at the time of observation. The reverse side of the bridge carries, presumably a declination scale, divided for each degree and groups of 6° numbered 24, 18, 12, 6, 6, 12, 18, 24.

BIBLIOGRAPHY

Skinner 2002, lot 200, p. 31.

Tesseract, catalogue C74, Spring 2003, no. 15.

X002⦿ SANSKRIT UNIVERSAL EQUINOCTIAL DOUBLE RING DIAL

Not signed, not dated, 19th century

Diameter 131 mm

Jaipur, Shree Sanjay Sharma Museum & Research Institute



Figure X002.1 – Ring Dial (photo by S. R. Sarma)

This is also a neatly crafted and neatly engraved specimen. The two upper quadrants of the meridian ring are divided in 1° and 6°; groups of 6° are numbered from 6 to 90. The inner equatorial ring is calibrated for *ghaṭīs,* and labelled as 17, 16,

… 2, 1, 1, 2, …16, 17, i.e., for measuring time for 17 *ghaṭīs* (= 6;48 hours), before and after noon. Each *ghaṭī* divided in 6 units of 10 *palas,* i.e., 4 minutes.

The swivel bridge attached to the meridian ring has ornate ends. On one side of the bridge are engraved the names of the zodiac signs in the following manner.

Upper panel: *Ma[kara], Kuṃbha, Mīna | Meṣa, Vṛṣa, Mi[thuna]*;

Lower panel: *Dha[nuḥ], Vṛści[ka], Tula | Kanyā, Siṃha, Ka[rkaṭa].*

Each sign is divided into 5 units.

On the reverse side of the bridge are engraved the declination scales numbered as 24, 18, 12, 6, 6, 12, 18, 24.

Inside the long slit of the bridge is a small plate with a pinhole and a small knob to assist the sliding of the plate to the desired solar longitude.

X003⊙ SANSKRIT UNIVERSAL EQUINOCTIAL DOUBLE RING DIAL

Not signed, not dated, 19th century

Diameter 101 mm

New York, Columbia University, Butler Library (# 27-262)



Figure X003.1 – Ring Dial (photo courtesy Butler Library, Columbia University)

This ring dial is equipped with a simple suspension bracket and a ring. The two upper quadrants of the meridian ring are divided in 2° and 6° and groups of 6° are numbered as 90—6; 6—90.

The equatorial ring carries a *ghaṭī* scale, numbered 17—1; 1—17, to measure the apparent solar time from 17 *ghaṭīs* before and after midday. Each *ghaṭī* is subdivided into 3 units, each of 20 *palas* or 8 minutes.

The swivel bridge with a longitudinal slit in the middle is attached to the meridian ring with simple mounts on either end. It is engraved with the names of the zodiac signs (initial letters) in the usual manner. The reverse side carries the declination scales. Inside the long slit is a sliding plate with a pinhole.

PROVENANCE

This ring dial is in the collection acquired during his travels by the well-known historian of mathematics David Eugene Smith and donated to the Butler Library. The catalogue of this collection, at no. 5, records that this ring dial as an ‘armillary sphere (sic!), Hindu, purchased from the astrologer of the Maharaja of Jaipur, 1908.’

X004⊙ SANSKRIT UNIVERSAL EQUINOCTIAL DOUBLE RING DIAL

Not signed, not dated, 19th century

Diameter 88 mm

Patna, Khuda Bakhsh Oriental Public Library



Figure X004.1 – Ring Dial (photo by S. R. Sarma)

The simple suspension bracket is made of copper while the rest of instrument is of brass. The two upper quadrants of the outer meridian ring are graduated in 1° and 10°; groups of 10° are numbered 90—10; 10—90. The inner equatorial ring is marked with 17 *ghaṭīs* before and after midday; each *ghaṭī* is subdivided in 12 units of 5 *palas,* i.e., 2 minutes.

The bridge is attached to the meridian ring with plain mounts and engraved with the names of the zodiac signs on one side in the following order:

Upper panel: *Ma[karara], Kuṃbha, Mīna* | *Meṣa, Vṛṣa, Mi[thuna]*

Lower panel: *Dha[nuḥ], Vṛ[ścika], Tulā* | *Kanyā, Sīṃha, Ka[rkaṭa].*



Figure X004.2 – Reverse side of the bridge (photo by S. R. Sarma)

On the reverse side of the bridge, both the upper and the lower panel are divided in groups of 5° and numbered as 24, 18, 12, 6, 6, 12, 18, 24. On the left is written *uttara[krāntiḥ]* (northern declination) and on the right *dakṣiṇa[krāntiḥ]* (southern declination).

In the longitudinal slit of the bridge is a sliding plate with a pinhole and a knob.

BIBLIOGRAPHY

Sarma 1999c.

X005⊙ SANSKRIT UNIVERSAL EQUINOCTIAL DOUBLE RING DIAL[1664]

Not signed, vs 1922 (ad 1865-66)

Diameter 122 mm

Vicenza, PC of Giancarlo Beltrame (# 266)

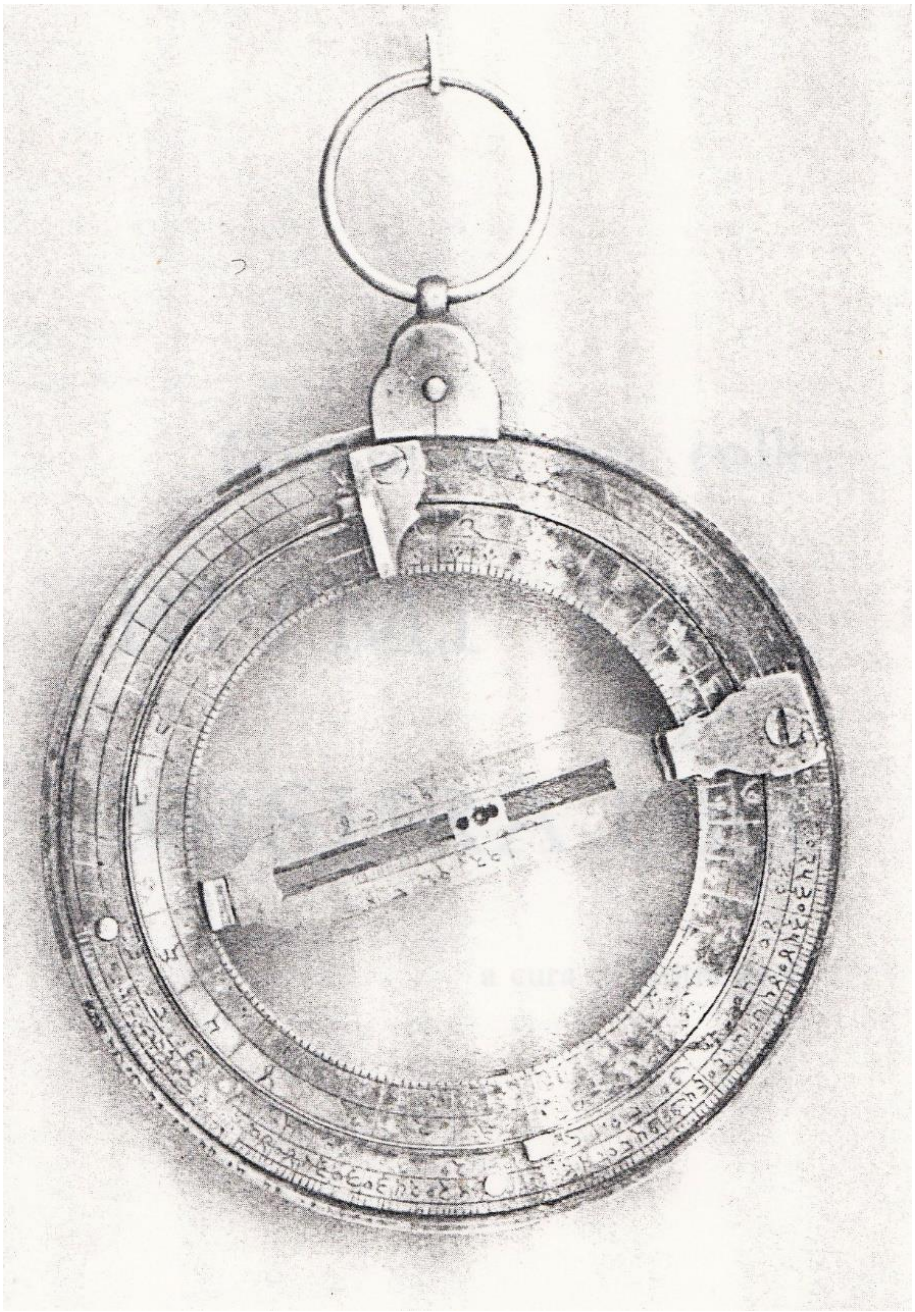


Figure X005.1 – Ring Dial (photo courtesy Anthony J. Turner)

[1664] Entry based on information kindly provided by Anthony J. Turner.

This is the only Sanskrit ring dial which carries a name and a date; the date mentioned is '*Saṃvat* 1922' which corresponds to AD 1865-66; the name, however, is indecipherable except the last syllable *sya,* which is the genitive singular particle, used in the sense of 'of' or 'belonging to'. Therefore, the name must be that of the owner, that is, the person for whom the dial was made. Anthony J. Turner describes the dial as follows:

> 'An Indian copy inscribed in Devanagari script of the typical European universal equinoctial ring dial. The hour scale reads 1-12 in each half and being subdivided to 8, minutes read to 7' 30 seconds, the degree scale reads to 1°. The instrument may be used in both the northern and the southern hemispheres, but on one side a series of mistakes in the numbering of the five degree divisions in the degree scale has been crossed through, the correct numbers being written above them.'

X006 SANSKRIT UNIVERSAL EQUINOCTIAL DOUBLE RING DIAL

Not signed, not dated, 19th century

Diameter 145 mm

Washington DC, National Museum of American History (# 323621)

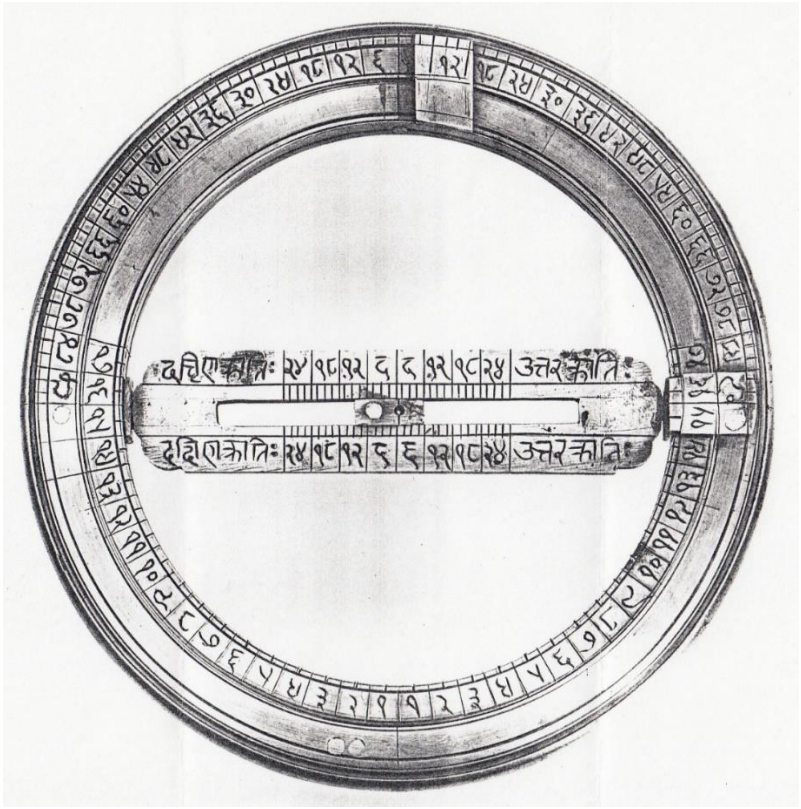


Figure X006.1 – Ring Dial (photo courtesy National Museum of American History)

It is a neatly made specimen. The suspension bracket and the ring are missing. The two upper quadrants of the meridian ring are divided in 2° and 6°; groups of 6° are numbered as 90—6; 6—90. The equatorial ring carries a *ghaṭī* scale, marked with 17 *ghaṭīs* before and 17 *ghaṭīs* after midday. Each *ghaṭī* is divided in 2 parts.

The bridge with the longitudinal slit in the middle is mounted to the meridian ring; a small plate with a relatively large pinhole and a knob slides inside the slit. Both the upper and the lower panels of the bridge are divided in 8 parts and numbered as 24, 18, 12, 6, 6, 12, 18, 24. In both panels is written *dakṣiṇa-krāntiḥ* (southern declination) on the left and *Uttara-krāntiḥ* (northern declination) on the right. Presumably, the other side of the bridge is engraved with the names of the zodiac signs.

X007⊙ SANSKRIT UNIVERSAL EQUINOCTIAL DOUBLE RING DIAL IN SILVER

Not signed, not dated, 20th century

Diameter 124 mm

PLU; ex-London, Christie's

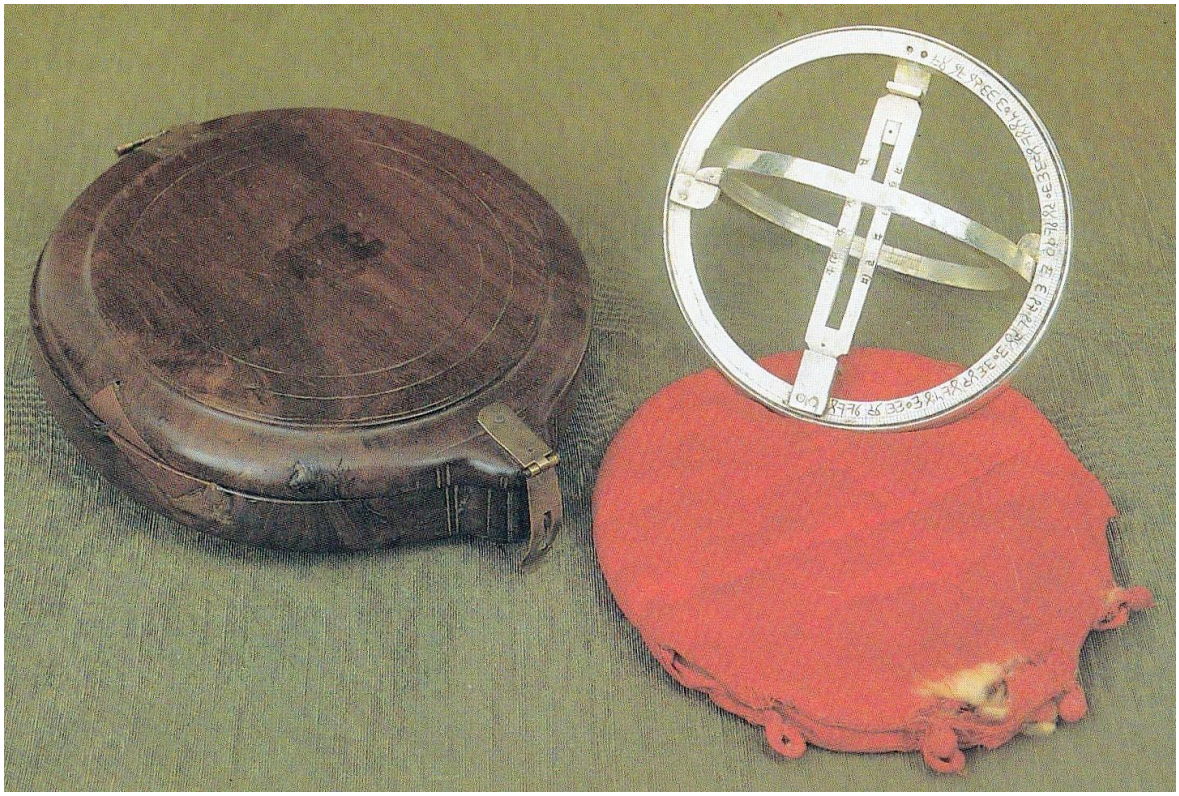


Figure X007.1 – Silver ring dial, with a pouch and wooden case (from Christie's catalogue)

The jewellers of Jaipur who produced five Sanskrit astrolabes in silver (D028 - D032) appear to have created also Sanskrit rings dials in silver, two of which are known: this and the next one (X008).

The present one was offered for sale by Christie's of London in their auction of 27 September 1990. The suspension ring and bracket are missing.

In the meridian ring, the two upper quadrants carry latitude scales, divided in 1° and 6° and numbered as 90—6; 6—90. The inner equatorial ring is engraved with a scale of *ghaṭīs,* extending to 17 on either side of the midday mark. Each *ghaṭī* is subdivided into three units, each of 20 *palas* or 8 minutes.

The bridge with the sliding pin-hole sight carries a zodiac calendar scale on one side and a declination scale on the other side. In the former the initial syllables of the

zodiac signs are engraved. The declination scale on the reverse side is divided in single degrees and groups of 6° are numbered 24, 18, 12, 6, 6, 12, 18, 24.

There is a cotton-padded pouch and neatly made wooden case.

BIBLIOGRAPHY

Christie's, London, *Fine Scientific and Philosophical Instruments,* auction catalogue of 27 September 1990, lot 190, p. 40.

X008⊙ SANSKRIT UNIVERSAL EQUINOCTIAL DOUBLE RING DIAL IN SILVER

Not signed, not dated, 20th century

Diameter 122 mm

New Delhi, National Museum (# 86.193/2)



Figure X008.1 – Silver ring dial (photo by S. R. Sarma)

Like the previous specimen, this too was produced at Jaipur in the twentieth century, almost in an identical manner.

In the meridian ring, the two upper quadrants carry latitude scales, divided in 1° and 6° and numbered as 90—6; 6—90. The inner equatorial ring is engraved with a scale of *ghaṭīs,* extending to 17 on either side of the midday mark. Each *ghaṭī* is subdivided into three units, each of 20 *palas* or 8 minutes. On the inner thickness, however, each *ghaṭī* is subdivided into six parts of 10 *palas* or 4 minutes, but very unevenly.

The bridge with the sliding pin-hole sight carries a zodiac calendar scale on one side and a declination scale on the other side. In the former the initial syllables of the

zodiac signs are engraved. The declination scale on the reverse side is divided into 1°; groups of 6° are numbered 24, 18, 12, 6, 6, 12, 18, 24.

X009⊙ INDO-PERSIAN UNIVERSAL EQUINOCTIAL DOUBLE RING DIAL

Not signed, not dated, 19th century

Diameter 318 mm

London, Nasser D. Khalili Collection of Islamic Art (# SCI 47)



Figure X009.1 – Indo-Persian ring dial (photo by S. R. Sarma)

The scales in this ring dial are numbered in the *Abjad* notation and on the bridge are engraved the names of the zodiac signs in Arabic. But it is certain that this ring dial was produced in India; elsewhere in Arabic- or Persian-speaking countries, there is no record of adaptation of the European ring dial. Second, as will be shown below, the units of time engraved on the equatorial ring are the traditional Indian units of *ghaṭīs* of 24 minutes and not the hours of 60 minutes. With the outside diameter of 318 mm, it is also the largest double ring dial produced in India.

The meridian ring has a diameter of 318 mm, width of 11 mm and thickness of 6 mm. Its two upper quadrants are divided in 1° and 6°; groups of 6° are numbered from 6 to 90 thus: 90—6; 6—90.

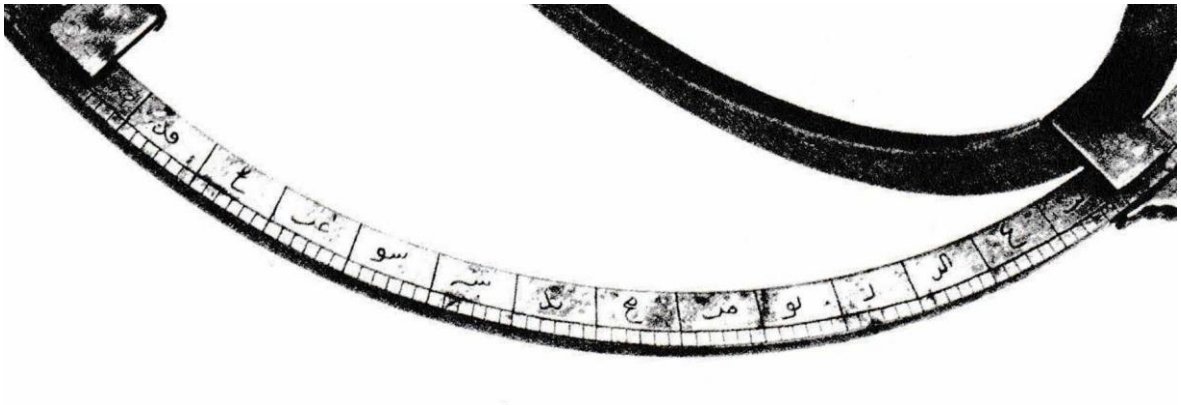


Figure X009.2 – Scale on the meridian ring marked in *Abjad* notation (detail from Khalili Catalogue)

About the markings on the inner equatorial ring, the Khalili catalogue states as follows: 'Its lower section is engraved with two scales of equal hour divisions, rising from 0 to 17. Each hour is numbered in *abjad* notation and is marked in thirds, that is, at intervals of 20 minutes.' If that were so, 17 hours before midday would mean 7 pm in the previous evening and 17 hours after midday would be 5 am in the next morning. This time range is too absurd. On the other hand, in the Sanskrit ring dials, with the exception of X001 which carries a scale of 20 *ghaṭīs* before and after midday, all others have scales of 17 *ghaṭīs* before and after midday. Therefore, the units in the present ring dial must also be *ghaṭīs.* It has been shown above that on some Indo-Persian astrolabes lines are drawn to measure time in *ghaṭīs* in addition to hours. Therefore, it is not unusual to have markings for *ghaṭīs* on Indo-Persian instruments.

In the two panels on the obverse side of the bridge, the names of the zodiac signs are written from solstice to solstice. Thus, on the upper panel are engraved from right to left: *al-Sarṭān, al-Asad, al-Sunbulah* | *al-Mīzān, al-ᶜAqrab, al-Qaws* (Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius).

Likewise, on the lower panel, from right to left: *al-Jadī, al-Dalw, al-Ḥūt* | *al-Ḥamal, al-Thawr, al-Jawzā'*.

On the reverse side of the bridge, both panels are engraved with degrees of declination and groups of 6° are numbered thus in *Abjad*: 24, 18, 12, 6, 6, 12, 18, 24. One set of these numbers from 6 to 24 is to measure the northern declination and the other set for the southern declination.

Inside the slit in the middle of the bridge is a sliding plate with a pinhole and a small knob for moving the plate inside the slit.

BIBLIOGRAPHY

Maddison & Savage-Smith 1997, II, no. 142, p. 246

X010 INDO-PERSIAN UNIVERSAL EQUINOCTIAL DOUBLE RING DIAL

Not signed, not dated, 19th century

Diameter 120 mm

Karachi, National Museum of Pakistan



Figure X010.1 – Indo-Persian Ring Dial (photo by Mubashir Ul-Haq Abbasi)

In this specimen, the two upper quadrants of the meridian ring (diameter 120, width 22 mm) are divided in 1° and 10°, and groups of 10° are numbered from 10 to 90, separately in each quadrants. The numbers are in common Arabic/Persian numerals. Interestingly, in these decuple numbers the zero is represented by four small dashes symmetrically arranged. The lower quadrants are filled with oblique lines. On the reverse side, groups of 10° are numbered in modern 'English' numerals.

The equator ring is divided in 24 hours which are numbered with Roman numerals twice from I to XII. Each is hour is subdivided into 15 parts of 4 minutes in a scale above, and into 10 parts of 6 minutes in a scale below. Half hours are marked by a decorative design consisting of four symmetric dashes. On the reverse side, the hours are numbered similarly with Roman numerals.



Figure X010.2 – Numbers on the two rings; in the upper ring can be seen the numbers 30, 40, 50, 60, 70 from right to left (detail of Figure X010.1).

The bridge is 20mm wide and engraved with the Arabic names of the zodiac signs on both sides. There is a round suspension bracket and a small ring.

X011⊙ UNIVERSAL EQUINOCTIAL SUNDIAL BY MANGARAN, 1275 AH (AD 1858-59)

Dimensions ca. 125 x 120 x 100

Patna, Khuda Bakhsh Oriental Public Library



Figure X011.1 – Equinoctial Sundial (photo by S. R. Sarma)

DIAL

The dial is made of a rectangular sheet of brass (78 x 75 mm), bent to form a semi-cylindrical trough. The inner surface of the trough is engraved with two scales for measuring time in hours as well as in *ghaṭīs*. In the scale of hours, which is above, every hour on the left is numbered from 7 to 12 (forenoon) and on the right from 1 to 6 (afternoon). Each hour is divided into 4 parts of 15 minutes and then further subdivided into 3 units of 5 minutes.

In the scale of *ghaṭīs,* every second *ghaṭī* is numbered, on the left from 2 to 12 (forenoon) and on the right from 2 to 14 (afternoon); each *ghaṭī* is divided into two parts of 30 *palas* (12 minutes) and further subdivided into two units of 15 *palas* (6 minutes).



Figure X011.2 – Side view of the sundial (photo by S. R. Sarma)

On the outer surface of the trough, just below the edge, the Sanskrit names of the zodiac signs are engraved in Devanagari script in this manner: on the left are the names *Makara, Kuṃbha, Mīna, Meṣa, Vṛṣa* and *Mithuna,* read upwards from below, that is to say, from Capricorn to Gemini, or from the winter solstice to the summer solstice; this period is designated in Sanskrit astronomy as *Uttarāyaṇa,* the northern course of the sun.

On the right hand side of the outer surface are the names (read from the top downwards) *Karka, Siṃha, Kanyā, Tulā, Vṛścika* and *Dhana* (sic! *Dhanuḥ*), that is to say, from Cancer to Sagittarius, or from the summer solstice to the winter solstice, which period is designated in Sanskrit astronomy as *Dakṣiṇāyana,* the southern course of the sun. However, since these signs are not connected with the time scales in any manner, they do not serve any practical purpose.

At the bottom of the trough, precisely at the centre of its width, is affixed a gnomon perpendicular to the central axis of the trough; it is 74 mm long and has rectangular cross-section; the part above the edges of the trough is divided in 12 parts and numbered in 4s, as 6, 5, 4 upwards on one side; and as 6, 7, 8 on the other side. The purpose of this scale is not known. Two study bars with rectangular cross section are riveted to the bent edges of the trough at its two ends.

Stand

The entire ensemble of the trough and gnomon is set up on a stand. The stand consists of two sturdy bars with rectangular cross-section, which are joined together in the shape of the Roman letter T. Below the three ends of this frame are three ornate feet with adjustable screws which ensure that the sundial rests on a level ground. From the two ends of the horizontal bar of the T rise two flat pillars, to the ends of which are joined the upper edges of the lower part of the trough, by means of screws.

From the third end of the frame rises a curved scale which is divided in single degrees and numbered in 10s, from 0 to 50. This scale shows the complement of the terrestrial latitude. The bottom of the trough is attached to this curved bar by means of screws. The trough can be tilted along the scale of the bar and the screw can be tightened at the desired degree of co-latitude. However, since the scale it is marked only up to 50°, the sundial can be adjusted only for the terrestrial latitudes of 40° or more. Thus it cannot be used in most Indian latitudes.

On the T-frame, at the joint of the two bars is set up a magnetic compass which ensures that the sundial is placed on the north-south axis for observation. To the front of the trough are attached at either end two bell-shaped weights, to keep the trough in position when it is tilted to the required angle. These bells are missing in the present specimen, but can be seen in X013.

Inscription

On the surface of the dial, above the two time scales, is an inscription in Persian, which reads as follows:

> *ṣāniᶜ īn kampās mangaran shāgird-i rashīd lālah makhan laᶜl sākin muhallah mainpurah …(?) shahar paṭnah sanah 1275 hijrī*
>
> 'The maker of this compass [is] Mangaran, worthy pupil of Lālā Makhan Lāl, resident of the locality Mainpura … in the city of Patna, [in the] year 1275 Hijrī.'

Bibliography

Sarma 1999c.

Sarma 2001a.

X012⊙ UNIVERSAL EQUINOCTIAL SUNDIAL BY MANGARAN, 1284 AH (AD 1867-68)

Dimensions ca. 125 x 120 x 100

London, Victoria & Albert Museum (# IS 06484)[1665]

This piece is almost identical to the previous specimen, but better preserved. The dial (77 x 85 mm) is engraved with the two scales of hours and *ghaṭīs* as the previous one. On the outer surface of the dial, Sanskrit names of the zodiac signs are engraved in the same manner as in X010. The curved scale of co-latitude at the back of the dial is marked up to 56° and numbered in 10s.

INSCRIPTION

Engraved on the dial above the two scales:

ʿṣāniᶜ īn kampās managaran shāgird-i rashīd lālah makhan laᶜl sanah 1295 hijrī

'The maker of this compass [is] Mangaran, worthy pupil of Lālā Makhan Lāl, [in the] year 1295 Hijrī.'

BIBLIOGRAPHY

Anderson 1982, no. 135, p. 36.

[1665] Victoria & Albert Museum wrote to say that they do not permit publication of private photography of their objects. Therefore, this entry is regretfully without my photo.

X013 UNIVERSAL EQUINOCTIAL SUNDIAL BY MANGARAN, 1295 AH (AD 1878-79)[1666]

Height 148 mm, length 158 mm, width 112 mm

PLU; ex-London, Sotheby's



Figure X013.1 – Equinoctial Sundial (from Sotheby's catalogue)

[1666] Entry based on Sotheby's, London, *Arts of the Islamic World, including fine Carpets and Textiles,* auction catalogue of 24 October 2007, lot 200, p. 191.

DIAL

This specimen is constructed in the same manner as the previous two pieces, but it is well preserved. The dial is made of a rectangular sheet of brass which is bent to form a trough. The inner surface of the trough is engraved with two scales for measuring time in hours as well as in *ghaṭīs*. In the scale of hours every hour on the left is numbered from 7 to 12 (forenoon) and on the right from 1 to 6 (afternoon). Each hour is divided into 4 parts of 15 minutes and then further subdivided into 3 units of 5 minutes.

In the scale of *ghaṭīs,* every second *ghaṭī* is numbered, on the left from 2 to 12 (forenoon) and on the right from 2 to 14 (afternoon); each *ghaṭī* is divided into two parts of 30 *palas* (12 minutes) and further subdivided into two units of 15 *palas* (6 minutes).

At the bottom of the trough, precisely at the centre of its width, is affixed a gnomon perpendicular to the central axis of the trough; it has rectangular cross-section; the part above the edges of the trough is divided in 12 parts. Two sturdy bars with rectangular cross section are riveted to the bent edges of the trough at its two ends.

Unlike in the previous two specimens (X011 and X012), the outer surface here does not carry the Sanskrit names of the zodiac signs.

STAND

The stand consists of two sturdy bars with rectangular cross-section, which are joined together in the shape of the Roman letter T. Below the three ends of this frame are three ornate feet with adjustable screws which ensure that the sundial rests on a level ground. From the two ends of the horizontal bar of the T rise two flat pillars, to the ends of which are joined the upper edges of the lower part of the trough, by means of screws.

From the third end of the frame rises a curved scale; the available photo does not show any graduations. It is not known whether the other side is marked with the degrees of co-latitude. Sotheby's catalogue gives the impression that the curved scale is not marked with the degrees of co-latitude.[1667]

On the T-frame, at the joint of the two bars is set up a magnetic compass. There is pair of cross-wires above the trough. To the front of the trough are attached at either end

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[1667] Sotheby's Catalogue: 'This could be achieved if the curved scale would measure the complement of the latitude. But it does not.'

two bell-shaped weights, to keep the trough in position when it is tilted to the required angle.

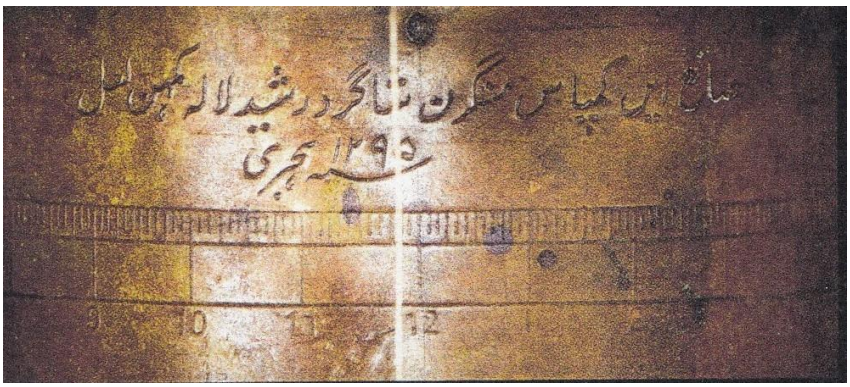


Figure X013.2 – Inscription on the dial (from Sotheby's catalogue)

INSCRIPTION

On the surface of the dial, above the two time scales, is an inscription in Persian, which reads as follows:

> *ṣāniᶜ īn kampās managaran shāgird-i rashīd lālah makhan laᶜl*
>
> *sanah 1295 hijrī*
>
> 'The maker of this compass [is] Mangaran, worthy pupil of Lālā Makhan Lāl, [in the]
>
> year 1295 Hijrī.'

BIBLIOGRAPHY

Sotheby's, London, *Arts of the Islamic World, including fine Carpets and Textiles,* auction catalogue of 24 October 2007, lot 200, p. 191.

X014 UNIVERSAL EQUINOCTIAL SUNDIAL IN SILVER BY MANGARAN & RAM CHARAN, 1292 AH (AD 1875-76)[1668]

Dimension 162 x 150 x 113 mm

London, Royal Collection

This piece was made of silver as a special gift for the Prince of Wales (the future Edward VII). Syed Lutf ᶜAlī Khān, a zamindar of Patna, had it made by Mangaran and his pupil Ram Charan and presented it to the Prince, when he stopped at Patna on 4 January 1876 during his tour of India.[1669]

This specimen is made entirely of silver, except the magnetic compass which is of blue steel. Its construction is identical with that of the other brass specimens, except perhaps in the dimensions and inscriptions. The dial is engraved with the two scales of hours and *ghatis.* The gnomon carries, above the level of the trough, a scale on which are engraved the numbers 6, 7, 8, 9; the space between 6 and 7 is divided in four units, that between 7 and 8 also in four parts, and the space between 8 and 9 is also divided in four parts, and each part is further subdivided in 3 units. The purpose of this scale is not known. The curved scale of co-latitude is engraved with a degree scale, numbered in 10s, up to 60°. There is a pair of cross-wires above the trough. To the front of the trough are attached at either end two bell-shaped weights, to keep the trough in position when it is tilted to the required angle.

INSCRIPTIONS

There are three inscriptions. The first is engraved on the base of the stand, probably in Persian:

‘The year 1292 Hijri’

On the front of the dial above the two scales, in Persian, which is translated as follows:

1668 Entry based on Meghani 2017, pp. 194-195.

1669 The next day, 5 January, the Price visited the Maharaja of Benares. On the astronomical instruments gifted to the Prince by the Maharaja of Benares on this occasion, see Sarma 2014b.

‘The maker of this compass is Mangaran very capable student of Lala Makhan Lal

[and ?] Ram Charan student of Mangaran.’

On the back of the dial, in English:

‘Presented to HRH the Prince of Wales by Syud Lootfi Ali Khan Zamindar and Banker. Patna 4 January, 1876.’

BIBLIOGRAPHY

Meghani 2017.

X015⊙ PERPETUAL CALENDAR & HORARY QUADRANT BY JOSHI DHARM CHAND, 1918 VS (AD 1861-62)[1670]

Diameter 114 mm, height 134 mm

Rampur Raza Library, Rampur



Figure X015.1 – Perpetual Calendar (photo courtesy Rampur Raza Library)

[1670] I am highly obliged to the late Akbar Ali Khan Arshizada for deciphering and translating the Persian inscriptions on this device.

Perpetual Calendar on the Obverse

The obverse side of this device constitutes a perpetual calendar, consisting of a main plate in which two volvelles, or circular plates, rotate. The main plate has a diameter of 114 mm, the middle volvelle of 57 mm and the inner volvelle of 41 mm. The main plate is shaped like an alidade with a *kursī* at the top. The profiles of the *kursī* are made up of ogees at the base and at the top with a lobe in the middle. The *kursī* terminates in a trifoliate finial, in which there is a hole for the suspension ring to pass through.

The main plate and the middle volvelle have circular depressions, or recesses, inside their inner edges, so that in the recess of the main plate rotates the middle volvelle, and in the recess of the middle volvelle rotates the inner volvelle. A pin passing through the hole at the centre of all the three parts keeps them in position. The middle and inner volvelles have a handle each to facilitate rotation. The middle volvelle is made brighter than the other two for the sake of contrast.



Figure X015.2 – Parts of the perpetual calendar
(photo courtesy Rampur Raza Library)

On the outermost rim of the main plate are inscribed instructions in Persian about the use of this perpetual calendar:

bāyed dānist keh dāirah-i bālā rā bᶜaad chahār sāl istemāl namāyand keh dar sāl-i-mazkūr māh-i-farwarī bist-nah 29 yaum mī-shawad. azīn bāᶜas bā dāira-i-zerīn ikhtilaf-nāyāb mī-manad.

'It should be known that the upper circle should be used after [every] four years because in the leap year the month of February has twenty-nine 29 days. For this purpose the lower circle (i.e. the lower volvelle; actually the two lower volvelles) should be aligned with the [desired month] accordingly.'

As stated in this inscription, there are two circular rows just below this inscription, each containing the names of the twelve English months inscribed in Persian script. The two circles are divided into seven equal parts and each part is filled with the names of certain months. In the first circle, the months are as follows, starting from the top and going clockwise: *sitambar, disambar, jūn* | *mārch, navambar* | *farwarī, agast* | *maī* | *aktūbar* | *jūlāyī, april, janwarī* . These are to be used in leap years. In the second circle, the months are, again starting from the top and going clockwise: *jūlāyī, april* | *sitambar, disambar* | *jūn* | *mārch, navambar, farwarī* | *agast* | *maī* | *janwarī, aktūbar*. These are to be used in common years.

The middle volvelle also has seven equal divisions which are filled with the Persian names of the weekdays in clockwise direction: *jumaᶜ* (Friday), *shanbah* (Saturday), *yakshanbah* (Sunday), *dūshanbah* (Monday), *sahshanbah* (Tuesday), *chahārshanbah* (Wednesday), *panjshanbah* (Thursday).

The outer rim of the inner volvelle contains the numbers 1 to 31 but not consecutively. Starting from the knob and going clockwise, they are as follows: 1, 8, 15, 22, 29, 2, 9, 16, 23, 30, 3, 10, 17, 24, 31, 4, 11, 18, 25, 5, 12, 19, 26, 6, 13, 20, 27, 7, 14, 21, 28. The logic of this arrangement will become clear when these numbers are arranged in seven different rows. These are the dates of English months arranged in weekly cycles:

1	8	15	22	29
2	9	16	23	30
3	10	17	24	31
4	11	18	25	
5	12	19	26	

6 13 20 27

7 14 21 28

Below these numbers are written the days of Sanskrit solar months on which the first days of the English months fall. The names of the Sanskrit solar months are written in their Panjabi phonetic form.[1671] These are transcribed in the table below.

Table X015-1 Concordance of English months and Indian Solar months

English Months	Indian solar months	
	Panjabi	**Sanskrit**
1 January	20 *Poh*	20 *Puṣya*
1 February	21 *Māgh*	21 *Māgha*
1 March	20 *Phāgun*	20 *Phālguna*
1 April	20 *Chayt*	20 *Chaitra*
1 May	21 *Baysāk*	21 *Vaiśākha*
1 June	21 *Jeṭh*	21 *Jyeṣṭha*
1 July	20 *Hāṭ*	20 *Āṣāḍha*
1 August	19 *Sāwan*	19 *Śrāvaṇa*
1 September	18 *Bhādon*	18 *Bhādrapada*
1 October	17 Assū	17 *Āśvayuja*
1 November	18 *Katak*	18 *Kārtika*
1 December	18 *Maghar*	18 *Mārgaśira*

Function of the Perpetual Calendar

The purpose of the perpetual calendar is to provide the weekday for any given date in the Christian calendar, that is to say, to match the weekly cycle of seven days with

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[1671] On this and on the following specimens, the Panjabi names are not always written consistently; but these orthographic peculiarities will not be reproduced here; for these, cf. Dar 1994, p. 178.

the monthly cycle of 30 or 31 or 28|29 days. Therefore, the basic principle is to arrange the dates, months and years of the Christian calendar in cycles of seven. In the table below, the data from the main plate and the two volvelles is arranged one below the other, in order to show how Dharm Chand tackled the problem.

Table X015-2 Sevenfold arrangement months, dates and weekdays

Leap Years	January April July	October	May	February August	March November	June	September December
Com-mon Years	January October	May	August	March November February	June	September December	July April
Week days	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Dates	1, 8, 15, 22, 29	2, 9, 16, 23, 30	3, 10, 17, 24, 31	4, 11, 18, 25	5, 12, 19, 26	6, 13, 20, 27	7, 14, 21, 28

The logic of this arrangement is quite simple. When January commences on a Sunday in a leap year, April and July also commence on a Sunday, October begins on a Monday and so on. Then in the months of January, April and July, the dates 1, 8, 15, 22, 29 fall on a Sunday, the dates 2, 9, 16, 23, 30 fall on a Monday, and so on. Similarly, when January commences on a Sunday in a common year, October will also do the same; May will commence on a Monday, and so on.

However, in order to use this perpetual calendar, one should know on which weekday the first day of the desired year or of the month falls. Then the calendar will tell the weekdays corresponding to the remaining dates. For example, let us take AD 2000. First we have to find out from some other source that the first of January in this year falls on a Saturday. Accordingly we set up the perpetual calendar. Since AD 2000 is a leap year, we take January in the upper circle of the main plate and rotate the middle volvelle with the weekdays in such a way that the segment with Saturday falls exactly below the segment in the upper circle where January is inscribed (July and April are also in this segment, and the following applies to them also). Then we rotate the inner volvelle in such a way that the segment with the numbers 1, 8, 15, 22, 29 falls exactly below the segment of Saturday.

Then we see that in January 2000, the dates 1, 8, 15, 22, 29 fall on a Saturday, the dates 2, 9, 16, 23, 30 on a Sunday and so on. We also see that January 31 falls on a Monday. So 1 February occurs on a Tuesday. In February, therefore, we turn the outer volvelle in such a way that Tuesday comes below February in the upper circle, and then turn the inner volvelle so that the dates 1, 8, 15, 22, 29 are under Tuesday. This means all these dates in February 2000 fall on Tuesdays. Since 29 February is Tuesday, the month of March commences on a Wednesday and so on.

This is rather a cumbersome procedure because the calendar can be used only when it is known on which weekday the required month falls.

Horary Quadrant on the Reverse

The reverse side of the device is designed as a horary quadrant. Besides the time of the day, this one indicates the ascendant as well. Since the solar declination varies, separate scales are needed, either for each zodiac sign, or for each solar month, or at certain intervals of solar longitude. However, separate scales need not be provided for all the 12 signs or solar months; the same scale can be used for two signs or solar months which are symmetrical in relation to the equinoxes. In the present case the seven scales are for the following months: (i) *Ḥāṭ* (Sanskrit: *Āṣāḍha*); (ii) 2. *Bhādon* (*Bhādrapada*) and *Baysāk* (*Vaiśākha*); (iii) *Kātak* (*Kārtika*) and *Phāgun* (*Phālguṇa*); (iv) *Poh* (*Puṣya*); (v) *Sāwan* (*Śrāvaṇa*) and *Jeth* (*Jyeṣṭha*); (vi) A*ssū* (*Āśvayuja*) and *Chayt* (*Caitra*); and (vii) *Māgh* (*Māgha*) and *Maghar* (*Agrahāyaṇa*).



Figure X015.3 – Horary Quadrant (photo courtesy Rampur Raza Library)

Horary quadrant is latitude-specific, but Dharm Chand does not mention the latitude for which this horary quadrant is intended; presumably it is made for 32°, the latitude of Lahore. He fills all the four quadrants with different *ghaṭī* scales in the same manner as is done in the *Yantrādhipati* designed by Sawai Madho Singh of Jaipur (T001).

On the face of the instrument, there are eight circular rows. Starting from the outer periphery, these contain the following data:

1. Scale of single degrees
2. Groups of 6°, numbered in common Arabic/Persian numerals, separately for each quadrant from 6 to 90, starting from the horizontal diameter and going upwards and downwards to the vertical diameter.
3. Four *ghaṭī* scales, one in each quadrant. The scales are divided into *ghaṭīs* and numbered, starting from the horizontal radius and proceeding towards the vertical radius. In the empty space at the end of the scale, the name of the month is written for which the scale is meant. Thus in the upper left is the scale for *Ḥāṭ,* upper right *Bhādon* and *Baysāk,* lower left *Kātak* and *Phāgun,* and lower right *Poh.*
4. Three more *ghaṭī* scales, but the cells here are shorter than those above. The scale in the upper left is labelled as *Sāwan* and *Jeth,* that in the upper right *Assū* and *Chayt,* lower left *Māgh* and *Maghan.* There is no scale in the lower right; the quarter circle is blank.
5. A scale of 60 *ghaṭīs*, numbered from 1 to 60, starting at the top and going anti-clockwise.
6. 1/15th parts of a zodiac sign.
7. 1/5th parts of a zodiac sign, labelled separately for each sign as 6, 12, … 30.
8. Arabic name of the zodiac signs. These are represented in their oblique ascensions, as shown in the following table.

Table X015-3 Oblique Ascensions

	Signs		**Signs**	**Oblique Ascensions**
1	*Ḥamal*	12	*Ḥūt*	3;30 *ghaṭīs*
2	*Thawr*	11	*Dalw*	4;00 *gh*
3	*Jawjā'*	10	*Jadī*	5;00 *gh*
4	*Saraṭān*	9	*Qaws*	6;30 *gh*
5	*Asad*	8	*ᶜAqrab*	5;00 *gh*
6	*Sunbulah*	7	*Mīzān*	6:00 *gh*

How to use the Horary Quadrant

For measuring time, one chooses the appropriate *ghaṭī* scale according to the current solar month, and holds the instrument in such a way that the sun's rays pass through the holes in the two sights of the alidade. This done, the point where the alidade touches the current *ghaṭī* scale will give the time in *ghaṭīs* for this moment; in the forenoon it is the time that has elapsed since sunrise; in the afternoon it is the time that is yet to elapse up to sunset. The alidade also touches the first two scales containing single degrees and groups of 6°. Here one reads the altitude of the sun for this moment in degrees. Furthermore, from the points where the alidade touches the scale nos. 6, 7 and 8, one can find the ascendant.

ALIDADE

The alidade has a length of 98 mm. It is made by joining two narrow strips of metal in an ingenious manner so that the two sides of the alidade are equally balanced. The sighting plates have one hole each. There must have been a wedge to hold the pin in place which is now missing.

INSCRIPTIONS

On the front of the *kursī* is an inscription which reads

> *dharm chand joshī ikhtara^{c} naw 1918 saṃvat*
>
> 'Dharm Chand Joshi, new invention, [Vikrama] Saṃvat 1918 [= AD 1861-62].'

At the back of the *kursī* there is another inscription which states

> *barā-i naẓr khudāwand-i n^{c}imat ḥuzūr faiz-i ganjūr mahārājah ṣāhib bahādur*
>
> 'Dedicated to the beneficent master (*khudāwand-i n^{c}imat*), the exalted lord *(ḥuzūr*), benevolent (*faiz-i ganjūr*), *Mahārājah Ṣāhib Bahādur*.'

In it is strange that this inscription contains only the titles of the Mahārāja but not his actual name. He cannot be Nihal Singh Aluwalia (1837-1852), the Raja of Kapurthala, who was a patron of Dharm Chand's contemporary Bulhomal, because the present device was made after the Maharaja's lifetime; probably the dedicatee is a successor of Nihal Singh.

BIBLIOGRAPHY

Sarma 2003, pp. 78-84.

Sarma 2015b, no. [29], pp. 288-289.

X016⊙ PERPETUAL CALENDAR & HORARY QUADRANT BY JOSHI DHARM CHAND, 1929 VS (AD 1872-73)

Diameter 104 mm; height 134.5 mm

New Delhi, National Museum (# 56.155/5)



Figure X016.1 – Perpetual Calendar (photo courtesy National Museum)

This specimen is similar in construction to the previous one (X015), but slightly smaller. The surface is much worn out and the inscriptions are difficult to decipher. It appears that the front of the *kursī* carries the same inscription as in X015. The date is not completely visible; the third and fourth digits are 29; the first and second are likely to be 19. Therefore the date can be 1929 VS = AD 1872-73. There is no inscription on the back of the *kursī.*



Figure X016.2 – Horary Quadrant (photo courtesy National Museum)

PERPETUAL CALENDAR ON THE OBVERSE

It consists of three parts; the main plate has a diameter of 104 mm, the middle volvelle has a diameter of 54.5 mm and the inner volvelle 42 mm. The main plate is surmounted by a lobed *kursī* with a large trifoliate finial, through which passes a suspension ring.

On the rim of the main plate are engraved the same instructions in Persian as on X015 about the leap years and common years. Below this inscription, there are two circular rows on which the names of English months are written in Persian script in groups of seven; the months in the upper row are to be used for leap year and those in the lower row for common years. The middle volvelle is inscribed with the Persian names of the weekdays. The inner volvelle carries three circular rows; in the outer row are the dates of English months, arranged in seven groups. Below these are written the

days of Sanskrit solar months on which the first days of the English months fall and below them the names of the English months.

Horary Quadrant on the Reverse

The horary quadrant engraved on the reverse side consists of eight circular rows. Starting from the outer periphery, these are as follows:

1. Scale of single degrees
2. Groups of 6°, numbered in common Arabic/Persian numerals, separately for each quadrant from 6 to 90, starting from the horizontal diameter and going upwards and downwards to the vertical diameter.
3. Four *ghaṭī* scales, one in each quadrant. The scales are divided into *ghaṭīs* and numbered, starting from the horizontal radius and proceeding towards the vertical radius. In the empty space at the end of the scale, the name of the month is written for which the scale is meant. Thus in the upper left is the scale for *Ḥāṭ,* upper right for *Bhādon* and *Baysāk,* lower left for *Kātak and Phāgun,* and lower right for *Poh.*
4. Three more *ghaṭī* scales, but the cells here are shorter than those above. The scale in the upper left is labelled as *Sāwan* and *Jeth,* that in the upper right *Assū* and *Chayt,* lower left *Māgh* and *Maghan.* There is no scale in the lower right; the quarter circle is blank.
5. A scale of 60 *ghaṭīs*, numbered from 1 to 60, starting at the top and going anti-clockwise.
6-8. Row 8 is engraved with the Arabic names of the zodiac signs in their oblique ascension, in row 7 each sign is divided in 5 parts and numbered as 6, 12, … 30, and row 6 is marked with 1/15th parts of the signs.

Bibliography

Behari & Govind 1980, p. 96 (they treat the device erroneously as an astrolabe).
Sarma 2015b, no. [30], pp. 289-290.

X017 PERPETUAL CALENDAR & HORARY QUADRANT BY JOSHI DHARM CHAND

Not dated; second half of the 19th century

Diameter ca. 130 mm

Lahore, Lahore Museum (# M.m.44 H)



Figure X017.1 – Perpetual Calendar (photo by Mubashir Ul-Haq Abbasi)

PERPETUAL CALENDAR ON THE OBSERVE

The two previous versions of the perpetual calendar (X015 and X016) are cumbersome to use, since the years are not included there. The present specimen is a

more advanced version. Here on the main plate are engraved the years 1 to 100, arranged in cycles of seven. These represent the years 1801 to 1900. The construction is also simplified with just one volvelle.

As in the other specimens, the main plate is shaped like an astrolabe with a *kursī* on the top, but the *kursī* is more elegant with elongated ogees in the profiles. The finial has the shape of a tear-drop with a hole for the suspension ring, which is missing.

In the main plate, there are five circular rows. In the outermost row are written the correspondences between the English months and Sanskrit solar months (as is done on the inner volvelle of X015). Engraved from the top and proceeding anti-clockwise, these read as follows:

20 māh poh awwal māh janwarī[1672]	*21 māh māgh awwal māh farwarī*
20 māh phāgun awwal māh march	*21 māh chayt awwal māh aprīl*
21 māh baysāk awwal māh mayī	*21 māh jeṭh awwal māh jūn*
19 māh hāṭ awwal māh jūlāyī	*19 māh sāwan awwal māh agast*
18 māh bhādon awwal māh sitambar	*17 māh assū awwal māh aktūbar*
18 māh kātak awwal māh navāmbar	*18 māh maghar awwal māh disambar.*

Circular rows 2 to 5 are divided into 7 columns corresponding to the seven days of the week which are written in the fifth row. In rows 2 to 4, the years 1 to 100 are arranged in cycles of seven.

The inner volvelle carries 3 circular rows which are also divided into seven columns. In the first row are the numbers 1 to 31, arranged in seven cycles as in the upper row of the inner volvelle in X015. In the middle row are the names of one or two English months, followed by the number of days in that month. In the third row are again the names of one or two English months followed by the number of days in that month.

[1672] Literally, '20 month poh first month January,' i.e., the 20th day of the month Poh corresponds to the first of the month of January, or 1 January = 20 Poh (Puṣya). There is no need to translate the other parts; cf. Table X015-1. There is one difference; elsewhere 1 July is equated to 20 Ḥāt; here it is 19 Ḥāṭ.

Thus, for example, in the first column in the upper right in Figure X017.1, in the first row are the dates 6 | 13 | 20 | 27, written at intervals of 7. In the second row the month names '*Akast 31*'. In the third row '*Mayī 31*'.

How to use this calendar

Suppose one wishes to know the weekday on 1 January 1801. One has to locate '1' in the three rows in which the numbers 1 to 100 are written. It is at the bottom, in the fourth row counted from below, a little to the left of the vertical diameter, under the name of the weekday *Panjshanbah* (Thursday). Then one should rotate the volvelle so that the column containing the month name *janwarī* in the volvelle coincides with column containing 1 in the main plate. Then above January in the volvelle are the dates 1, 8, 15, 22, 29. All these dates in January 1801 fall on Thursdays; 2 January on Friday, 3 January on Saturday and so on. For a graphic illustration, see Figure X017.2.

HORARY QUADRANT ON THE REVERSE

The reverse side of this devise is designed as a horary quadrant. The horary quadrant in X015 and X016 is made to find the time of the day and also the ascendant. The horary quadrant in the present specimen is designed to show also the culmination. Thus it is a combination of the horary quadrant and the *Sarvatobhadra-yantra.* Dharm Chand designates this new creation as *āyinah falqī* (mirror of the heavens). There are 11 circular rows. Starting from the outer periphery, these contain the following scales:



Figure X017.2 – Horary Quadrant (photo by Mubashir Ul-Haq Abbasi)

1. Scale of single degrees

2. Groups 6°, numbered in common Arabic/Persian numerals, separately for each quadrant from 6 to 90, starting from the horizontal diameter and going upwards and downwards up to the vertical diameter.

3. Four *ghaṭī* scales, one in each quadrant. The scales are divided into *ghaṭīs* and numbered, starting from the horizontal radius and proceeding towards the vertical radius. In the empty space at the end of the scale, the name of the month is written for which the scale is meant. The arrangement of the four scales is slightly different from

the two previous specimens. Here the upper left has the scale *Baysāk* and *Bhādon*; upper right *Kātak* and *Phāgun*; the lower left *māh Ḥāṭ,* and the lower right *māh Poh.*

4. Three more *ghaṭī* scales, but the cells here are shorter than those above. The scale in the upper left is labelled as *Chayt* and *Assū,* in the upper right *māh Māgh* and *Maghar,* lower left *Jeṭh* and *Sāwan.* There is no scale in the lower right; there is a long inscription which commences with the designation of the instrument, *āyinah falqī* (mirror of the heavens), and concludes with the maker's name Dharm Chand; the rest of the inscription presumably explains the purpose of the zodiac signs engraved lines 8 and 11.

5. A scale for 60 *ghaṭīs*, numbered from 1 to 60 clockwise from the top.

6. 1/15th parts of a zodiac sign marked in line 8, or 1/3 of the next.

7. 1/5th part of a zodiac sign, labelled separately for each sign as 6, 12, … 30.

8. Signs of the zodiac in their right ascensions, starting from the vertical radius on the top and proceeding clockwise.

9. 1/15th parts of a zodiac sign marked in line 11, or 1/3 of the next.

10. 1/5th part of a zodiac sign, labelled separately for each sign as 6, 12, … 30.

11. Signs of the zodiac signs in their oblique ascensions, starting from the horizontal radius on the right (i.e., 90° away from the previous set in row 8) and proceeding clockwise.

How to use the Horary Quadrant

For measuring time, one chooses the appropriate *ghaṭī* scale according to the current solar month, and holds the instrument in such a way that the sun's rays pass through the holes in the two sights of the alidade. When this is done, the point where the alidade touches the current *ghaṭī* scale will give the time in *ghaṭīs* for this moment; in the forenoon it is the time that has elapsed since sunrise; in the afternoon it is the time that is yet to elapse up to sunset. The alidade also touches the first two scales containing single degrees and groups of 6°. Here one reads the altitude of the sun for this moment in degrees. Furthermore, from the points where the alidade touches the scale nos. 6, 7 and 8, one can find the culmination in signs and degrees; the points where the alidade touches the scale nos. 9, 10 and 11 indicate the ascendant in signs and degrees.



Figure X017.3 – The maker's signature (detail of Figure X017.1)

INSCRIPTION

On the obverse side, in upper row on the main plate, to the right of the vertical radius, is the signature of the maker which reads thus:

ᶜamal joshī dharm chand

'The work of Joshi Dharm Chand.'

BIBLIOGRAPHY

Dar 1994, pp. 165-198, pl. X (Dar realises that this is a 'perennial calendar', but still refers to it as a 'planispheric astrolabe'!).

X018⊙ ENGLISH PERPETUAL CALENDAR & HORARY QUADRANT BY JOSHI DHARM CHAND

Not dated; second half of the 19th century

Diameter 102 mm, height 127 mm

London, Victoria & Albert Museum, London (# IM410-1924)[1673]

PERPETUAL CALENDAR

This is basically an English version of the Persian specimen at Lahore (X017), with a single volvelle rotating in the middle of the main plate. The main plate carries five circular rows. The upper row is divided into 12 parts and in each is written the name of an English month and below it the name of the corresponding Sanskrit month and the day on which the first of the English month falls.

Circular rows 2 to 5 are divided into 7 columns corresponding to the seven days of the week, the names of which are written in the fifth row. In rows 2 to 4, the years 1 to 100 are arranged in cycles of seven.

The inner volvelle carries 3 circular rows which are divided into seven columns. In the first row are the numbers 1 to 31 arranged in seven cycles as in the upper row of the inner volvelle in X015. In the middle row are the names of one or two English months, followed by the number of days in that month. In the third row are again the names of one or two English months; here the names are starkly abridged because of the shortage of space and the number of dates in the months are not mentioned.

For the method of using this device for finding the weekday of a given date, see X019.

HORARY CALENDAR ON THE REVERSE

The reverse side is also an English version of X017 which is designed to provide the time of the day and also the ascendant and culmination. However, here the scale of

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[1673] The Victoria & Albert Museum wrote to say that they do not permit the publication of private photography of their objects. Therefore, I cannot include my photos in this entry. Without photos, however, it is difficult to understand the description. Since X019 is almost similar to the present one, the readers may look at the photos of X019 in order to understand the description of the present specimen.

ghaṭīs numbered from 1 to 60 (i.e. row 5 in X017) is omitted. Consequently, there are only 10 circular rows.

The outermost row is divided in 1°. In the second row groups of 6° are numbered from 6 to 90, separately in each quadrant, starting from the east and west points and reaching up to the north and south points. In the two next rows are arranged six *ghaṭī* scales for different English months. Row 7 is divided in the twelve signs of the zodiac and labelled with their Latin names, while in row 6 each sign is divided in groups of 6° and numbered from 6 to 30. In row 5, each of the divisions in row 6 are divided in three parts of 2° each. Rows 10, 9 and 8 are similarly divided, but here the signs are 90° behind of those in rows 5-7.

An alidade is pivoted to the centre of the plate. When the sun's altitude is measured with the alidade, the cell where the alidade intercepts the *ghaṭī* scale appropriate for the current English month is the local time in *ghaṭīs*, where it intercepts the rows 5, 6, 7 can be seen the ascendant in signs and degrees and where it intercepts the rows 8, 9, 10 is the culmination in signs and degrees.

Inscription

On the reverse side of the *kursī* is the signature of the maker:

Subscribed by Joutshee Dhurm Chund

The name is spelt in the fashion of the nineteenth century; 'subscribed' is a miswriting for 'inscribed'.

Bibliography

Sarma 2015b, no. [32], pp. 290-291.

X019 ENGLISH PERPETUAL CALENDAR & HORARY QUADRANT BY JOSHI DHARM CHAND[1674]

Not dated; second half of the 19th century

Diameter ?

PLU

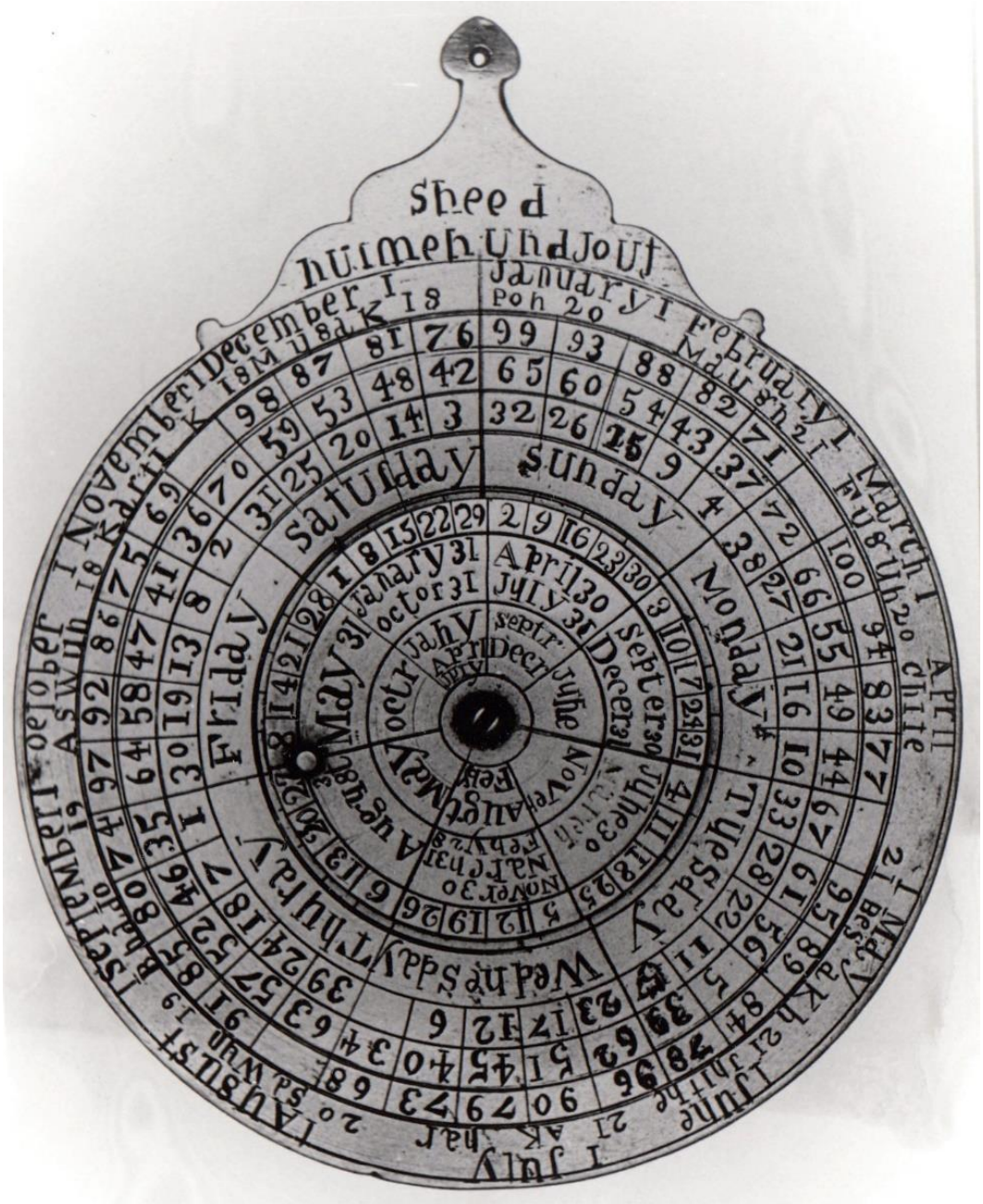
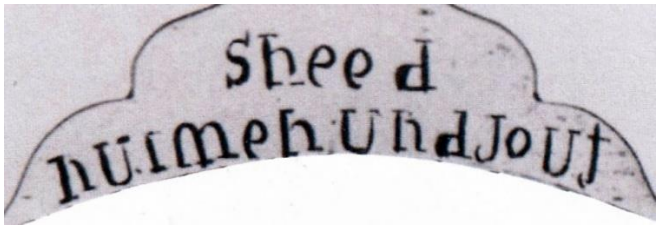


Figure X019.1 – Perpetual Calendar (photo courtesy Museum of the History of Science)

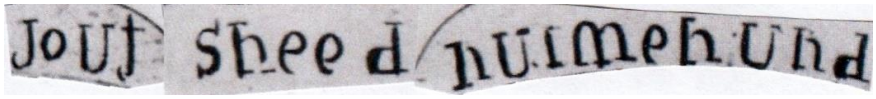
[1674] Entry based on the two photos in the archives of the Museum of the History of Science, Oxford.

This appears to be a copy of the previous specimen (X018) engraved probably by an assistant of Dharm Chand who was not comfortable with the Roman script; he confuses between upper and lower cases, between ‘c’ and ‘e’, between ‘h’ and ‘n’ and so on. Moreover, almost each name of the English month is misspelt, and even the name of Dharm Chand is badly mutilated. On the front of the crown is to be seen this strange melange of English letters.



This was achieved by cutting up the following name in three arbitrary parts and arranging these in at random.

JOUTSHEE DHURM CHUND



But, luckily, this does not prevent us from understanding the misspelt words.

The present specimen is endowed with an elegant crown. It consists of only one volvelle which rotates in the depression in the middle of the main plate. The main plate is engraved with five circular rows.

The upper row is divided into 12 parts and each is filled the name of an English month and below it the name of the corresponding Sanskrit solar month and the day on which the first of the English month falls (as is done on the inner volvelle of X015). Thus in the first cell is written ‘January’ and below it ‘*Poh 20*’, which means that 1 January corresponds to the 20th day of the solar month *Poh* (Sanskrit: *Puṣya*). These month names are written clockwise, starting from the centre at the top.

Circular rows 2 to 5 are divided into 7 columns corresponding to the seven days of the week which are written in the fifth row. In rows 2 to 4, the years 1 to 100 (i.e., 1801 to 1900) are arranged in cycles of seven.

The inner volvelle carries 3 circular rows which are divided into seven columns. In the first row are the numbers 1 to 31 arranged in seven cycles as in the upper row of the inner volvelle in X015. In the middle row are the names of one or two English months, followed by the number of days in that month. In the third row are again the

names of one or two English months; here the names are starkly abridged because of the shortage of space.

Thus, for example, in the first column in the upper right in the photo, in the first line are the dates 2 | 9 | 16 | 23 | 30, written at intervals of 7. In the second row are the month names ‘April 30’ and below it ‘July 31’. The third row carries just ‘Septr’ and ‘Decr’; here the numbers of dates in the months are not mentioned.

How to use this calendar

Suppose one wishes to know the weekday on 1 January 1801. First, one has to locate ‘1’ in the three rows in which the numbers 1 to 100 are written on the main plate. It is in the column headed by ‘September’ (marked * in the figure below). Then one has to rotate the volvelle so that the column with ‘January’ (marked * in the figure below) in the volvelle coincides with the column containing ‘1’on the main plate. Then above the name of January are the dates 1, 8, 15, 22, 29. All these dates in January 1801 fall on a Thursday. Consequently 2 January occurs on Friday, 3 January on Saturday and so on.

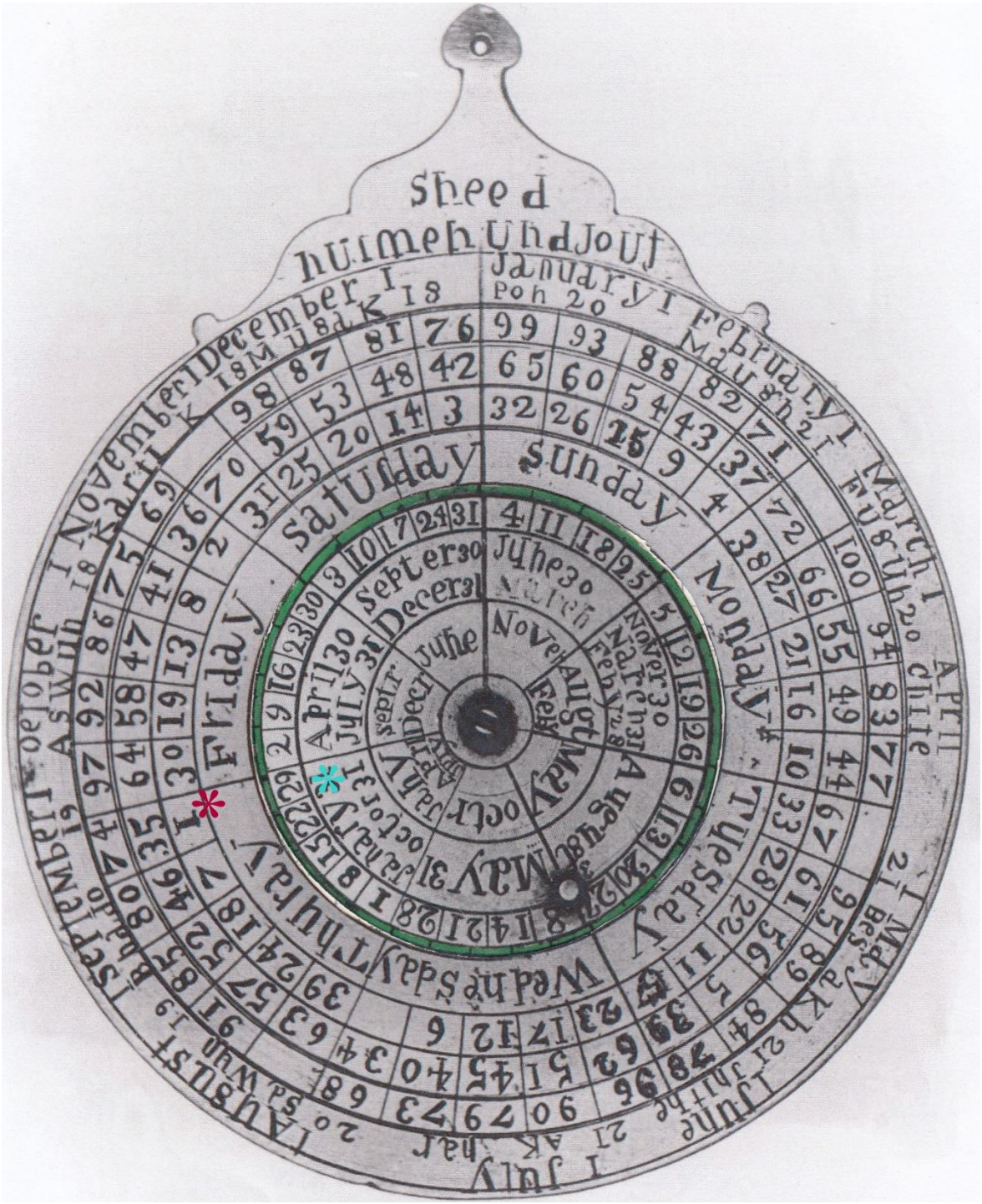


Figure X019.2 – Calendar adjusted to January 1801[1675]

Or one wishes to find the weekday of 15 August 1847. First the number ‘47’ should be located in the three rows where the years are written. It is in the column

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[1675] I cut out the inner volvelle from a printout of the photo so that it could be rotated and arranged at any desired point; the outer edge of the volvelle is painted in green for the sake of contrast between the two parts.

October-November (marked *); one should move the volvelle so that the column with August (marked *) on the volvelle coincides with the column containing 47 in the main plate. Then the number ‘15’ should be located in the scale of dates in the upper row of the volvelle. It is on the right (marked *) and is a Sunday.

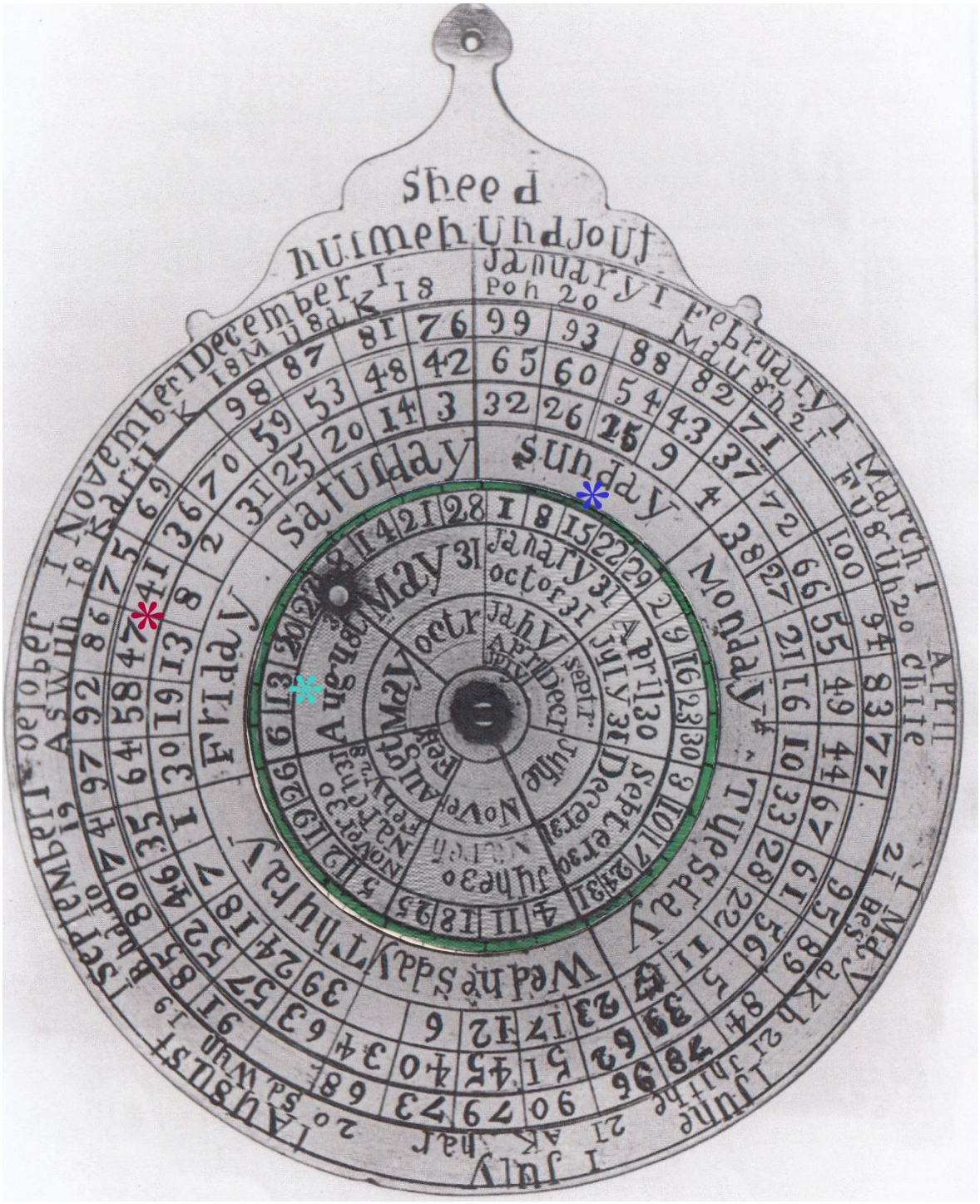


Figure X019.3 – Calendar adjusted to August 1847

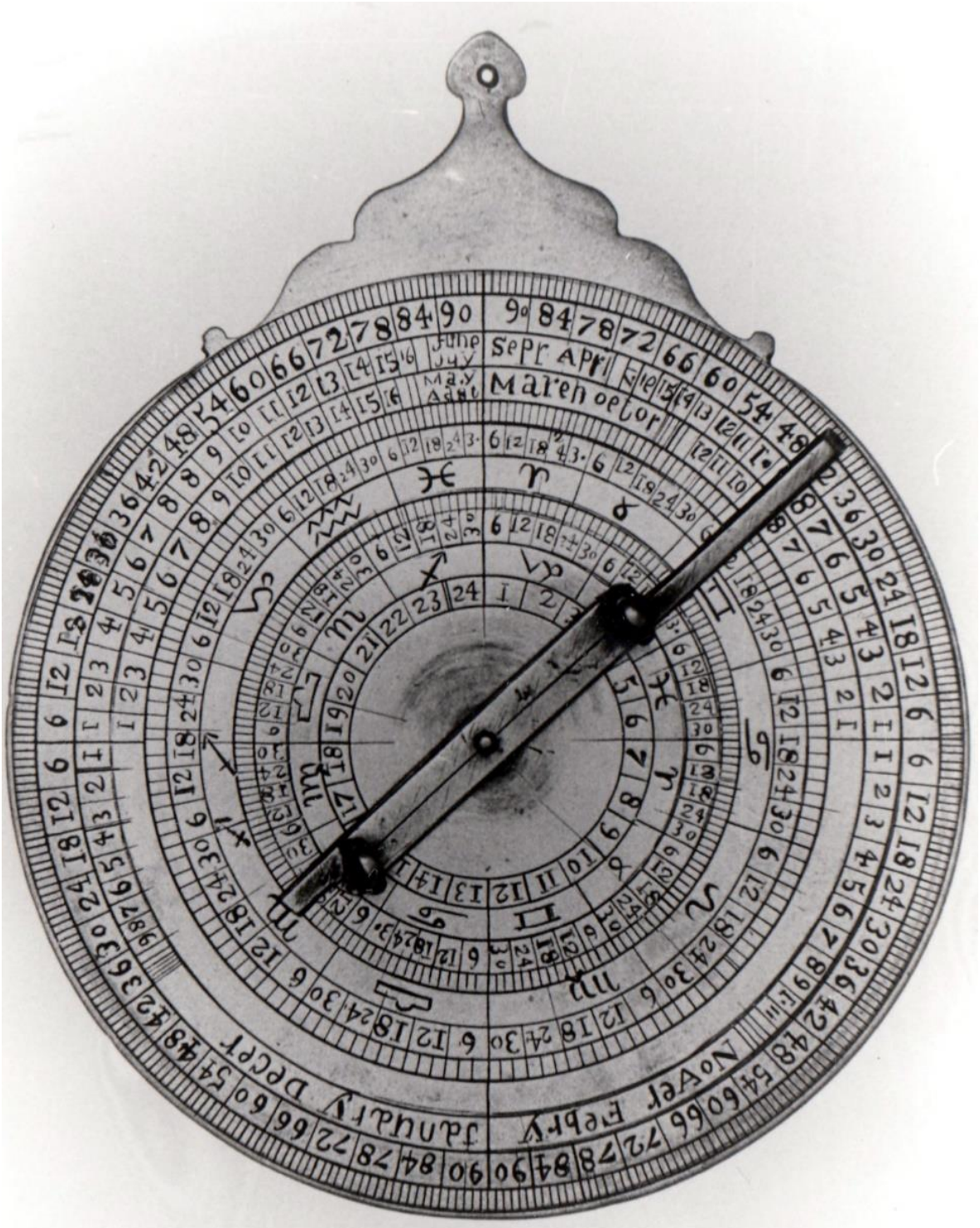


Figure X019.4 – Horary Quadrant (photo courtesy Museum of the History of Science)

HORARY QUADRANT ON THE REVERSE

The reverse side is a copy of the same in X018, with two differences. Here, in rows 7 and 10, instead of the Latin names of the zodiac signs, their symbols are engraved. Second, in addition to the 10 rows which are on X018, there is an eleventh row here. Obviously, these are caused by Dharm Chand himself and not by his assistant.

Counting from outside, these 11 rows are filled with the following data:

1. Degree scale, divided in 1°.

2. Groups of 6° are numbered from 6 to 90, separately in each quadrant, starting from the horizontal diameters and reaching up to the vertical diameters.

3. Four *ghaṭī* scales for four pairs of English months, one in each quadrant: in the upper left for June-July, in the upper right for April-September, in the lower left for January-December, and in the lower right for February-November.

4. Two *ghaṭī* scales for two pairs of English months, in the two upper quadrants: In the upper left for May-August and in the upper right for March-October. The two lower quadrants are empty.

5-6-7. Row 7 is divided in 12 parts according to the right ascensions of the signs, and in each part, the symbol of a zodiac sign is engraved, starting at top on the left of the vertical radius and proceeding clockwise. In row 6, groups of 6° are numbered 6, 12, 18, 24, 30 anti-clockwise. In row 5, 1/15th parts of the signs are marked.

8, 9, 10. Row 10 is divided into 12 parts, according to oblique ascensions of the signs and filled with their symbols, starting from the horizontal radius on the right (that is, 90° away from the upper set of signs) and proceeding clockwise. In row 9, groups of 6° are numbered anti-clockwise as 6, 12, 18, 24 and 30. In row 8, 1/15th parts of the signs are marked.

11. Divided in 24 equal parts and numbered from 1 to 24, starting from the top and proceeding clockwise. This must be a scale of hours, but its purpose is not known.

How to use the Horary Quadrant

For measuring time, one chooses the appropriate *ghaṭī* scale according to the current solar month, and holds the instrument in such a way that the sun's rays pass through the holes in the two sights of the alidade. When this is done, the point where the alidade touches the current *ghaṭī* scale will give the time in *ghaṭīs* for this moment; in the forenoon it is the time that has elapsed since sunrise; in the afternoon it is the time that is yet to elapse up to sunset. The alidade also touches the first two scales containing single degrees and groups of 6°. Here one reads the altitude of the sun at this moment in degrees. Furthermore, from the points where the alidade touches the scale nos. 6, 7 and 8, one can read the culmination in signs and degrees, and from the points where the alidade touches the scales 8, 9, 10, one can read the ascendant in signs and degrees.

One arm of the alidade is partly broken.

BIBLIOGRAPHY

Sarma 2015b, no. [33], pp. 291-292

X020⦿ PARTS OF A CIRCUMFERENTOR ATTRIBUTABLE TO JOSHI DHARM CHAND

Not dated; second half of the 19th century

Outer ring, diameter 157 mm, width 13 mm, thickness 6 mm;

inner plate, diameter 131 mm

New Delhi, National Museum (# 56.155/3 and 56.155/7 (a))



Figure X020.1 – Circumferentor (photo by S. R. Sarma)

Circumferentor is an instrument used for measuring angles in land survey. It consists of a graduated horizontal circle with an inbuilt compass and an alidade with sighting plates; it is usually mounted on a tripod. After the advent of the theodolite, the circumferentor became obsolete, but images of several specimens can be seen in the Wikipedia.

There exist two Indian adaptations of the circumferentor; one is the present specimen and the other will be described in the next entry (X021). Neither specimen is fully preserved; there are extant two parts each of the two specimens. The present specimen carries neither a signature nor a date, but X021 is signed by Dharm Chand.

In the present specimen, the labels on the horary scales are similar to those on X017 which is made by Dharm Chand. Therefore, it is fairly certain that the present specimen was also made by Dharm Chand.

Of the present specimen, there are extant two parts; a graduated outer ring and a graduated circular plate which fits in the outer ring.



Figure X020.2 – Ring with horary scales (photo by S. R. Sarma)

The ring is quite heavy with a diametral bar attached to it. The bar is constituted by joining two metal strips together. There are no markings on the bar except a hole in the middle. The upper side of the ring is engraved with three concentric bands. The outer one is graduated in 1°; the two inner ones carry seven horary scales for different periods of the year. The scales are divided in hours and numbered in common Arabic/Persian numerals. The labels on these scales, in descending order, are as follows:



Figure X020.3 – Detail showing the labels Akast wa māh Aprīl below and Sitambar wa māh Mārch above (photo by S. R. Sarma)

1. *Akast wa māh Aprīl* (August and the month of April)
2. *Sitambar wa māh Mārch* (September and the month of March)
3. *Janwarī Navambar* (January [and] November)
4. *māh Farwarī wa Aktūbar* (Month of March and October)
5. *māh Mayī Jūlāyī* (Month May and July)
6. *māh Jūn* (Month of June)
7. *māh Disambar* (Month of December)

As mentioned above, these labels on the horary scales are similar to those on X017 signed by Dharm Chand.

There are three bands on the back of the ring as well; the outer one is divided in single degrees and the middle in 30°, but not numbered.



Figure X020.4 – Graduated circular plate, upper side (photo by S. R. Sarma)

The circular plate is divided into four quadrants by two diameters which are perpendicular to one another. The rim is graduated in 1° and groups of 6° are numbered in common Arabic/Persian numerals from 6 to 90, separately in each quadrant. At the centre of the plate is a large hole, enclosed in a high rim, where a magnetic compass was originally incorporated under a glass cover. The glass cover is still there but the compass is missing.

Around the centre rotates an alidade (width 17 mm) with two large sighting plates hinged at both ends; these sights can be stretched flat to be at level with the surface of the alidade; at the time of use, these can be raised so that they are perpendicular to the plane of the alidade. There are long slits in the sighting plates.

The horary scales on the outer ring appear to be Dharm Chand's innovation; these are meant for measuring time during the day. This can be accomplished only by suspending vertically the entire ensemble of the ring and the circular plate with the alidade. But there is no suspension bracket, nor a ring which would enable the suspension.

X021⊙ PARTS OF A CIRCUMFERENTOR BY JOSHI DHARM CHAND[1676]

Not dated; second half of the 19th century

Outer ring: diameter 195 mm; width 9 mm, thickness 8 mm

Circular plate with alidade: diameter 157 mm

London, Victoria & Albert Museum (# IM 413-1924; IM 413c-1924)

Two parts of this instrument are extant, a graduated ring and a perforated circular plate with an alidade. On the inner diameter of the ring are two grooves to support some circular object, but the perforated plate is too small to fit there, for it has a diameter of 157 mm as against the inner diameter of the ring measures 177 mm.

The ring is graduated in 1° and 6° on both sides; on one side groups of 6° are numbered in 'English' numerals from 6 to 90, separately in each quadrant thus: 6—90; 90—5; 5—90; 90—5. On the other side are the signatures of the maker in English and Persian.

The circular plate bears six tear-drop-shaped perforations, arranged symmetrically like the petals of a flower. On the circular rim is engraved N. S. L. (in Roman letters) and *Māna-yantra* (in Devanagari). It is not known what the abbreviation N. S. L. stands for. The Sanskrit name *Māna-yantra,* which translates to 'measuring instrument', does not convey much on the nature of the instrument. A thick alidade with circular sighting plates is pivoted to the centre of the plate.

Inscription

On the ring is engraved in clumsy English letters, similar to those on X019:

JOUTSHEE DURM CHUND

Below this is an Inscription in Persian which reads

joshī dharm chand īn dā'irah taṣnīf al-nahār ast

'Joshi Dharm Chand; this circle is an invention of the day (?).'

[1676] The Victoria and Albert Museum wrote to say that they do not permit publication of private photography of their artefacts. Therefore, this entry does not include my photos.

X022⊙ SYNCHRONOME CLOCK WITH A DIAL FOR HOURS AND GHAṬĪS CA. 1930-40

Varanasi, Sampurnanand Sanskrit University, Saraswati Bhavan Library



Figure X022.1 – Synchronome Clock (photo by S. R. Sarma)

The ‘Synchronome’ clock is a highly accurate pendulum clock which was invented in 1921 by William Hamilton Shrott and manufactured by the Synchronome Co. of London. These clocks were in great demand for accurate timekeeping until the introduction of quartz clocks 1940s. [1677]

The present specimen is either from a batch of clocks specially manufactured for India with a scale of *ghaṭīs,* or it is a unique exemplar specially ordered by the Banaras Sanskrit College, as the Sampurnanand Sanskrit University was known earlier.



Figure X022.2 – Dial of the Clock (photo by S. R. Sarma)

[1677] https://en.wikipedia.org/wiki/Shortt%E2%80%93Synchronome_clock [also https://goo.gl/aX8vEP, last accessed in November 2017].

The dial of the clock carries four graduated scales. The innermost scale is divided in 24 hours and every second hour is numbered in Roman numerals from II to XXIV. Below the scale is the label 'HOUR'. The next scale is divided in 60 *ghaṭīs* and every second *ghaṭī* is numbered in 'English' numerals from 2 to [6]0. Below this scale is the label 'GHATI'. The third scale is also divided in 60 parts, but not numbered. It carries the label 'PALA', but *palas* (units of 24 seconds) cannot be measured on this scale. The outermost scale is also divided in 60 parts; here every second unit is numbered in 'English' numerals printed in red colour. The label beneath this scale reads 'VIPALA', but again *vipalas* (units of 24 thirds) cannot be measured on this scale.

In other words, all the three outer scales are divided in 60 parts and can be used to measure only *ghaṭis.* The labels 'PALA' and 'VIPALA' appear to have been added only for didactic reasons. Strangely, there is no scale on which minutes can be measured.

The dial is equipped with three hands. The shortest one, which is reticulated, reaches up to the scale marked 'GHATI'. The next one, lance-shaped, reaches up to the scale labelled 'PALA'. The longest one, painted red, reaches up to the outermost scale named 'VIPALA'. What these three hands actually show is not known, because when I saw the clock first in 1991 it was not functioning.

At the bottom, just above the outermost scale, is the name of the company which manufactured the clock -SYNCHRONOME- . It is surprising that a company reputed for its high precision clocks creates a dial for hours with no provision for minutes, adds three extra scales, all identically graduated to measure *ghaṭīs,* but names each one of them differently.

X023⦿ SANSKRIT ASTRONOMICAL CLOCK BY MULCHAND, 1872

Ca. 1.25 x 1.25 m

Varanasi, Ramnagar, Maharaja Banaras Vidyamandir Trust Museum

This is an elaborately made astronomical clock, designed to show various Sanskrit astronomical and astrological parameters. There are five dials with different functions.

Dial 4 shows time in hours and minutes as also in *ghaṭīs* and *palas*. It strikes hours, half hours and quarter hours. The weekday is indicated in dial 5.

Dial 1 shows the times of the sunrise and sunset in hours and minutes; it also indicates the English month and date, and the sun's position in the zodiac, in signs and degrees.

Dial 2 shows the phases of the moon and the *tithi* (day of the lunar month).

Dial 3 is the largest and occupies the central position. It displays the figure of the zodiac sign occupied by the sun once in a year. The black needle in this dial, which makes a full circle in 24 hours, indicates the ascendant, i.e., the zodiac sign which is rising above the eastern horizon, the novenary or the ninth part of that sign (*navāṃśa*) and also the nature of that sign, namely, whether it is fixed (*sthira*), movable *(cala*) or mixed (*miśra*).

Dial 5 shows the weekday and the figure of the planet after which the weekday is named. It also indicates planetary hours in the daytime and at night, in terms of *muhūrtas* (30th part of the day) and *horas* (half of the zodiac sign).

Mulchand, the clockmaker of the princely state of Banaras, is mentioned as the one who made this clock. But he must have had the advice of a scholar of Sanskrit astronomy and astrology. In early 1876 when the Prince of Wales visited the Maharaja of Banaras, he was presented with a set astronomical instruments, including a small scale model of the present astronomical clock, all of which were fabricated specially for the prince. A detailed list of these presents was printed in the chronicle of the Prince's tour entitled *Prince of Wales' Tour* by William Howard Russel. I have argued that the list must have been prepared by Bapu Deva Sastri, Professor of Astronomy at the

Banaras College.[1678] It is entirely probable that this Sanskrit Astronomical Clock was fabricated under the advice of this Bapu Deva Sastri.

Photography was not allowed in this private museum set up in the palace of the Maharaja of Banaras. Therefore, I reproduce in the next pages (i) a description which is displayed next to the clock, (ii) my sketch showing the position of the five dials and (iii) my sketch showing the details of these dials. Ideally there should be a complete monograph on the construction and function of this unique clock which represents the pinnacle of clockmaker's art in India.

[1678] Sarma 2014b.

Maharaja Banaras Vidyamandir Trust Museum

Astronomical Clock (*Dharma Ghari*)

Made by	Made in	Repaired by
Mulchand	Ramnagar Benares	B. Munni Lal
1872 AD	State	1923 AD

"This unique instrument was constructed in the year 1872 by B. Mulchand, the State clock maker and gives a variety of chronological and astronomical information for which ordinarily a number of scientific instruments would be necessary.

"It shows not only correct time of day but also the position of the sun and phases of the moon together with the signs of zodiac and the date of the month and year.

"On the right [1] are shown the hours of sunrise, English names of months in Hindi and date, whilst opposite on the left [2] are shown the phases of the moon and the date of Hindi months for each day.

"The circle in the centre [3] shows the figures of the Zodiacal Signs over which the sun passes once in a year. From the movement of the black needle which passes over the circle in 24 hours, the ascendant or horoscope and Navamsa can be ascertained. The Navamsa is the ninth part of the Sign of thirty degrees indicated by the lines marked after the signs of the Zodiac to which the needle points. The names of the 12 signs of the Zodiac are shown and these are divided into three parts according to their three different properties, fixed, movable and common.

"Below the clock [5] are indicated the day of the week, the forms of the signs of the Zodiac with their names, and Muhurta and planetary hours.

"Between the circle and the lower portion of the frame [4] a finger of the index hand and a blue star above it point to the number of hours and minutes already expired and gives exact time of the day.

"The hours are divided by lines into four parts of 15 minutes each whilst simultaneously the hours are shown according to Indian calculation in which twenty-four minutes equal one ghari.

"The clock ticks out the seconds, and strikes the hours, half hours and quarters. It requires winding once in eight days. It is correctly calculated and regulated according to latitude, longitude and height of the Benares city above mean sea level.

"After a long period of disuse it was eventually completely overhauled, repaired and regulated by B. Munnilal, artist of Ramnagar, under whose supervision and care it remained since 1923."

Figure X023.1 – Description of the clock on display

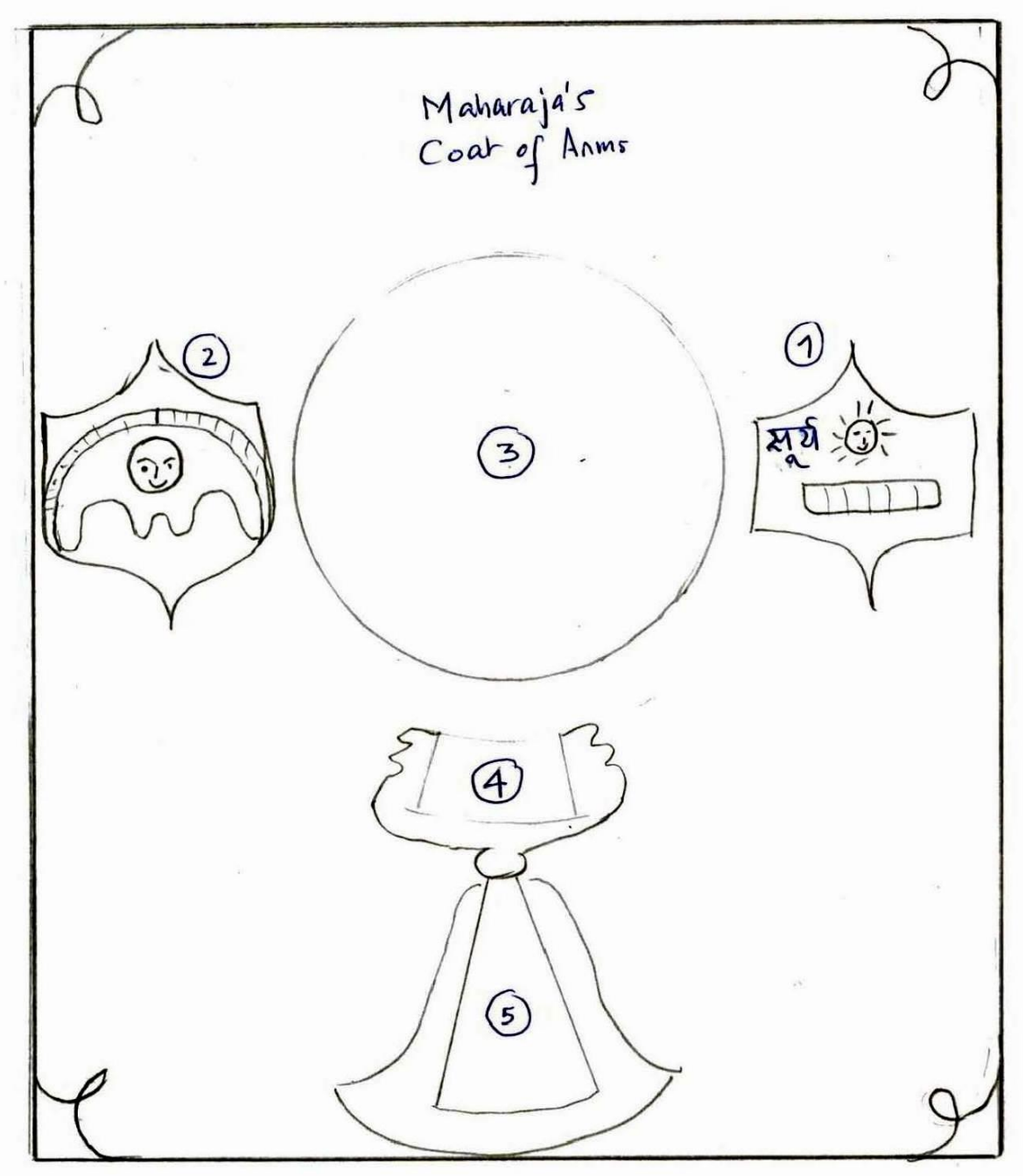


Figure X023.2 – Sketch showing the five dials

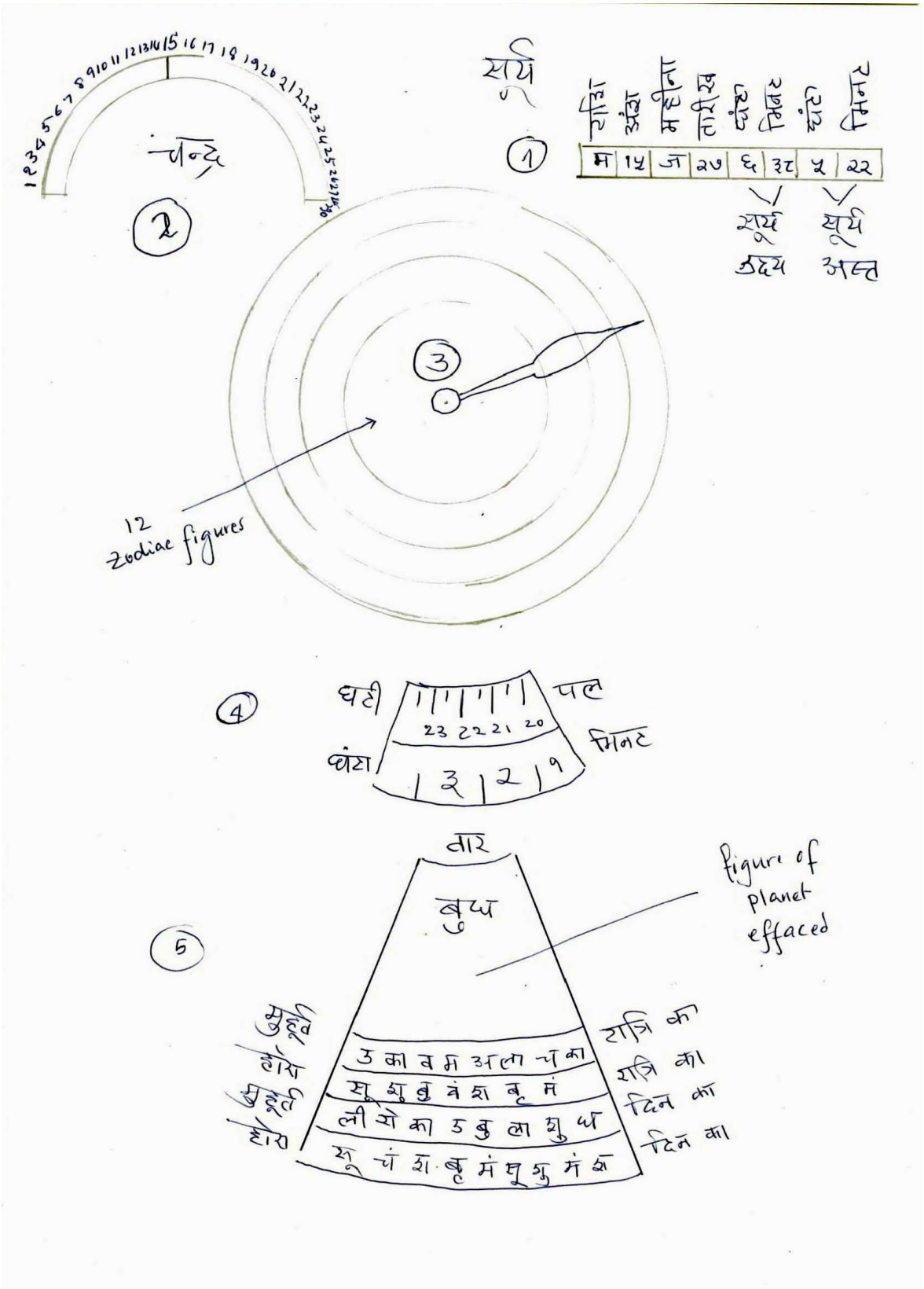


Figure X023.3 – Sketch showing the details of the dials

X024 SANSKRIT ASTRONOMICAL CLOCK MADE FOR THE PRINCE OF WALES CA. 1875

Dimensions ?

London, Royal Collections

This is a smaller version of the previous clock (X023), made specially as a gift for the Prince of Wales (the former Edward VII). When the prince visited the Maharaja of Banaras on 5 January 1876, the latter presented him a set of astronomical instruments, including this astronomical clock. [1679] Probably it was fabricated by the same clockmaker Mulchand who created the original version in 1872 (X023).

[1679] Cf. Sarma 2014b.

X025 SANSKRIT ASTRONOMICAL CLOCK (LOOSE PARTS), 1772 ŚAKA (AD 1850-51)

Leeds, PC

This is a set of 17 loose parts belonging to an astronomical clock produced in Gujarat in Śaka 1772 (= AD 1850-51), which the present owner acquired in 1988. There are 12 circular discs, 1 annular ring and 4 oblong plaques, all made of guilt brass.

The various dials are so designed that the clock shows time in hours and minutes (a1) and dates of the English calendar (a2); weekdays (b1) and *tithis* or days of lunar month (b2); planetary hours, separately for Mars, Mercury, Jupiter, Venus and Saturn (c1-c5); zodiac signs and lunar mansions (d1) and planetary aspects (d2); altitude scales (e1) and *ghaṭikodaya-cakra* of unidentified function (e2).

In these circular dials, there is a large hole at the centre for the pointer which rotates around the dial and indicates a particular parameter. There are some smaller holes at the circumference where the dials would be nailed to the main board.

Two oblong plaques (f1, f2) are engraved with the values of the declination of the 28 lunar mansions (*nakṣatras*). Another oblong plaque mentions the dates on which the sun enters different signs in each calendar month (g1) and the fourth plaque is engraved with the mean motions of Venus, Jupiter, Mercury and Saturn, and some material in Gujarati (g2).

These parts are engraved in Devanagari script; the letters on several parts look as though they were created the type fonts in a hand printing set. There are no conjunct consonants and the *halanta* sign is frequently used to join consonants. Thus स् वाति instead of स्वाति, उ is written as अ with ु the *u-mātrā* beneath it. Such script occurs on a number of plates. On others, the letters are engraved by hand.

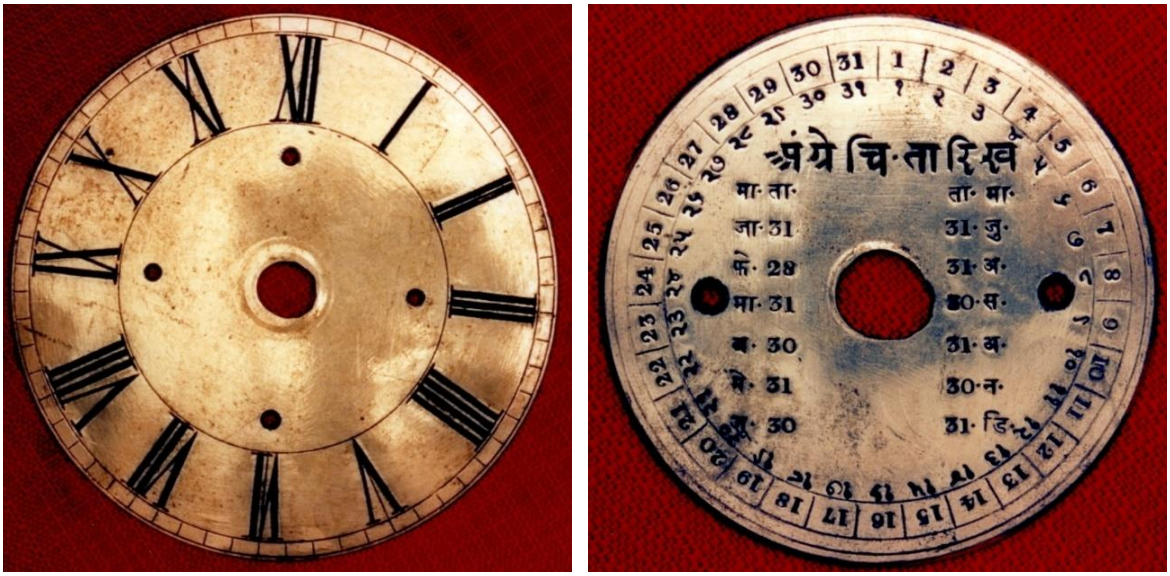


Figure X025.1 – Dials a1 and a2 (photos courtesy the owner)

a1. Circular Dial, d. 143 mm. Shows time in hours and minutes. Hours are represented by Roman digits. There must have been two hands to indicate hours and minutes respectively. A large hole at the centre, for the hour hand. There are four smaller holes symmetrically placed below the Roman digits, probably for the screws with which this dial was nailed to the main board.

a2. Circular Dial, d. 91 mm. Shows the dates of the English calendar (*aṃgreci tārikh*). On the circular scale, the dates are marked both in English and Devanagari digits from 1 to 31. In the middle there is a table showing the number of dates in each calendar month from January to December. There should be one hand showing the current date, for which there is a large hole at the centre. There does not seem to be any provision to show the month here.

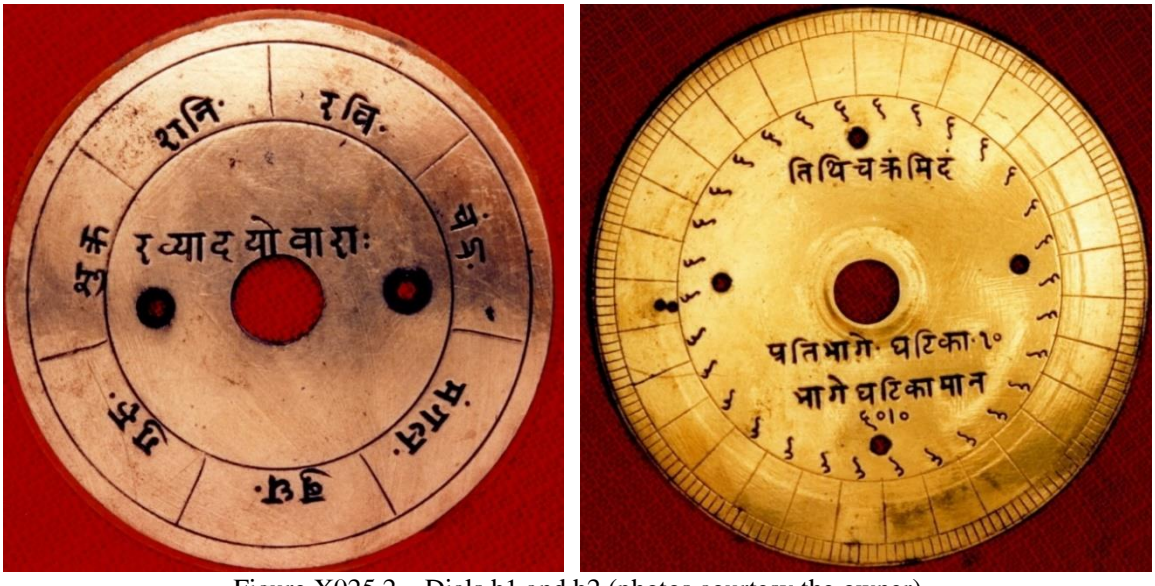


Figure X025.2 – Dials b1 and b2 (photos courtesy the owner)

b1. Circular Dial, d. 93 mm. Days of the Week. Two concentric circles divide the disc into three rings. The middle ring is divided into 7 segments and labelled clockwise *ravi, candra, maṃgala, budha, guru, śukra, śani* (Sun, Moon, Mars, Mercury, Jupiter, Venus, Saturn). The inner ring bears the legend *ravyādayo vārāḥ* (days of the week beginning with Sun[day].

b2. Circular Dial, d. 130 mm. Outer rim is divided into 180 parts, followed by divisions for groups of 6 each. Below each division is written the Devanagari numeral '6'. Above the central hole is written in large letters *tithicakram idaṃ* (this is the circle of lunar days). The two lines below the central hole read

*pratibhāge ghaṭikā 10 (*in each division*, ghaṭikās 10)*

*bhāge ghaṭikāmāna 60/0 (*In division the measure of *ghaṭikā 60/0)*

It is not clear how the *tithis* can be shown on this dial. The rim has of course 30 divisions, corresponding to the 30 *tithis* in a lunar month. But these are not numbered, nor is any provision made to indicate the bright half and the dark half of the lunar month. Moreover, the exact connotation of *bhāga* (division) here remains unknown.



Mars Mercury Jupiter Venus Saturn

Figure X025.3 – Dials c1 – c5 (photos courtesy the owner)

c1-c5 Five Circular Dials, d. 60. These are named *kāla-cakras* (circles of time) of the five planets Mars, Mercury, Jupiter, Venus and Saturn. The outer rim is divided into 60 units. There must have been a hand, which pointed to one of the 60 *ghaṭī* that is connected to the planet concerned. A large hole is in the centre, for the pointer, two smaller holes on either side for the screws.

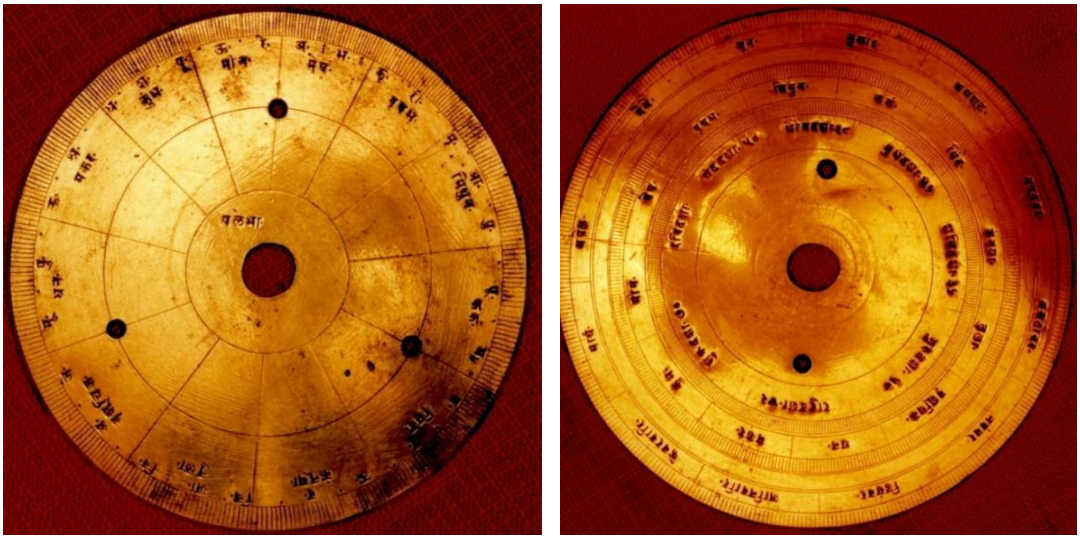


Figure X025.4 – Dials d1 and d2 (photos courtesy the owner)

d1. Circular Dial, d 131. Three concentric circles divide the disc into four annular rings. The outer ring appears to be divided into 360 degrees. The next two rings are divided into 12 segments by radial lines. In the second annular ring, the 12 segments are filled with the Sanskrit names of the zodiac signs: *Meṣa, Vṛṣabha, Mithuna, Karka, Siṃha, Kaṃnyā* (! *Kanyā*), *Tulā, Vṛścika, Dhana* (! *Dhanuḥ*), *Makara, Kuṃbha, Mīna.*

A circular line between the first and the second ring is divided into 27 units by single dots and these are labelled as the *nakṣatras* with the initial letters of each *nakṣatra*, also starting at the top and going clockwise. The fourth ring surrounding a large hole is not divided but bears the legend *palabhā* (equinoctial shadow).

d2. Circular Dial, d. 165. There are seven concentric rings. These contain, starting from the outer rim, (i) degree scale, (ii) names of the English months, starting from the bottom and proceeding clockwise (iii) blank, (iv) degree scale, (v) zodiac signs in Sanskrit, starting below April and proceeding clockwise, and (vi) degree scale. In the seventh ring are written, starting again below April and proceeding clockwise: *ravidaśā* (aspect of the Sun); *caṃdradaśā 50* (aspect of the Moon 50); *bhaumadaśā 28* (aspect of Mars 28); *śanidaśā 36* (aspect of Saturn 36); *gurudaśā 56* (aspect of Jupiter 56), *rāhudaśā 42* (aspect of Rāhu 42); *śukradaśā 70* (aspect of Venus 70).



Figure X025.5 – Dials e1 and e2 (photos courtesy the owner)

e1.Annular Ring, outer diameter 213, inner diameter 156. Both the outer and the inner rim are graduated in degrees. Each group of 6° marked and labelled, once in 'English' numerals and below in Devanagari numerals, from 6 to 90, separately in each quadrant, starting from the meridian line and reaching up to the horizontal line.

e2. Circular Dial. d. 84. Four concentric circles divide the disc into five annular rings. Starting from the outer rim, the first three are divided into five segments each by double radial lines. In the first ring, these five segments are numbered in English numerals clockwise from 1 .. 5. In the second ring, under each English numeral are written *akāra, okāra, cakāra, takāra, yakāra* (symbol for 'a', symbol for 'o', symbol for 'ca', symbol for 'ta', symbol for 'ya'). In the third ring, under each of these legends are written the Devanagari numerals 1 to 5. The fourth ring bears the legend *ghaṭikodayacakraṃ* (wheel of the risings of *ghaṭikās*, i.e., wheel of the successive risings of the zodiac signs in the east in the time units of *ghaṭikās* ?). The fifth ring is blank. The function of this disc is unknown; the five-fold division and the names of these divisions do not have any connection with the measurement of time.



Figure X025.6 – Plaques f1 and f2 (photos courtesy the owner)

f1-f2. Two oblong plaques (140 x 30 mm), one the continuation of the other. On both is written at the top *Śāke 1772* (= AD 1850). The next line reads *nakṣatra krāṃti* (declination of the lunar mansions). The third line presents the arguments of the table *nāma, aṃ[śa], ka[lā]* (name, degrees and minutes). This is followed by the table of declinations. At the bottom of the first plaque is written 14 [lunar mansions] and at the bottom of the second 24 [lunar mansions].

The complete table from the two plaques is reproduced below [n = northern declination; s = southern declination].

Table X025-1 Declination of the Lunar Mansions

Lunar Mansion	declination
Aśvinī	20;4° n
Bharaṇī	27;4° n
Kttikā	23;38° n
Rohiṇī	15;12° n
Mṛga[śirā]	15;45° n
Ārdrā	13;50° n
Punarvasu	28;23° n
Puṣya	18;42° n
Aślesā !	10;37° n
Maghā	12;42° n
Pūrvā Phā[*lgunī*]	15;15° n
Uttarā [*Phālgunī*]	15:25° n
Hasta	15;41° s
Citrā	10;23° s
Svāti	19;48° n
Viśā[*khā*]	19;13° s
Anurā[*dhā*]	19;23° s
Jyeṣṭ[*h*]*ā*	25;5° s
Mūla	27;10° s

Lunar Mansion	declination
Pūrvāṣā[*ḍhā*]	29;53° s
Uttarā[*ṣāḍhā*]	27;8° s
Abhiji[*t*]	38;39° n
Śravaṇa	8;28° n
Dhaniṣ[*ṭhā*]	15;23° n
Śatabhe![*ṣā*]	8:23° n
Pūrvā Bhā[*drapadā*]	18;28° n
Uttarā [*Bhādrapadā*]	18;15° n
Revatī	5;4?° n



Figure X025.7 – Plaques g1 and g2 (photos courtesy the owner)

g1. Oblong plaque (134 x 64 mm) contains a table of English dates on which the sun enters into each zodiac sign (*saṃkrānti*). The first two lines read (in Gujarati)

aṃgreci ki yā yā sanī kei tārikhe kei

saṃkrāṃti beseche. te nīce likhyā pramāṇe.

The third line contains the argument of the table: *tā[rīkha]* = date, *māsa* = month, *saṃkrāṃti* = sun's passage ortransit into a zodiac sign. This is followed by a table which is reproduced below.

Table X025-2 Dates of transits

Date	Month	Transit (*saṃkrānti*)	
12	January	*Makara* (Capricorn)	12
10	February	*Kumbha* (Aquarius)	10
12	March	*Mīna* (Pisces)	12
11	April	*Meṣa* (Aries)	11
12	May	*Vṛṣabha* (Taurus)	12
12	June	*Mithuna* (Gemini)	12
14	July	*Karka* (Cancer)	14
15	August	*Siṃha* (Leo)	15
15	September	*Kanyā* (Virgo)	15
15	October	*Tulā* (Libra)	15
14	November	*Vṛścika* (Scorpio)	14
13	December	*Dhana* (Sagittarius)	13

g2. Oblong plaque (134 x 64 mm). The first line reads

udayanā kālāṃśanāṃ ce likhyā pramāṇe

'the risings [of the planets] in the east in degrees are written below (?).'

The second line provides the argument of the table: *aṃśa* = degrees; *graha* = planet; *ma[dhya] gati* = mean motion; *aṃ[śa]* = degree. The first and the last columns contain identical degrees, written in English numerals on the left and Devanagari numerals on the right.

Table X025-3 Mean Motion of the planets

aṃśa	***graha***	***ma. gati***	***aṃ.***
9	śukranā (of Venus)	37.0 keṃ.	9
11	*gurunā* (of Jupiter)	5.0	11
13	*budhanā* (of Mercury)	18?.24 keṃ	13
15	*śaninā* (of Saturn)	2.0	15
17	*bhaumanā* (of Mars)	31.38	17

This is followed by six lines in Gujarati explaining the use this plaque.

Y. FOREIGN INSTRUMENTS IN INDIAN COLLECTIONS

INTRODUCTION

There is a small number of foreign instruments in Indian collections, brought by travelling scholars at various points of time. The oldest of these is a Kufic celestial globe (Y013) made in 834/1430 by Muḥammad ibn Jaᶜfar Kirmānī, which is in the Rampur Raza Library. The next in chronological order are two Kufic astrolabes made respectively in 623/ 1226 and 626/ 1228-29 by al-Sirāj of Damascus. [1680]

KUFIC ASTROLABES

Al-Sirāj of Damascus is known through three astrolabes which are extant. It is remarkable that two (Y001 and Y002) of the three extant astrolabes by this Syrian astrolabe maker are now in Indian collections.

Besides these, three other Kufic astrolabes are now in Indian collections. The Khuda Bakhsh Oriental Public Library at Patna owns a Kufic astrolabe made in 706/1306 by Maḥmūd ibn Shaukat al-Baghdādī (Y003). An astrolabe made by Jaᶜfar ibn ᶜUmar of Kerman in 790/1388 is in the Indian Museum, Kolkata (= Calcutta). The Archaeological Museum at the Red Fort in Delhi possesses a Kufic astrolabe (Y005), which is unsigned and undated, but assigned to about 1270 by G. R. Kaye.[1681]

The degree scales in these Kufic astrolabes graduated in 1° and numbered in 5s a peculiar manner. While the decades are fully marked (10, 20, 30 …), the numbers which end in 5, are shown as mere 5; thus 5, 15, 25 etc. are marked with the *Abjad* symbol for 5; the actual value has to be understood by the decade which precedes or follows.

These astrolabes must have been brought to India in the thirteenth and fourteenth centuries by scholars for their own use when they migrated to the court of the Sultan of

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[1680] He should not be confused with Ibn al-Sarrāj (actually Shihāb al-Dīn Aḥmad ibn Abī Bakr) who flourished at Aleppo about a century later and was renowned for his universal astrolabe, made in 729/1328-29, which now at Benaki Museum, Athens; cf. King 1987a, IX; King 2005, pp. 694-700.

[1681] There is evidence of at least three other astrolabes (E001, E002 and E003) of this period having been present in India.

Delhi. These and similar other astrolabes which may no longer be extant in India had a certain influence in the design of some early Sanskrit astrolabes.[1682]

SAFAVID ASTROLABES

At present there are five Safavid astrolabes in Indian collections. Like Lahore in the latter half of the sixteenth and seventeenth centuries, Iṣfahān was the centre of astrolabe production in the latter half of the seventeenth and the eighteenth centuries. The notable astrolabe makers here were Muḥammad Zamān of Mashhad, Muḥammad Mahdī al-Khādim al-Yazdī, ᶜAbd al-A'imma and ᶜAbd al-ᶜAlī, who produced large number of opulently decorated astrolabes. [1683] All these masters are represented in the astrolabes extant in Indian collections (Y007 - Y011).

Although some of these belonged to different cities like Mashhad and Yazd, they all seem to have worked in Iṣfahān. An interesting feature of these Safavid astrolabe makers is that sometimes two persons worked together on the same astrolabe. ᶜAbd al-A'imma produced about three dozens of astrolabes on his own, but also decorated the astrolabes made by Muḥammad Amīn bin Muḥammad Ṭāhir (Y010), Khalīl Muḥammad and others. Muḥammad Mahdi al-Khādim al-Yazdī created about 24 astrolabes on his own, but also decorated some of the astrolabes made by ᶜAbd al-A'imma, Muḥammad Khalīl and Muḥammad Muqīm al-Yazdī. It would be interesting to know how these astrolabe makers divided their work in a joint production and where the boundary lay between 'making' and 'decorating'.

Another remarkable feature is that, unlike the astrolabe makers of Lahore, the Safavid astrolabists often repeat the same design of retes or employ the same configuration of different elements on the back exactly in the same style.[1684]

MARINER'S ASTROLABE

Mariner's astrolabe is a drastically simplified version of the common astrolabe designed to measure the solar altitude in the high seas. A single specimen is in India, in

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1682 See the Introduction to C. Sanskrit Astrolabes, Section 2.

1683 King 1999b, pp. 170-193; 255-274. .

1684 For example, in Gibbs & Saliba 1984, astrolabe nos. 31, 37, 39, 40, 42, 59, 61 and 62 contains retes of the identical design.

the Rampur Raza Library (Y012). According to Alan Stimson, the leading authority on the mariner's astrolabes, the specimen in India was produced in France or Portugal in about 1575.

CELESTIAL GLOBES

As mentioned above, the oldest foreign instrument in Indian collections is the Kufic celestial globe (Y013) made in 834/1430 by Muḥammad ibn Jaᶜfar of Kerman. This globe is with the Ramapur Raza Library. The same institution owns an English celestial globe, made of papier-mache with a printed surface (Y014).

TURKISH QUADRANTS

The astrolabic quadrant (*rubᶜ al-muqanṭarāt*), also known as 'astrolabe quadrant', represents the reduction to a quarter of a circle of the essential projections of the

the astrolabe plate (*ṣafīḥah*) made for a particular latitude. A cord with a movable bead is tied to its apex, with which diverse kinds of computations can be made. It was invented sometime before the twelfth century, but became popular in Turkey since the seventeenth century. The Turkish quadrants are made of lacquered wood, on which the lines and legends are drawn in black, red and gilt. As they contain a universal horary quadrant at the apex and also lines for determining the times of Muslim prayers, they become useful devices for the *muwaqqits* of mosques.

Dozens of these quadrants produced in the Ottoman period are extant. However, no complete description of any of these extant specimens has been made so far, and there is no account available on how to use astrolabic quadrant for the different kinds of computations, in particular for determining the times of Muslim prayers.

Partial descriptions of the astrolabic quadrants are available in the following sources. Morley 1860 describes a brass quadrant, 'constructed for the use of the Shaikh Shams ad-Din Ben Sa'id, the chief of Muezzins in the Jami' al-Umawi (the mosque of the descendants of Umayyah), in the year 735 (A.D. 1334) by 'Ali Ben ash-Shihab and engraved by Muhammad Ben al-Ghazuli'; it was made for the latitude of Damascus. It was bought at Damascus for Morley, but the present location is not known.

Würschmidt 1918 writes on a quadrant which he saw with a dealer in Istanbul.

Christie's, London, *Fine Scientific and Philosophical Instruments,* auction catalogue of 27 September 1990, lot 195, p. 46: Ottoman astrolabic quadrant for the latitude of Istanbul at 41° with a radius of 121 mm.

Sotheby's, London, *Arts of the Islamic World,* auction catalogue of 27 April 2005, Lot 41, pp. 58-59: brass quadrant made by Shams al-Dīn, son of Ghars al-Dīn, of Aleppo, 967/1559-60, for the latitude of Aleppo at 35;50° with a radius of 157 mm.

Sotheby's, London, *Arts of the Islamic World, including fine Carpets and Textiles,* auction catalogue of 24 October 2007; Lot 198, p. 189: Ottoman astrolabic quadrant made for the latitude of 39° with radius of 158 mm.

Michel 1976 (pp. 117-120) and Morrison 2007 (221-238) describe, with detailed diagrams, the construction and use of the Profatius Astrolabe Quadrant, but it is slightly different from the Turkish quadrants.

Two specimens of Ottoman astrolabic quadrants are in Indian collections. One of these (Y015), made in 1136/1723-24, is with the K. R. Cama Oriental Institute, Mumbai; it was described, rather inadequately in Khareghat 1950, pp. 75-82. The second one (Y016), not dated, is in the Saidiya Library at Hyderabad.

GUNTER'S QUADRANT

The Sanskrit University at Varanasi owns a Gunter's Quadrant (Y017), probably made in 1768.

OTHERS

There are two other foreign instruments in Indian collections; one is a French model of the heliocentric system (Y018) and another an English Orrery (Y019).

Y001⊙ KUFIC ASTROLABE BY AL-SIRĀJ DIMASHQĪ, 623 AH (AD 1226)

Diameter 113 mm

Hyderabad, Salar Jung Museum (# 113/2/xxxv)



Figure Y001.1 – Front of the astrolabe (photo by S. R. Sarma)

Al-Sirāj Dimashqī, a muezzin of Damascus (*fl.* 619-628 / 1222-1230) is known through three astrolabes. Besides the present one, two other astrolabes by him are extant: an astrolabe made in 626/1229 in the Rampur Raza Library (Y002) and another dated 628/1231 in the National Maritime Museum at Greenwich.[1685] He also decorated with

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[1685] Charette 2005d.

silver inlay an astrolabe made by ᶜAbd al-Raḥmān ibn Sinān al-Baᶜlabakkī in 619/1222-23 for the Ayyubid Sultan al-Muᶜazzam Sharaf al-Dīn ᶜĪsā.[1686]

There is some controversy whether the name should be read al-Sarrāj or al-Sirāj, but David King is in favour of the latter, stating that it is the short form of Sirāj al-Dīn.[1687]

The three astrolabes contain almost the same style of rete with the same set of 25 stars, but the backs are different in each one. In the present astrolabe, the two upper quadrants are filled with trigonometric tables, while the lower left quadrant has a universal horary quadrant and the lower right a shadow square. In Y002, inside the degree scale on the rim, there is a kind of calendar scale, which encloses trigonometric tables in the upper half and double shadow squares in the lower half. In the third astrolabe at Greenwich, there is no calendar scale, but the rest is as in Y002. The signature is engraved in the present astrolabe at the bottom of the lower left quadrant on the back, while in the other two it is engraved prominently on the back of the *kursī.*

COMPONENTS

Main body (d. 113, t. 5) with *kursī,* shackle and ring, rete for 25 stars, 2 plates. The original alidade is missing. It is substituted by a copper sighting tube, as in all the astrolabes in the Salar Jung Museum. The pin appears to be original. The horse is missing, and also the washer.

FRONT

The *kursī* is low and plain with three lobes on either side, the last lobe pierced with a large perforation. The astrolabe is suspended by a small shackle and a large ring. The limb and the *kursī* are made in one piece and riveted to the back plate.

The limb of the mater is divided in 1° and 5° and groups of 5° are numbered in *Abjad* notation from the south point at the top centre in clockwise direction in the following manner: 5, 10, 5, 20, … 100 (represented by the letter *qāf*); 5, 10, 5, 20, 5, … 200 (*re*); 5, 10, 5, 20, … 300 (*shīn*); 5, 10, 5, 20, … 60.

1686 Cf. King 2005, pp. 724-244: ‘A monumental astrolabe for the Ayyubid Sultan al-Muᶜaẓẓam’.

1687 Cf. King 2005, p. 734, n. 6.

RETE

The rete consists of the Capricorn ring, ecliptic ring and the central ring which are held together by the equinoctial bar which has no counter change. The ecliptic is represented by a small segment below the ecliptic ring; it is joined to the Capricorn ring by two upright supports; its two ends are nicely shaped as sharp pointers. The ecliptic is divided into the twelve zodiac signs and labelled with their names. The signs are divided in groups of 6° but not numbered. There are 25 dagger shaped star pointers, 11 to the north of the ecliptic and 14 to the south. Two handles for rotating the rete are located on the Capricorn ring on either side of the meridian. A small triangular extension at the uppermost point of the ecliptic ring represents the Capricorn index (*al-murī*).

The other two astrolabes by al-Sirāj have almost identical retes with some slight changes. François Charette calls this the 'classical' Islamic rete design which occurs on all extant astrolabes dated or datable before *c.* 1150.[1688]

Table Y001-1 Stars on the Rete

	Star Name	Identification
1	*Ṣadr Qayṭus*	π Ceti
2	*Ghūl*	β Persei
3	*al-Dabarān*	α Tauri
4	*ᶜAyyūq*	α Aurigae
5	*Qadm al-Jawzā'*	β Orionis
6	*Yad al-Jawzā'*	α Orionis
7	*al-Yamānī*	α Canis Majoris
8	*al-Shāmī*	α Canis Minoris
9	*al-Fard*	α Hydrae
10	*Qalb al-Asad*	α Leonis
11	*Qafzah*	γ and μ Ursae Majoris

[1688] Charette 2005d, p. 216.

	Star Name	Identification
12	*Janāḥ al-Ghurāb*	γ Corvi
13	*al-Aᶜzal*	α Virginis
14	*al-Rāmiḥ*	α Bootis
15	*Fakkah*	α Coronae Borealis
16	*Ḥayyah*	α Serpentis
17	*Qalb al-ᶜAqrab*	α Scorpii
18	*al-Ḥawwā*	α Ophiuchi
19	*Wāqiᶜ*	α Lyrae
20	*al-Ṭā'ir*	α Aquilae
21	*Minqār*	β Cygni
22	*Dhanab al-Jadī*	δ Capricorni
23	*Mankib*	β Pegasi
24	*Dhanab al-Qayṭus*	ι Ceti
25	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are two plates serving the latitudes of 20°— 24° and 37°—38°. On the inner surface on the mater is engraved a fifth projection for the latitude of 21°. The plates have a projecting bit that goes into a hole under the rim.



Figure Y001.2 – Plate for lat. 21° engraved on the inner side of the mater (photo by S. R. Sarma)

On the plates, altitude circles are drawn for every 6° and numbered on either side of the meridian; there are no azimuth curves; lines are drawn for seasonal hours; these are numbered once in *Abjad* symbols just below the circle of Cancer and once in words expressing ordinals just above the circle of Capricorn. The western and eastern segment of the horizon are labelled as *al-maghrib* and *al-mashriq.* Twilight arcs are drawn about 18° below the oblique horizon with dotted lines, to indicate the two prayer times at twilight.

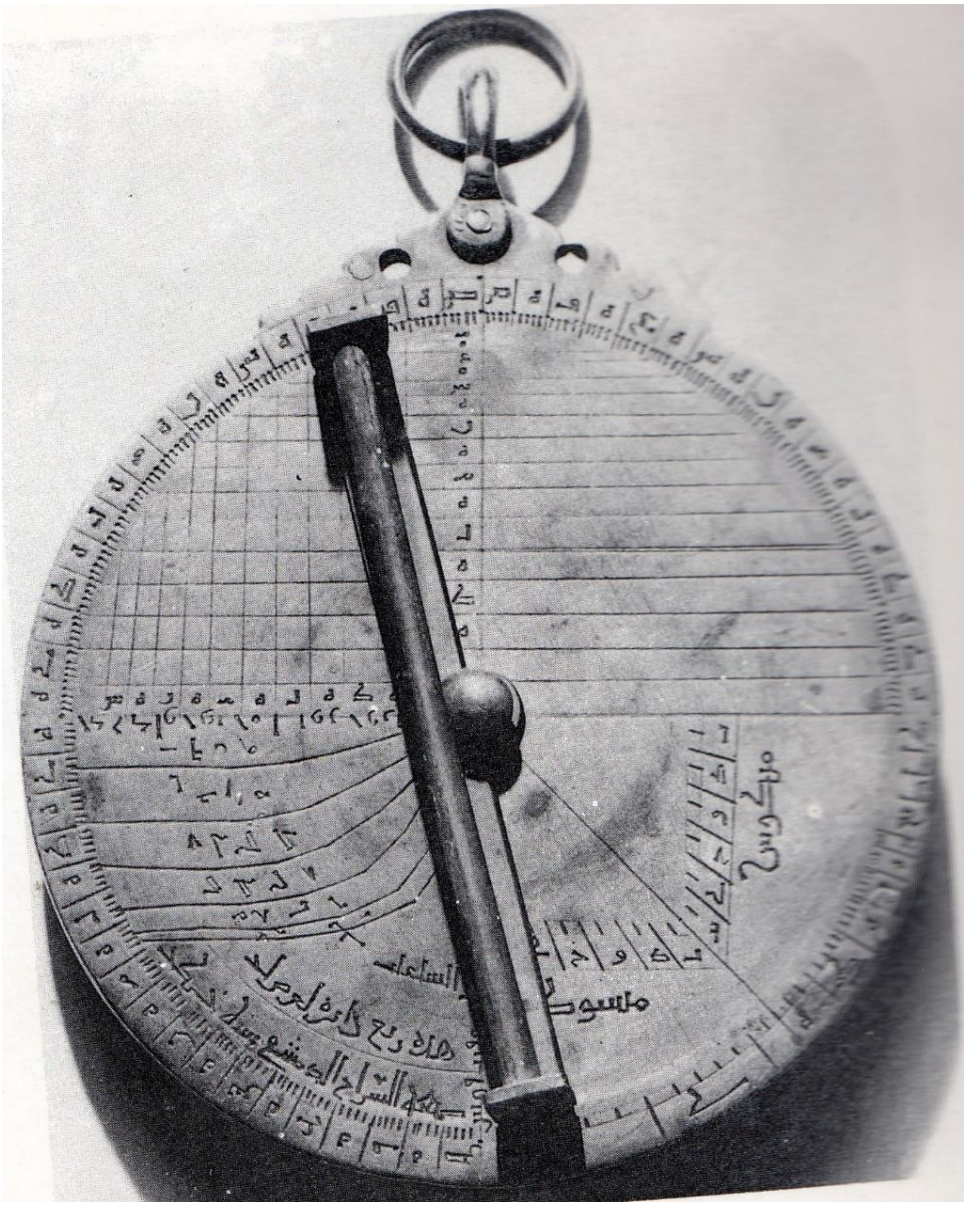


Figure Y001.3 – Back of the astrolabe (photo courtesy Salar Jung Museum)

BACK

The upper left quadrant on the back carries a sine-cosine grid with 15 horizontal parallels and 12 vertical parallels, drawn stereographically and numbered along the two axes. In the upper right quadrant, there are just the horizontal parallels which are extended from the quadrant on the left. In the lower left is a universal horary quadrant. The rim of these three quadrants is graduated in 5° and numbered from 5 to 90 to measure the altitudes of the heavenly bodies. The lower right quadrant is occupied by a shadow square; both the vertical and the horizonal scales are divided in 12 digits and numbered in 2s, both times from right to left. The vertical scale is labelled *maᶜkūs* and the horizontal scale *mustawī.*

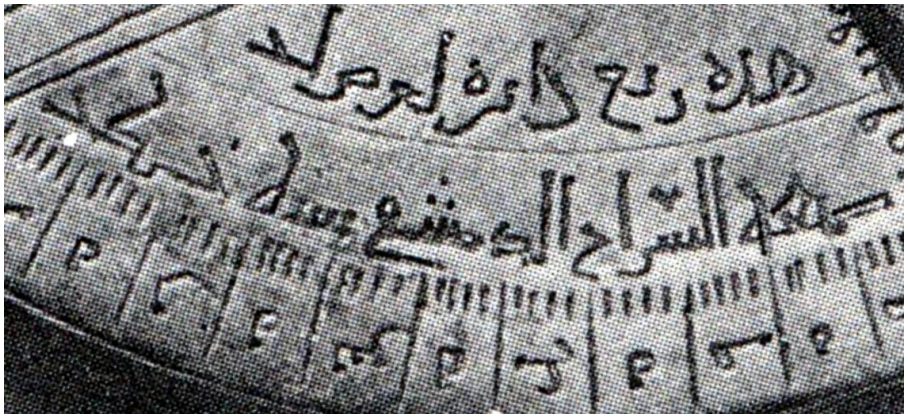


Figure Y001.4 – Signature of the astrolabe maker (detail of Figure Y001.3)

INSCRIPTION

The maker's name is engraved at the bottom of the lower left quadrant:

ṣanaᶜat al-sirāj dimashqī sanah 623

'Made by al-Sirāj of Damascus [in the] year 623 [Hijrī = AD 1226].'

BIBLIOGRAPHY

Sarma 1996a, pp. 23-24, pl. 12

King 2005, pp. 724-244.

Charette 2005d.

Y002⊙ KUFIC ASTROLABE BY AL-SIRĀJ, 626 AH (AD 1228-29)[1689]

Diameter 137 mm

Rampur, Rampur Raza Library (# 1832 D)

CCA 3765



Figure Y002.1 – Front of the astrolabe (photo courtesy Rampur Raza Library)

[1689] I am highly obliged to the late Akbar Ali Khan Arshizada for deciphering and translating the Kufic inscriptions on this astrolabe.

COMPONENTS

Main body (d. 137, t. 7) with *kursī*, shackle and ring, rete (d. 129) for 25 stars, 4 plates (d. 129), alidade and pin. The original wedge is missing. Three plates are not original; they are substitutes. Otherwise, the astrolabe is in a perfect state of preservation.

FRONT

The astrolabe is surmounted by a rather low *kursī.* The body, the *kursī* and the limb are cast as one piece. The *kursī* is solid and plain and has three lobes on either sides. The middle lobe on either side is pierced with a large hole. To the tip of the *kursī* a shackle is attached through which a large ring passes. The shackle and the ring have diamond-shaped cross section.

The outer rim of the limb is graduated for 1° and groups of 5° are numbered in *Abjad* notation from the south point at the top centre in clockwise direction in the following manner: 5, 10, 5, 20, … 100 (represented by the letter *qāf*); 5, 10, 5, 20, 5, … 200 (*re*); 5, 10, 5, 20, … 300 (*shīn*); 5, 10, 5, 20, … 60.

At the north point, there is a slot in the thickness of the rim into which are received the corresponding projecting tabs of the plates.

RETE

The rete is almost similar to the rete in the previous astrolabe. Here also the Capricorn ring, the ecliptic ring and the central ring are held together by the equinoctial bar, but here the equinoctial bar is counter-changed once at its intersection with the ecliptic on the right. The ecliptic is divided into the twelve zodiac signs and labelled with their names. Each sign is divided into five parts on the edge of the ecliptic ring.

The equator is represented as a small segment below the ecliptic; it is joined to the Capricorn ring with two upright struts. In order to accommodate the star pointer of α Hydrae, a circular notch was cut in the equator band.

As in the previous astrolabe, here also there are two handles on the Capricorn ring on either side of the meridian. A small triangular extension at the uppermost point of the ecliptic ring represents the Capricorn index (*al-murī*). The rete is endowed with the same set of 25 star pointers as in Y001, but here the star pointers are quite elegantly shaped.

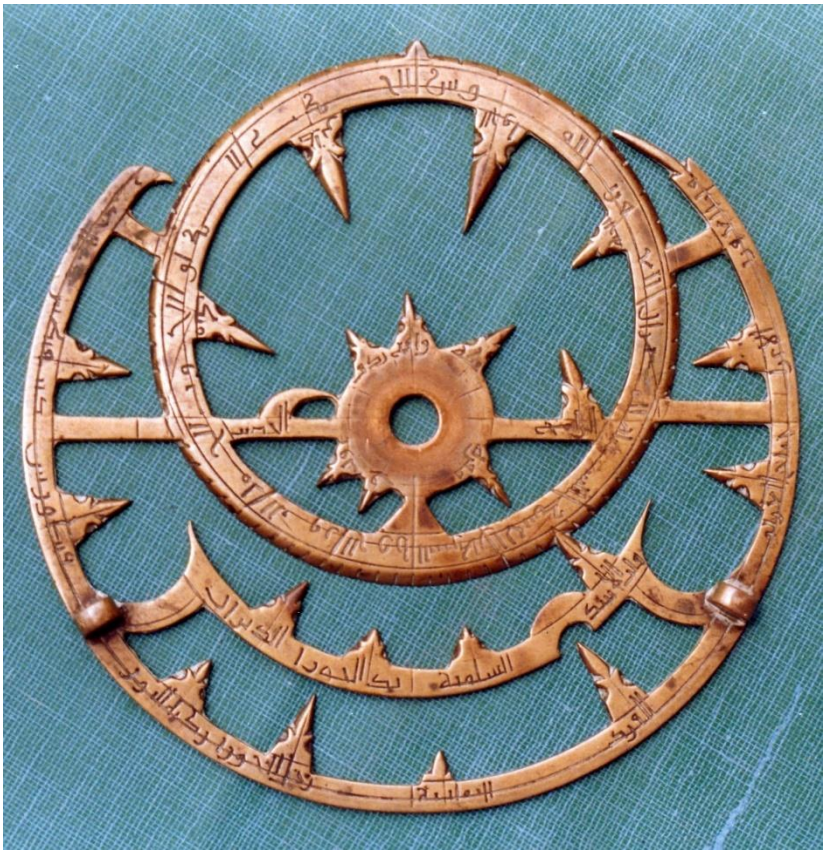


Figure Y002.2 – Rete in the astrolabe (photo courtesy Rampur Raza Library)

Table Y002-1 Stars on the Rete

	Star Name	Identification
1	*Ṣadr Qayṭus*	π Ceti
2	*Ghūl*	β Persei
3	*al-Dabarān*	α Tauri
4	*ᶜAyyūq*	α Aurigae
5	*Qadm al-Jawzā'*	β Orionis
6	*Yad al-Jawzā'*	α Orionis
7	*al-Yamānī*	α Canis Majoris
8	*al-Shāmī*	α Canis Minoris
9	*al-Fard*	α Hydrae
10	*Qalb al-Asad*	α Leonis
11	*Qafzah*	γ and μ Ursae Majoris

	Star Name	Identification
12	*Janāḥ al-Ghurāb*	γ Corvi
13	*al-Aᶜzal*	α Virginis
14	*al-Rāmiḥ*	α Bootis
15	*Fakkah*	α Coronae Borealis
16	*Ḥayyah*	α Serpentis
17	*Qalb al-ᶜAqrab*	α Scorpii
18	*al-Ḥawwā*	α Ophiuchi
19	*Wāqiᶜ*	α Lyrae
20	*al-Ṭā'ir*	α Aquilae
21	*Minqār*	β Cygni
22	*Dhanab al-Jadī*	δ Capricorni
23	*Mankib*	β Pegasi
24	*Dhanab al-Qayṭus*	ι Ceti
25	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

The astrolabe is equipped with four plates carrying stereographic projections for eight different latitudes. Projections for a ninth latitude are engraved on the inner side of the mater. Of the four plates, only no. 1 is original. The other three are replacements made in India in the subsequent centuries when the astrolabe was in active use; they are made of much thinner brass sheets and are inscribed in *Naskhī* characters, while the other parts of the astrolabe are inscribed in Kufic script.



Figure Y002.3 – Plate for lat. 24° engraved on the inner side of the mater
(photo courtesy Rampur Raza Library)

Table Y002-2 Latitude plates

	φ	Longest day
1a	35°	14;25 hours
1b	36°	14;30 hours
2a	21°	13;18 hours
2b	32°	14;08 hours
3a	27°	13;44 hours
3b	30°	13;18 hours (sic!)
4a	34°	14;19 hours
4b	41°	15;01 hours

	φ	Longest day
Mater	24°	13;21 hours



Figure Y002.4 – Substitute plate for lat. 41°
(photo courtesy Rampur Raza Library)

On all the plates, altitude circles are drawn for each 6° and azimuth lines are drawn for each 10°. The latter are shown only above the horizon. Below the western horizon is written *maghrib* (west) and below the eastern horizon *mashriq* (east). On the inner side of the mater calibrated for 24°, there are lines only lines for the seasonal hours. On the other plates plain lines are drawn for the seasonal hours and dotted lines from the western horizon for the equal hours.



Figure Y002.5 – Back of the astrolabe
(photo courtesy Rampur Raza Library)

BACK

On the back, the entire outer rim is graduated for groups of 5° and labelled in *Abjad* notation separately for each quadrant from 5° to 90°, starting from the east and west points and proceeding to the south and north points in the following manner 5, 10, 5, 20, … 80, 5, 90. This scale is followed by a circular scale of single degrees. Next there is an blank circle, followed by a series of concentric bands which carry a kind of calendar scale. Here the first annulus is divided into 28 parts and filled with the names of the lunar mansions in *Naskhī* characters, starting from *al-Sharaṭayn* and ending with *Baṭn al-Ḥūt* (another name for the more common *Rishā'*). Next come three circular scales pertaining to the signs of the zodiac. The first one, rather narrow, displays 1/ 6 part of the sign or 5°; the second is very narrow and contains the scale of single degrees. The third scale, which is much broader, is divided into 12 parts and is labelled with the names of the twelve signs of the zodiac in Kufic characters.

The scale of the zodiac signs is followed by a scale engraved with the names of the Syrian-Macedonian solar months, also in Kufic script. In a narrow circle just above, these units are sub-divided into 6 parts each and each part is further subdivided into 5 single untis; that is to say, each month is divided in 30 days.

These three scales, although they proceed anti-clockwise, do not commence at the same point. The scale of the zodiac signs commences at the horizontal radius on the right; the lunar mansions commences 12° after the zodiac signs and the solar months 15° after the zodiac signs.

The area inside these circular scales is divided into four quadrants. The two upper quadrants contain a simple sine graph with six horizontal lines. The lower quadrants contain double shadow squares. On the left is the shadow scale for a gnomon of seven feet. Here both the horizontal and vertical scales are sub-divided into 7 parts and numbered in *Abjad*. On the outside is written *zill aqdām* (shadow in feet). On the inside along the horizontal scale *maᶜkūs* (direct) and along the vertical scale *mustawī* (reverse). On the right hand side is the shadow scale for the gnomon of 12 digits. Here both the horizontal and vertical scales are sub-divided into 6 parts and labelled as 2, 4, … 12 in *Abjad* numbers. A narrow scale above displays the single units. Outside the square is written *zill aṣābiᶜ* (shadow in digits); inside along the horizontal scale is the label *maᶜkūs* and along the vertical scale the label *mustawī*.

However, the sequence of numbering on the two sides is rather unusual. Generally the units are counted from the centre on the horizontal scale and from the top in the vertical scale so that both terminate at the corner where the two scales meet. But on this astrolabe, in the vertical scale of 7 feet the numbering commences at the corner instead of at the top; likewise in the horizontal scale of 12 digits the numbering commences again at the corner instead of at the centre.

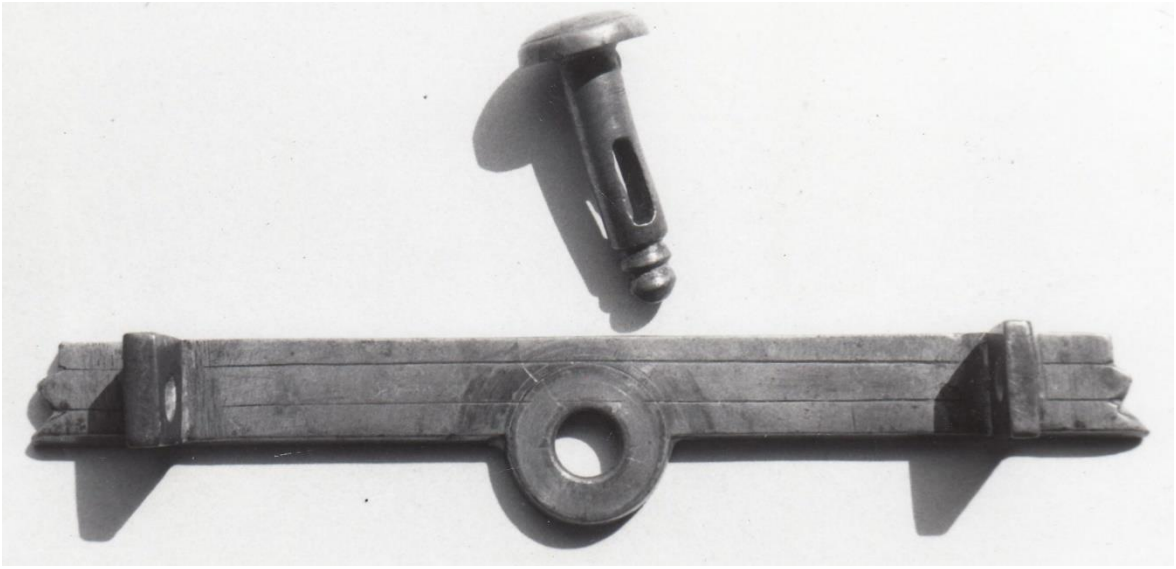


Figure Y002.6 – Alidade and pin (photo courtesy Rampur Raza Library)

ALIDADE, PIN AND HORSE

The alidade is heavy and plain. It is 125 mm long, 12 mm broad and 4 mm thick. On the surface run two parallel lines, cutting the width of the alidade into three parallel strips. No other scales are engraved on the alidade. The two sights (*lubna*) on the alidade measure 12 x 11 x 4 mm. There is a large hole in each sight. The pin (*qutb*) is original but the horse-shaped wedge (*faras*) with which the pin can be tightly secured is missing.



Figure Y002.7 – Signature of the astrolabe maker
(photo courtesy Rampur Raza Library)

INSCRIPTION

At the back of the *kursī* is the maker's signature which reads thus:

ṣanaᶜat al-sirāj ba dimashq sanah 626.[1690]

'Made by al-Sirāj at Damascus [in the] year 626.'

BIBLIOGRAPHY

Dube 1928

Sarma 2003, pp. 25-33, Figs. 1.1-1.5

[1690] Dube 1928, pp. 1, 3, erroneously reads the year as 615. But the year can be clearly seen as 626. CCA also reads 626.

Y003 KUFIC ASTROLABE BY MAḤMŪD IBN SHAUKAT AL-BAGHDĀDĪ, 706 AH (AD 1306-07)

Diameter 190.5 mm

Patna, Khuda Bakhsh Oriental Public Library

This astrolabe was added recently to the 'Album of Scientific Instruments' under the heading 'Digitized Album' in the website of the Khuda Bakhsh Oriental Public Library (http://kblibrary.bih.nic.in/ [also https://goo.gl/AnE5iT, last accessed in November 2017]). It was not in this library when I visited it in the early 1990s. Either it was acquired recently or it lay hidden in the stores and was rediscovered recently. No other astrolabe by this Maḥmūd ibn Shaukat al-Baghdādī is known. It is described thus in the above-mentioned album:

> 'It is a medium sized neatly produced astrolabe made of brass with a diameter of 190.5 mm and a thickness of 7 mm. The body, the *kursi* and the limb are cast as one piece. It is solid and plain. It contains six tympans. The diameter of the rete and tympans is 165.5 mm. All the six tympans contain, on both sides, stereographic projection to specific terrestrial latitudes. On the inner side of the mater there is a further projection. Thus, these tympans serve altogether 13 different latitudes.
>
> 'On the back, on the topmost part of the *kursi,* there is an inscription stating that the astrolabe was made by Mahmud bin Shaukat al-Baghdadi in the year 706 AH / 1306 AD, for the repository of *al-Sultan al-Adil.* The identity of this ruler is not definitely established.'

An image of the front, reproduced in the album, shows a low, lobed and pierced *kursī* with a small well-crafted shackle. The rim is calibrated in 1° and 5° and numbered 5, 10, 5, 20 …. Above each group of 10° is engraved what is probably the name of the decade. The rete consists of the two rings of Capricorn and equator, held together by the equinoctial bar which is not counter-changed. The equator is represented as a small segment below the ecliptic ring. There are 26 named star pointers, 12 to the north of the ecliptic and 14 to the south.

Y004 KUFIC ASTROLABE BY JAᶜFAR IBN ᶜUMAR AL-KIRMĀNĪ, 790 AH (AD 1388-89)[1691]

Diameter 78 mm

Kolkata, Indian Museum (# A.24432)

CCA 16

Jaᶜfar ibn ᶜUmar of Kirmān is known through six astrolabes dated between 751/1350 and 790/1388.[1692] Only one of these, CCA 15 which now at the National Museum of American History, Washington, D. C., has been properly studied.[1693]

COMPONENTS

Body (d. 78, h. 125) with *kursī* and shackle, rete (d. 65), four plates (d. 65); the alidade is missing.

The rim on the front is graduated in 1° and groups of 5° are numbered from 5 to 360. On the inner surface of the mater is a geographical gazetteer.

The rim on the back is also graduated in 1° and groups of 5° are numbered from 5 to 90, separately in each quadrant. Inside the degree scale, the names of zodiac signs are said to have been engraved, three in each quadrant, beginning with *al-Jadī* in the upper left quadrant and proceeding anti-clockwise; each sign is divided in 5 equal parts. But it is not known whether this zodiac is designed to serve as a calendar. There are shadow squares in the lower half.

BIBLIOGRAPHY

Govind 1979, pp. 14-15.

Gibbs & Saliba 1984, no. 15, pp. 64-65.

1691 Entry is based on the inadequate description in Govind 1979, pp. 14-15.

1692 CCA 15, 16, 1033, 1205, 2605 and 3660. However, 1033 at the National Maritime Museum, Greenwich, is said to be a fake.

1693 Gibbs & Saliba 1984, no 15, pp. 64-65.

Y005⊙ KUFIC ASTROLABE, NOT SIGNED, NOT DATED[1694]

Diameter 143 mm

New Delhi, Red Fort, Mumtaj Mahal Museum (# 40.418)



Figure Y005.1 – Front of the astrolabe (photo by S. R. Sarma)

This remarkable astrolabe does not contain any latitude plates. On the inner side of the mater is engraved the universal projection invented by Ibn Bāṣo 1274 in Andalusia.[1695] In the upper half of the back is engraved a *Zarqālī* projection invented by Al-Zarqālluh in Andalusia in the eleventh century.[1696] When Kaye described this

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1694 Entry based on Kaye 1921, pp. 2-5.

1695 On the Ibn Bāṣo projection, see Calvo 1996; see also in this catalogue, A. Introduction, 3.4; this projection can be seen A002 and A003.

1696 On the *Zarqālī* projection, see A. Introduction, 3.2, and A091.

astrolabe in 1921, he was not aware of Ibn Bāṣo's projection; he merely called it 'the projection of the celestial sphere.' On the basis of the star positions, Kaye proposed 1289 as the approximate date of this astrolabe. Superficially the design of the rete suggests that it may have been made in the Maghrib. But, Emilia Calvo, who wrote extensively on the Ibn Bāṣo's projection and surveyed all the existing astrolabes bearing this projection, considers that it was made for the latitude of Cairo. Her statement deserves to be cited in full:[1697]

> 'We also know of the existence of an astrolabe in which Ibn Bāṣo's projection was engraved in the mater. It was engraved in a Maghribi cufic style but, on the other hand, it seems to have made for a 30° degree latitude, because the upper half of the back bears a meridian stereographic projection very similar to the one we find in a *ṣafīḥa,* but here the equator and the complete coordinates are represented as well as the horizon and its altitude circles. The relationship between the equator and the horizon is 30°. This latitude means that this instrument cannot be Maghribi. It is seems to have been made for use at Cairo.'

COMPONENTS

Body (d. 143, h. 159, t. 2) with *kursī* and shackle, rete (d. 135) for 29 stars; alidade (130) and the two rings are later additions.

FRONT

Low *kursī* with three lobes on either side. The rim is slightly upraised to accommodate just the rete. The rim is calibrated in 1° and 5°; groups of 5° are numbered in *Abjad* notation in Kufic style, from 5 to 360.

[1697] Calvo 1996, p. 764.

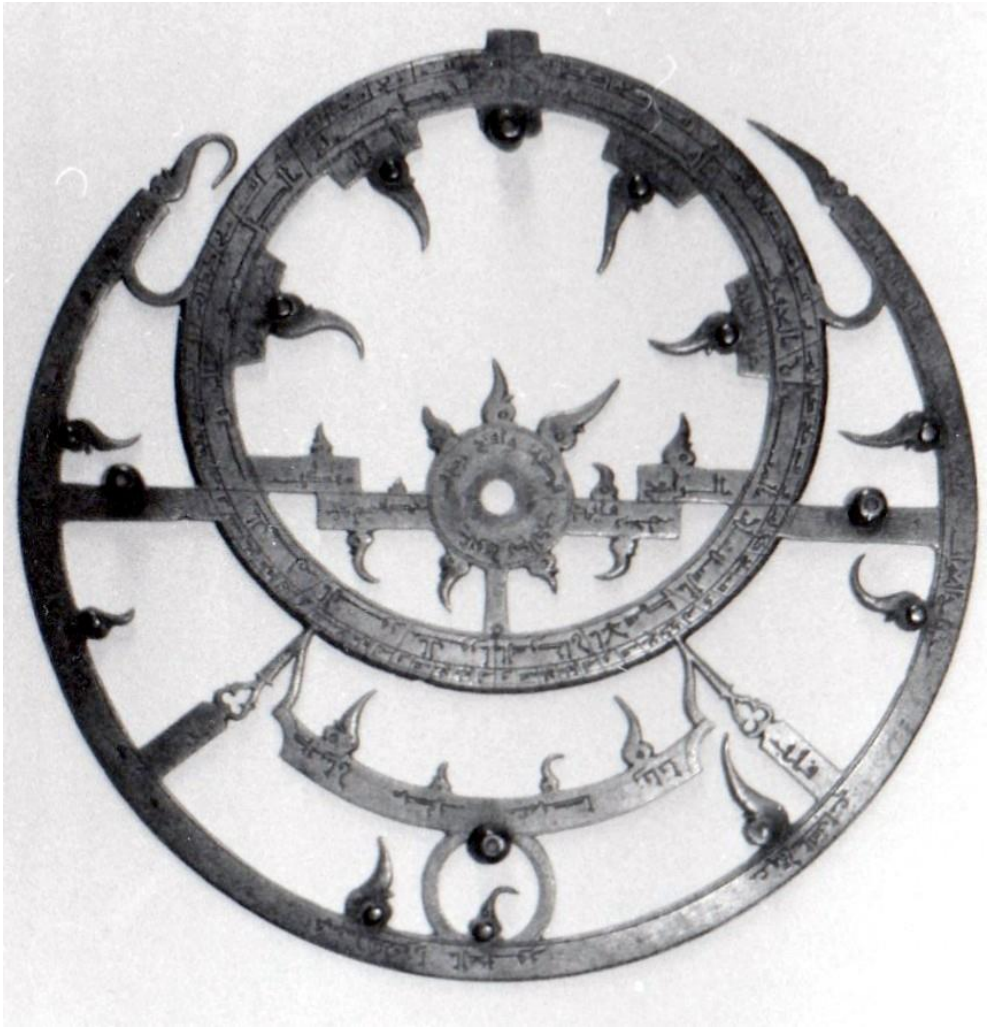


Figure Y005.2 – Rete (photo by S. R. Sarma)

RETE

The rete has a diameter of 135 mm. It consists of the two rings of Capricorn and ecliptic, held together by the east-west equinoctial bar. The ecliptic ring is wider than the Capricorn ring; it is divided into the 12 signs of the zodiac and engraved with their names. Each sign is divided in five parts which are numbered as 6, 12, 18, 24, 30. The equator is represented as small segment below the ecliptic ring. It is joined to the main frame by two upright pieces which arise from the Capricorn ring and reach up to the ecliptic ring. Interestingly, these two upright pieces are decorated by trifoliate perforations.

The equinoctial bar is counter-changed twice on either side of the central ring. There are 29 star pointers, shaped like bent hooks. Some of these have white metal bosses. Four large knobs serve as handles for rotating the rete.

Table Y005-1 Stars on the Rete

	Star Names	Identification
1	*Matn Qayṭus*	?
2	*Ghūl*	β Persei
3	*Dabarān*	α Tauri
4	*ᶜAyyūq*	α Aurigae
5	*Qadm al-Jawzā'*	β Orionis
6	*Mankib* (?)	α Orionis
7	*al-ᶜAbūr*	α Canis Majoris
8	*Ghumayṣā*	α Canis Minoris
9	*Yad* (?) *al-Dubb*	? Ursae Majoris
10	*Zabānā*	α Cancri
11	*ᶜUnuq al-Shujāᶜ*	α Hydrae
12	*Rijl*	α Ursae Majoris
13	*Qalb*	α Leonis
14	*Janāḥ al-Ghurāb*	γ Corvi
15	*al-Aᶜzal*	α Virginis
16	*Qāᶜidah*	α Crateris
17	*al-Rāmiḥ*	α Bootis
18	*Fakkah*	α Coronae Borealis
19	*ᶜUnuq al-Ḥayyah*	α Serpentis
20	*Qalb al-ᶜAqrab*	α Scorpii
21	*al-Ḥawwā*	α Ophiuchi
22	Wāqiᶜ	α Lyrae
23	*al-Ṭā'ir*	α Aquilae
24	*Riḍf*	α Cygni

	Star Names	Identification
25	*Dhanab al-Jadī*	δ Capricorni
26	*Kᶜab* (?) *al-Faras*	? Pegasi
27	*Mankib*	β Pegasi
28	*Dhanab Qayṭus*	ι Ceti
29	*Khaḍīb*	β Cassiopeiae



Figure Y005.3 – Ibn Bāṣo's universal projection on the inner surface of the mater (photo by S. R. Sarma)

INNER SURFACE OF THE MATER

There are no separate latitude plates in this astrolabe. The inner surface of the mater carries Ibn Bāṣo's universal projection which can be used at all latitudes.

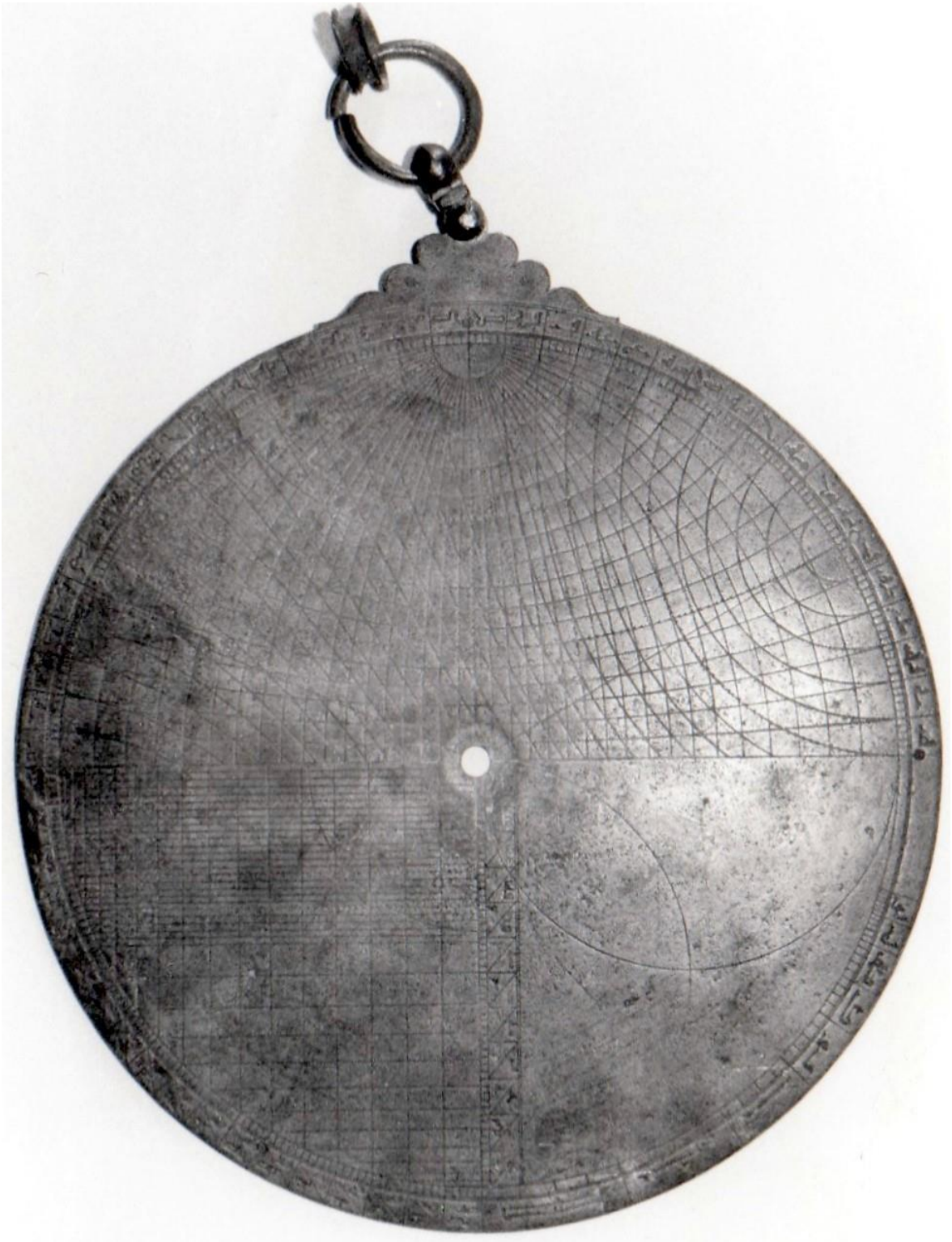


Figure Y005.4 – Back of the astrolabe (photo by S. R. Sarma)

BACK

The back is divided into four quadrants by the vertical and horizontal diameters. The rim of the two upper quadrants and the lower left quadrant carries altitude scales, divided in 1° and 5° and numbered from 5 to 90. The rim of the lower quadrant bears a cotangent scale. In the upper half is a *Zarqālī* projection of a part of the sphere. The lower left quadrant is filled with a sine-cosine grid; in the lower right quadrant are inscribed semi-circles along the two radii.

The alidade is counter-changed, but not graduated; it may be a later addition.

BIBLIOGRAPHY

Kaye 1921, Astrolabe A, pp. 2-5. Figs. 1, 2, 7, 10.
Gunther 1932, no. 134, pp. 179-180.
Calvo 1996.

Y006⊙ ASTROLABE, NOT SIGNED, NOT DATED[1698]

Diameter 95 mm

New Delhi, Red Fort, Mumtaj Mahal Museum (# 40.419)

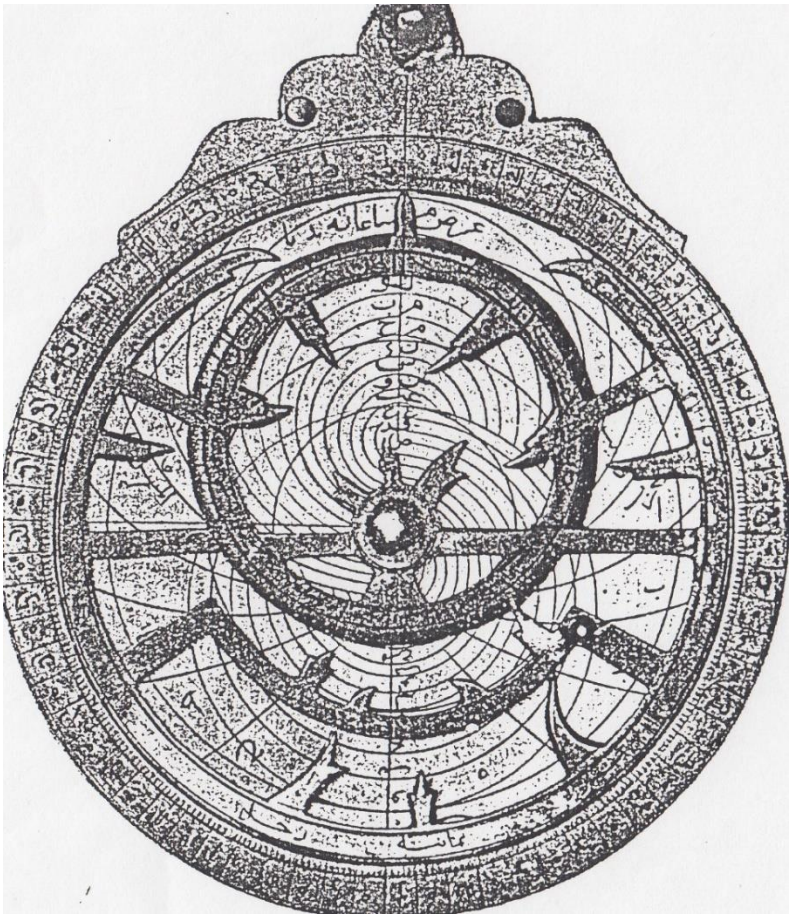


Figure Y006.1 – Front of the astrolabe (from Kaye 1921)

This astrolabe, produced somewhere in the Middle East, is neither signed, nor dated. Kaye estimates its date of manufacture to be 1495 and adds that 'the workmanship is excellent throughout, and gilding has helped to preserve the engraving.'

COMPONENTS

Body (d. 95, t. 7) with *kursī,* shackle and ring, rete, 6 plates (d. 81), alidade, pin and wedge.

[1698] Entry based on Kaye 1921, pp. 5-9, Figs. 3, 4, 11-22.

FRONT

The *kursī* is low with a pierced lobe on each side; the shackle has ornate bases and diamond cross-section; there is a small ring also with diamond cross-section. The rim is graduated in 1° and groups of 5° are numbered as 5, 10, 5, 20, … up to 360.

RETE

The rete consists of the two rings of Capricorn and ecliptic, held together by the straight equinoctial bar. The ecliptic is represented as a small segment below the ecliptic ring. There are 16 named star pointers. The rete broke into two and was repaired clumsily.

Table Y006-1 Stars on the Rete

	Star Names	Identification
1	*Dabarān*	α Tauri
2	*Rijl*	β Orionis
3	*Yad*	α Orionis
4	*Yamānīyah*	α Canis Majoris
5	*Shāmīyah*	α Canis Minoris
6	*Fard*	α Hydrae
7	*Qalb*	α Leonis
8	*Aᶜzal*	α Virginis
9	*Rāmiḥ*	α Bootis
10	*Fakkah*	α Coronae Borealis
11	*Qalb al-ᶜAqrab*	α Scorpii
12	*Hawwā*	α Ophiuchi
13	*Wāqiᶜ*	α Lyrae
14	*Ṭā'ir*	α Aquilae
15	(?)	
16	*Kaff*	β Cassiopeiae

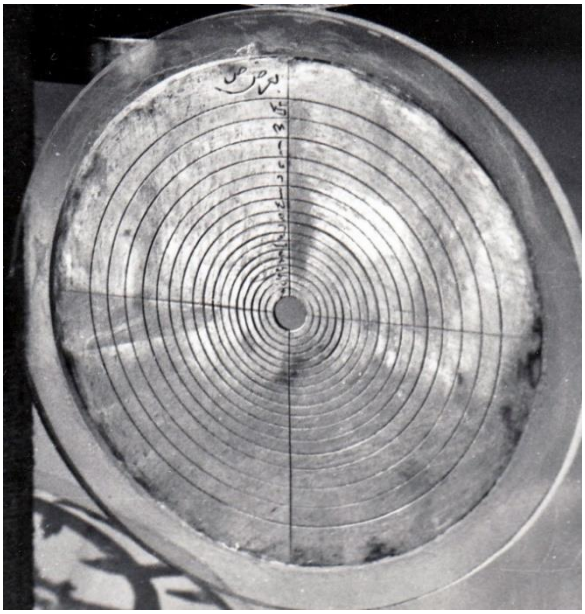


Figure Y006.2 – Plate for lat. 90°
(photo courtesy A. J. Turner)

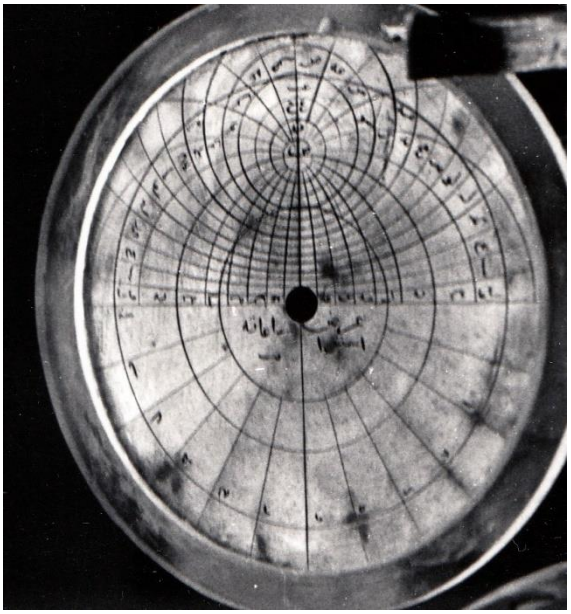


Figure Y006.3 – Plate for lat. 0°
(photo courtesy A. J. Turner)

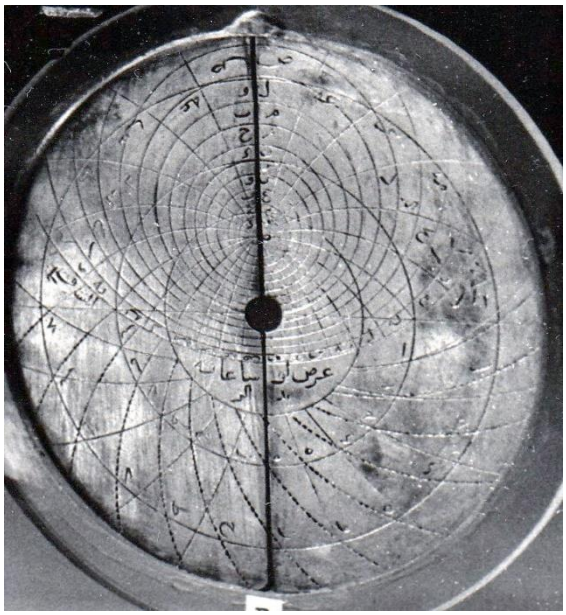


Figure Y006.4 – Plate for lat. 36°
(photo courtesy A. J. Turner)

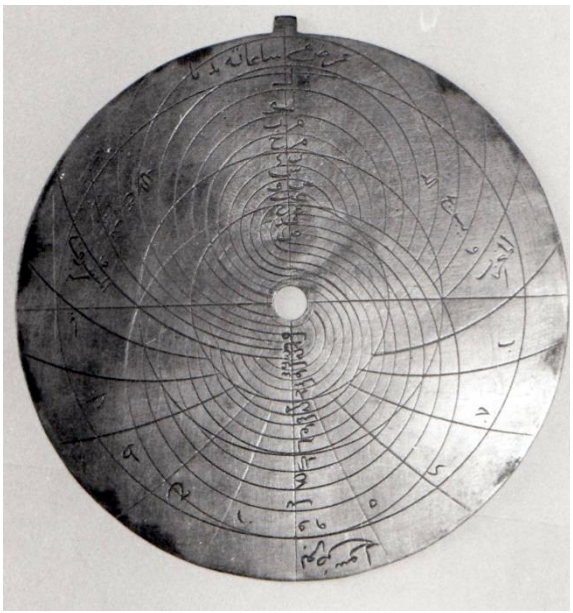


Figure Y006.5 – Plate for lat. 41° and 66;30°
(photo by S. R. Sarma)

PLATES

Beneath the rete are nested six plates, each with a projecting bit at the south point which fits into the slot in the rim of the mater.

Table Y006-2 Plates

	φ	Duration of the longest day
1a	90°	
1b	0°	12 hours
2a	18°	13.5 hours
2b	20°	13;13 hours
3a	21;40°	13;21 hours
3b	23°	13;25 hours
4a	25°	13;34 hours
4b	28° & 30°	13;46 hours & 13;56 hours
5a	32°	14;6 hours
5b	36°	14;27 hours
6a	40° & 66;30°	14;51 hours
6b	Plate of horizons	

On 1b, in the place of the latitude value in digits, *bi-ᶜarḍ istiwā'* (on the latitude of the equator) is written. Plate faces 4b and 6a carry double projections. Plate 6 is divided into two parts along the meridian line. Kaye says that 'this permits the use of either of the projections with one of the special tablets.'

On 6a, half horizons are drawn for latitudes between 8° and 71°. These are numbered in common Arabic/Persian numerals along the diameters of the disc, and in the *Abjad* notation along the circle of Capricorn.

8	12	16	…	60	64	68
9	13	17	…	61	65	69
10	14	18	…	62	66	70
11	15	19	…	63	67	71



Figure Y006.6 – Back of the astrolabe (photo by Dr Jean Michel Delire)

BACK

The rim on the back is divided in 1° and 5° and numbered from 5 to 90, separately in each quadrant, in the same style as in the front.

In the upper left is engraved a universal horary quadrant with six curves for seasonal hours marked 1/12, 2/11, 3/10, 4/9, 5/8, 6/7. The upper right quadrant is engraved with 11 equidistant horizontal parallels and 11 equidistant vertical parallels. The 12 spaces between these lines are numbered along the two radii from the centre to the periphery and also in the reverse direction. A quarter circle of obliquity is drawn around the centre and a semi-circle along the horizontal diameter. Two radial lines are drawn from the centre to the periphery, dividing the quadrant into three equal segments.

In the lower left quadrant are ‘what may be described as a set of polar co-ordinates’; there are eleven concentric quarter circles, numbered along the horizontal diameter as 10, 5, 20, 5 … 5, 60; upon these are superimposed radials for every 5°. A single shadow square is engraved in the lower right quadrant, in two bands, the inner one divided in 7 feet and the outer one in 12 digits. This square is enclosed by a circular cotangent scale.

BIBLIOGRAPHY

Kaye 1921, pp. 5-9, Figs. 3, 4, 11-22.

Y007⊙ ASTROLABE BY MUḤAMMAD ZAMĀN, 1070 AH (AD 1659-60)[1699]

Diameter 128 mm

Mumbai, K. R. Cama Oriental Institute

CCA 1153

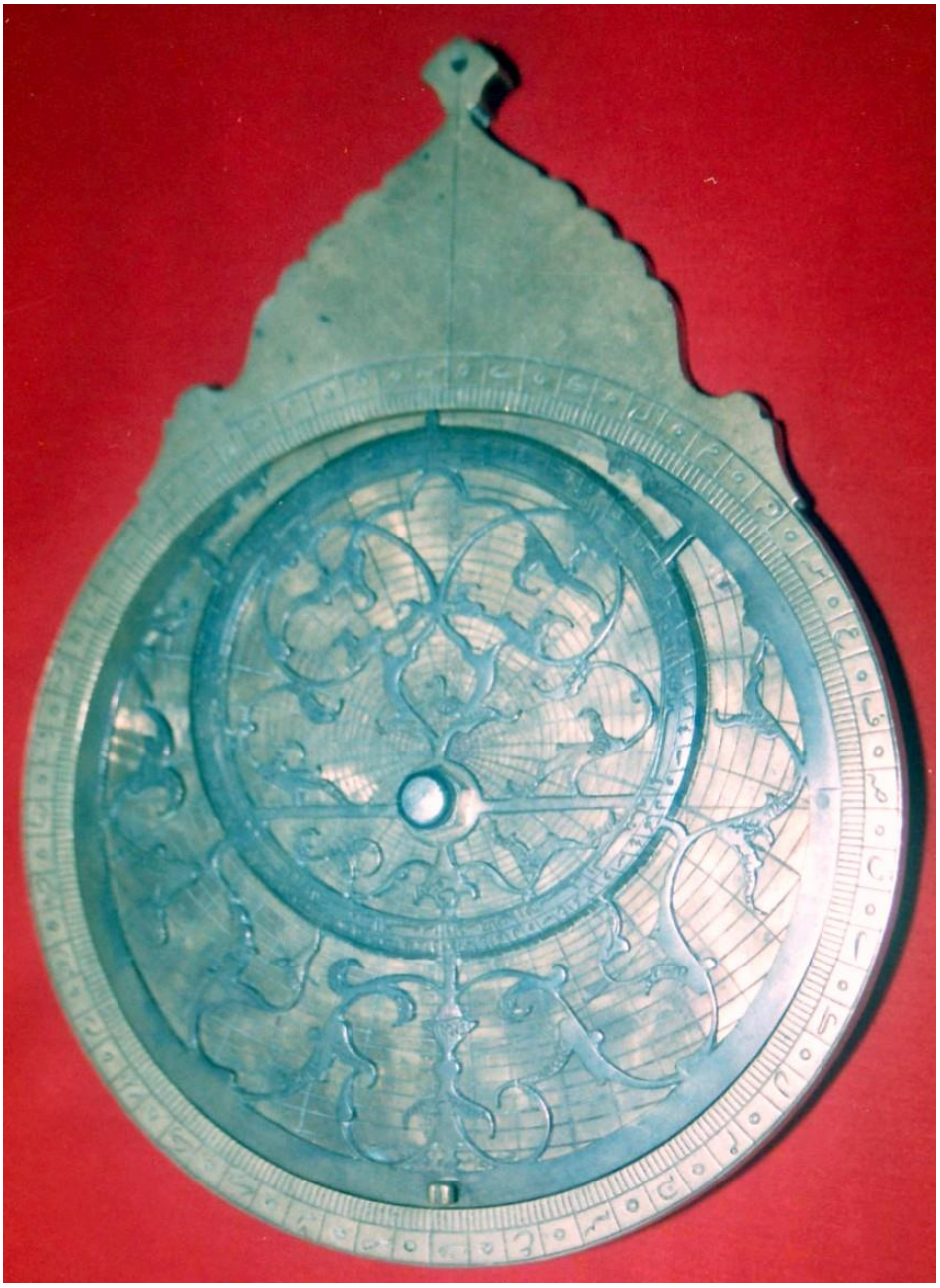


Figure Y007.1 – Front of the Astrolabe (photo by S. R. Sarma)

[1699] Entry based on Khareghat 1950, pp, 3-54, Figs. 1-9.

Muḥammad Zamān of Mashhad (*fl.* 1170-1125) is known through 9 astrolabes[1700] and 3 celestial globes[1701]; he also compiled a small *zīj* entitled *Tuḥfa-yi Sulaymānī* and composed a treatise on *qibla.*[1702] David King remarks that his astrolabes 'are distinguished by the quality of their execution and by the use of some initiative in both calligraphy and decoration. The cartouches on the plates and the back of the Berlin piece (#1155) are particularly remarkable.' The present astrolabe is his earliest one and does not display any decorations except on the plate made for the latitude of 34° (see Figure Y007.4).

COMPONENTS

Body (d. 128) with *kursī*, rete for 42 stars, 4 plates (d. 112), alidade (length 121), pin and horse; shackle and ring are missing.

FRONT

The *kursī* is high and lobed, with two wing like projections at the base and a finial with a stylised rhomboid shape. A hole is bored in the finial for the shackle, but the shackle as well as the ring are missing. The *kursī* is plain on both sides without any decorations.

The raised rim of the mater is calibrated in single degrees of arc; groups of 5° are marked and numbered in *Abjad* notation as 5, 10, 5, 20, …. 90, 5, 100; 5, 10, 5, 20, …. 90, 5, 200, 5, 10, …5, 60.

1700 The CCA enumerates 8 of these: CCA 1153, 1070/1659, the present astrolabe; CCA 2608, 1085/1674, formerly with Sotheby's at London, PLU; CCA 1155, nd, Museum für Islamische Kunst, Berlin; CCA 3550, nd, formerly in Landau Collection at Paris, PLU; CCA 3545, nd, Freer Gallery of Art, Washington; CCA 3550, nd, Metropolitan Museum of Art, New York; CCA 1154 of 1088/1677, State Museum of the History of Uzbekistan, Tashkent; and CCA 2603 of 1125/1713 formerly with Sotheby's at London, PLU. On CCA 1155, see the very detailed study by Helmecke 1985.

1701 ESS 16, 1050 / 1640-41, London, Victoria and Albert Museum; ESS 17, nd, Kuwait, PC; and ESS, nd, Cairo, Museum of Islamic Art; the first two are with constellation figures and the third is without them.

1702 King 1999b, pp. 172-175; 501-510.



Figure Y007.2 – Rete (photo by S. R. Sarma)

RETE

The openwork rete is constituted by the two rings of Capricorn and of the ecliptic which are held together by the tracery that connects the various star pointers. Inside the ecliptic is the equinoctial bar without any counter change, but it supports a ring around the centre. The solstitial bar is represented in the lower half. The celestial equator is not shown.

The ecliptic ring is divided into twelve zodiac signs, which are labelled with their names, starting from the vernal equinox and proceeding anti-clockwise. Each sign is divided in groups of 6° which are numbered in the usual fashion also anti-clockwise. The sloping edge of the ecliptic ring is divided in 3°, but the divisions became indistinct at places.

There are 42 star pointers which are joined by a floral tracery of an indifferent kind. Inside the ecliptic, the tracery displays a ‘bird in the cage’ pattern, which encloses the star α Lyrae which is given the shape of a bird, the tip of its beak constituting the

actual star pointer.[1703] Some of the stars shown here are not represented in the astrolabes produced in India; the meanings of their Arabic names are added in parentheses.

There is a small handle at the north point on the Capricorn ring; a small triangular projection at the south point on the ecliptic ring represents *al-murī,* the beginning of the sign of Capricorn.

The stars marked on the rete are listed in the following table in the order of their increasing right ascension.

Table Y007-1 Stars on the Rete

	Star Name	Identification
1	*[Dhanab] Qayṭus Janūbī*	β Ceti
2	*Janb Musalsalah*	β Andromedae
3	*Fam al-Qayṭus*	γ Ceti
4	*Ṣadr Qayṭus*	π Ceti
5	*Rās al-Ghūl*	β Persei
6	*Masāfat al-Nahr*	γ Eridani
7	*ᶜAyn al-Thawr*	α Tauri
8	*al-ᶜAyyūq*	α Aurigae
9	*Rijl al-Yusrā*	β Orionis
10	*Yad al-Yusrā*	γ Orionis
11	*Qaṭan al-Arnab*	α Lepus (lair of the hare)
12	*Yad al-Jawzā' al-Yumnā*	α Orionis
13	*Shiᶜrā Yamānīyah*	α Canis Majoris
14	*Uzn Kalb al-Akbar*	δ Canis Majoris (ear of the great dog)
15	*Shiᶜrā Shāmīyah*	α Canis Minoris

[1703] This pattern occurs frequently in Sanskrit astrolabes; see the Introduction to section C, 3.3.1 and B002.

	Star Name	Identification
16	*Fard al-Shujāᶜ*	α Hydrae
17	*Qalb al-Asad*	α Leonis
18	[*Ẓahr*] *Dubb al-Akbar*	α Ursae Majoris
19	*Qāidat al-Bāṭīyah*	α Crateris
20	*Safahat al-Bāṭiyah*	ζ Crateris (the lip the cup)
21	*Ṣarfah*	β Leonis
22	*al-Ḥafan*	ζ Ursae Majoris (?) (the double one)
23	*Janāḥ al-Ghurāb*	γ Corvi
24	*Simāk Aᶜzal*	α Virginis
25	*al-Simāk al-Rāmiḥ*	α Bootis
26	*Ṭarf al-Aṣā*	μ Bootis (head of extremity of the staff)
27	*Nayyir al-Fakkah*	α Coronae Borealis
28	*ᶜUnuq al-Ḥayyah*	α Serpentis
29	*Qalb al-ᶜAqrab*	α Scorpii
30	*Mirfaq al-Ḥawwā*	λ Ophiuchi
31	*Rās al-Ḥawwā*	α Ophiuchi
32	*Dhanab al-ᶜUqāb*	ζ Aquilae (tail of the eagle)
33	*Nasr al-Wāqiᶜ*	α Lyrae
34	*Nasr al-Tā'ir*	α Aquilae
35	*Dhanab al-Dulfīn*	ε Delphini
36	*Dhanab al-Jadī*	δ Capricorni
37	*Āssirat al-Dajājah*	ζ Cygni (feathers of the hen)

	Star Name	Identification
38	*Dhanab al-Dajājah*	α Cygni
39	*Sāq Sākib al-Mā'*	δ Aquarii
40	*[Dhanab] Qayṭus Shamālī*	ι Ceti
41	*Mankib al-Faras*	β Pegasi
42	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are four plates, each with a diameter of 112 mm and a rectangular notch at the north point.

Table Y007-2 Plates

	φ	Longest Day
1a	*ᶜarḍ Makkah* (21;40°)	13;30 hours
1b	*ᶜarḍ madīnah* 25°	13;34 hours
2a	30°	13;57 hours
2b	32°	14;7 hours
3a	34°	14;17 hours
3b	37	14;34 hours
4a	Plate of ecliptic coordinates	
4b	Plate of horizons	

The latitude plates are not uniformly designed. On 1a and 1b, prepared for Mecca and Medina, the two most holy cities of the Islamic world, the names of these cities are mentioned, the former without the latitude (*ᶜarḍ makkah*) and the latter with latitude (*ᶜarḍ madīnah 25*).

Equal latitude circles are drawn for every 3° and numbered on either side of the meridian. Azimuth arcs are drawn for every 10° above the horizon and numbered on either side of the meridian; on 1b, however, these are drawn both above and below the horizon.

Lines for seasonal hours are drawn on all plates, as also dotted lines for equal hours drawn from the western horizon. Both sets are numbered from the western horizon, but the seasonal hours in common Arabic/Persian numerals above the circle of equator and the equal hours in *Abjad* notation below the circle of equator.

While all the plate faces are plain, plate 3a for latitude 34° is elaborately decorated. In the segment inside the circle of Cancer and below the line of horizon, the arguments, *al-ʿard* and *al-sāʿātah* are written in large embossed letters; the floral decoration below these is also embossed. The actual values of latitude and hours, however, are done by simple engraving; the entire background is lightly chased. Likewise, in the two segments between the arc of horizon and the horizontal diameter in the west and east, the labels *al-Mashriq* and *al-Maghrib* are written in large embossed letters, together with some floral decorations. It is not clear why this plate received such special treatment. The instrument maker's native place Mashhad does not lie on this latitude, but on 36°. The cities that are situated on this latitude are, according to the geographical gazetteer, Kāshān on 34° and Mosul, Herat and Kabul on 34;30.

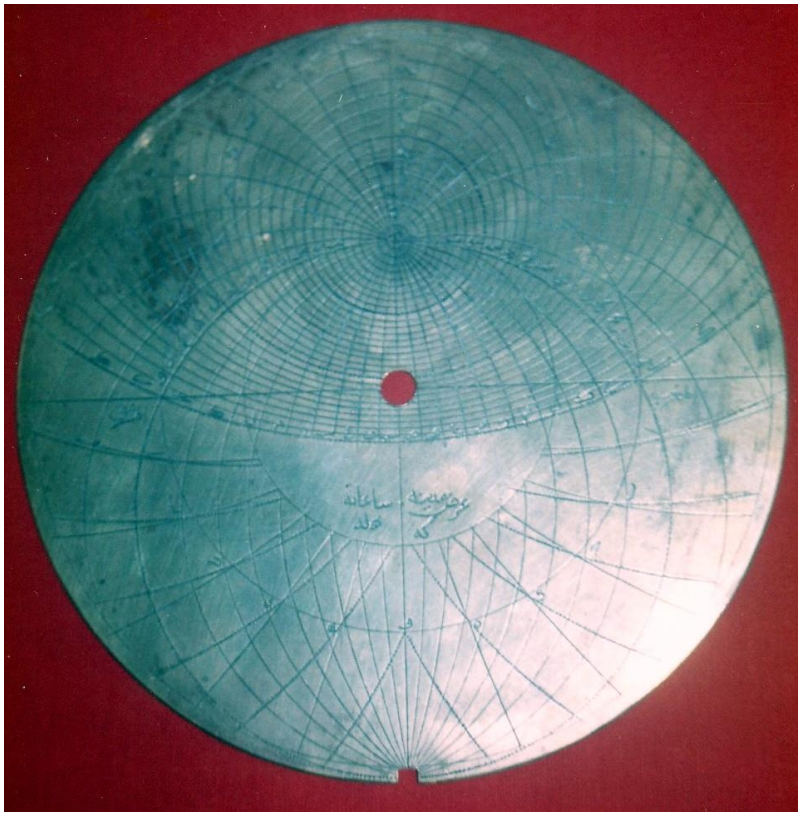


Figure Y007.3 – Plate for Medina on latitude 25° (photo by S. R. Sarma)

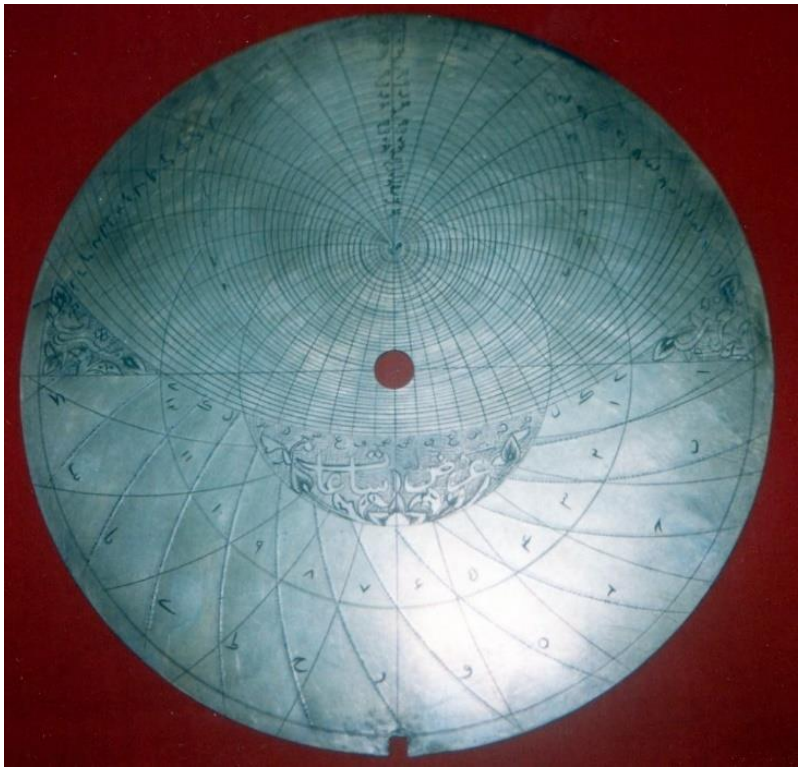


Figure Y007.4 – Plate for latitude 34° (photo by S. R. Sarma)

GEOGRAPHICAL GAZETTEER

On the inner surface of the mater is engraved a geographical gazetteer with the names, longitudes and latitudes of 57 localities; interestingly, these include as many as 14 from the Indian subcontinent. These are engraved in two concentric circles, separated on either side by double lines. In the centre, there is a large empty space. In the outer circle, the letters are written in such a manner that the upper parts of the letters are towards the centre of the plate; while in the inner circle, the tops of the letters are towards the periphery. In both cases, the gazetteer is read from right to left, in anti-clock direction. In both circles, the first cell carries the argument *al-bilād* (cities), *iṭwāl* (longitudes) and *ʿarūḍ* (latitudes). The zero is represented by a symbol which looks like a mirror-image of the Roman letter 'S'.



Figure Y007.5 – Geographical Gazetteer (photo by S. R. Sarma)

According to David King, the geographical gazetteers engraved in the astrolabes by Muḥammad Zamān do not match the high quality of the workmanship to be seen in these astrolabes.[1704] The gazetteers appear to have been copied carelessly. This becomes immediately evident in the longitudes assigned to many of the Indian cities (marked with *), where values like 104 and 114 are hopelessly mixed up.

Table Y007-3 Geographical Gazetteer

	Place Name	L	φ
	Outer Circle		
1	Makkah	77;10	21;40
2	Madīnah	75;20	25;0
3	Miṣr	63;20	30;20
4	Dimashq	70;0	35;50
5	Ḥalab	72;10	33;15
6	Rayy	86;20	35;0
7	Mawṣil	77;20	34;30
8	Nakhjawān	81;15	38;40
9	Marāghah	82;0	37;20
10	Tabrīz	82;0	38;0
11	Ardabīl	82;30	38;0
12	Bardaᶜah	83;0	40;30
13	Kūfah	79;30	31;30
14	Baghdād	82;0	35;25
15	Baṣrah	84;0	30;0
16	Shīrāz	88;0	29;36

[1704] King 1999b, pp. 174-175.

	Place Name	L	φ
17	Yazd	89;0	32;0
18	Iṣfahān	86;40	32;25
19	Kāshān	86;0	36;0
20	Samnān	88;5	36;0
21	Bisṭām	89;30	36;10
22	Sabzwār	91;30	36;5
23	Nīshābūr	92;30	36;21
24	Ṭūs	92;30	37;0
25	Harāt	94;20	34;30
26	Qain	93;20	34;40
27	Marw	96;0	36;40
28	Balkh	101;0	36;41
29	Bukhārā	97;30	39;50
30	Samarqand	99;36	39;36
31	Badakhshān	104;24	37;0
32	Kāshghar	106;30	44;0
33	Khujand	100;35	41;15
34	Hurmūz	92;0	25;0
35	Kirmān	91;30	30;5
	Inner Circle		
36	Lāhūr	109;20	31;50
37	Dihlī	*104;13	28;13
38	Ākrah	*104;0	27;13
39	Jawnpūr	*109;6	26;36

	Place Name	L	φ
40	Ajmīr	105;5	26;0
41	Dawlatābād	*111;0	20;30
42	Ahmadābād	108;40	23;15
43	Burhānpūr	108;0	20;30
44	Bījāpūr	105;30	17;20
45	Jaddah	*106;0	21;0
46	Tānīsar	111;20	30;10
47	Kābul	104;40	34;30
48	Bakkar	104;0	27;40
49	Somnāth	106;0	17;0
50	Qandahār	107;40	33;0
51	Tubbat	110;0	40;0
52	Kashmīr	108;0	35;0
53	Bānārasū	*107;20	26;55
54	Qannawj	115;50	26;35
55	Shās	109;0	42;30
56	Khutān	107;0	42;0
57	Khān Bāligh	124;0	46;0



Figure Y007.6 – Back of the Astrolabe (photo by S. R. Sarma)

BACK

On the back, the rim of the upper half carries altitude scales, divided in 1° and 5° and numbered 5, 10, 5, 20 … 5, 90; 90, 5, … 20, 5, 10, 5. The upper left quadrant is engraved with sixty horizontal parallels. In the upper right quadrant, declination circles are drawn for all latitudes between 23;30° N and 23;30° S. Upon these are superimposed seven curves with the names Multān, Kashmīr, Qandahār, Ṭūs, Iṣfahān, Basrah, Madīnah. The curves indicate meridian solar altitudes at these places. In a small rectangle along the horizontal radius are engraved the names of the six signs Aries to Virgo; in a small rectangle along the vertical radius are engraved the names of the six signs Libra to Pisces.

The rim of the lower half carries cotangent scales, in feet on the left and in digits on the right. The former is numbered clockwise from the meridian line as 6, 12, 18, 24, 30, 36. *ẓill aqdām.* The latter is numbered anti-clockwise 6, 12, … 60. In the inner row are their subdivisions.

Inside these cotangent scales, there are five concentric semi-circular scales containing the following:

(1) the names of the 12 zodiac signs;
(2) the names of 28 lunar mansions;
(3) each sign is divided into three decans (*wujūh*) and marked 10, 20, 30;
(4) the symbols the planetary regents of the 36 decans; and
(5) the symbols of the planetary regents in reverse order according to a rarely used system called *ardajān.*

Enclosed by these semi-circular tables are the shadow squares, drawn below the horizontal diameter, on the left for feet and on the right for digits with the usual labels.

Inside the shadow squares are rectangular tables of limits, entitled *jadwal ḥudūd miṣrayn* (table of limits in vogue among the Egyptians) and of the day trigons and their lords with the title *arbāb muthallathāt yūmī*. There is no table of the trigons of the night.

Alidade, Pin and Horse

The alidade is 121 mm long. The centre piece and the two ends are nicely shaped with lobes. The upper edge is bevelled; the right half is divided in 60 parts, and numbered in 5s starting from the centre and proceeding towards the right as 5, 10, 15, … 50, 55, 60. The left half is designed as a sundial; it is divided in five unequal parts. The lower parts are numbered 1, 2, 3, 4 and 5 up to the centre and the upper part as 8, 9, 10, 11, 12 from the centre.



Figure Y007.7 – Lower Half of the Back (photo by S. R. Sarma)

INSCRIPTION

Below the shadow squares is the signature of the astrolabe maker:

ṣanaᶜah muḥammad zamān al-munajjim al-asṭurlābī fī sanah gh-ᶜa

'Work of Muḥammad Zamān, the astronomer, the astrolabe-maker, in the year 1000+70 [i.e. 1070 Hijrī = AD 1659].'

PROVENANCE

The astrolabe was in the private collection of J. B. Petit when Khareghat examined it on 3.7.1925; therefore it is listed as the 'J. B. Petit astrolabe' in Khareghat 1950. It is now with the K. R. Cama Oriental Institute.

BIBLIOGRAPHY

Khareghat 1950, pp, 3-54, Figs. 1-9.

Helmecke 1985.

Y008⊙ ASTROLABE BY MUḤAMMAD MAHDĪ AL-KHĀDIM AL-YAZDĪ, 1071 AH (AD 1660-61)

Diameter 91 mm

Varanasi, Banaras Hindu University, Bharat Kala Bhavan (# 4/5879)

CCA 3711 (s.v. M Badi^{c})



Figure Y008.1 – Front of the astrolabe (photo courtesy Bharat Kala Bhavan)

Muḥammad Mahdī al-Khādim al-Yazdī (*fl.* 1649-1661**),** the son of Muḥammad Amīn al-Yazdī, is said to be 'one of the best reputed, prolific, and prestigious astrolabists of Safavid Persia'.[1705] The CCA lists 24 astrolabes made by him.[1706] Only three are dated; CCA 3694 (ex-Alain Brieux) is dated 1059/1649; CCA 20 (Cambridge, Whipple Museum) and CCA 3813 (Greenwich, National Maritime Museum, # A64/69-6) were made in 1070/1659. The present astrolabe carries the date 1071/1660-61. Moreover, he also decorated some astrolabes made by ᶜAbd al-A'imma, Muḥammad Khalīl, and Muḥammad Muqīm al-Yazdī.

His astrolabes are opulently decorated. Besides the usual legends in embossed letters against hatched backgrounds, he is also fond of engraving long quotations on the throne, on the thick edge and even on the Capricorn ring in the rete.

The master work of his creation is a small astrolabe; with a diameter of 48 mm, it is slightly larger than Muḥammad Muqīm's astrolabe with the 45 mm diameter (A050), but more exquisitely decorated.[1707] In the rete, the handle is of silver; on the ecliptic ring turquoises are inlaid to mark the boundaries between the signs. It contains 5 plates. Both the sides of the *kursī* are filled with long inscriptions. The full throne verse from the *Qur'ān* is engraved on the edge.

The present astrolabe is rather small with a diameter of 91 mm; the obverse side of the *kursī* bears the throne verse and the reverse side a benediction to the patron Muḥammad ibn Badīᶜ. On the edge, greetings are expressed to the Prophet and to the twelve Imāms who followed him. On the Capricorn ring in the rete is a poem and at the base of the back is a line from Shaykh Saᶜdī's *Gulistān* to express the hope that the astrolabe created by this master may last long after him.

COMPONENTS

Body (d. 91, h. 115) with *kursī* and shackle, rete for 30 stars, 5 plates; the suspension ring, alidade and wedge are missing, but there is extant a highly ornate pin.

1705 Turner 1985, p. 90.

1706 Twenty-three are listed under the name M MAHDI and the present one under M BADI.

1707 It was formerly with the Time Museum, Rockford, Ill, USA; the museum does not exist any more and the present location of the astrolabe is not known. For an excellent description and photographic documentation, cf. Turner 1985, no. 6, pp. 86-91.

FRONT

High, lobed *kursī* with a trifoliate finial to which is rivetted a small shackle. The obverse side of the *kursī* bears the throne verse in embossed letters and on the reverse side a benediction to the patron Muḥammad Badīʿ in large embossed letters, followed by the date of manufacture *sanah 1071.*

The limb is graduated in 1° with every fifth division marked by a thick dot; groups of 5° are numbered in *Abjad* notation in large embossed letters from 5 to 360.

RETE

The rete consists of the two broad rings of Capricorn and of the ecliptic which are held together by the equinoctial bar and by the floral clusters that join the star pointers. The equator is not represented. The equinoctial bar has two counter changes inside the ecliptic ring; a central ring is incorporated into the equinoctial bar. The solstitial colure is represented in the upper half.

The ecliptic ring is divided in the twelve signs of the zodiac; their names are written in embossed letters. Each sign is divided into groups of 6° and numbered anti-clockwise 6, 12, 18, 24, 30. The sloping edge is divided in 1°.

The Capricorn ring is marked eleven times at regular intervals with ornate symbols in the shape of the Roman letter X. Between these symbols is written in embossed letters a Persian poem. There is a large round knob at the south point for rotating the rete.

Some 30 positions of stars are marked along with their names on the rete. These are joined by almost symmetrical arrangements of leaves and tendrils, both with deep furrows. Because of the small size of the rete, the names are often difficult to decipher, although they can be identified by their location.



Figure Y008.2 – Rete (photo courtesy Bharat Kala Bhavan)

PLATES

The are astrolabe is fitted with five plates, each with a notch at the south point. The central panels are filled with arguments *al-ʿarḍ* and *al-sāʿāt* in very large embossed letters and the actual values of the latitudes and the hours of the longest day are presented in much smaller letters, with the result that quite often these values are difficult to decipher. These plates serve the latitudes of 22°, 24°, 30°, 32°, 34°, 36°, 37° (?), 38°, 44°, and multiple horizons.

The latitude plates are engraved with altitude circles for every 6° and every fourth is highlighted with a dotted line; azimuth arcs are traced for every 10° and every fourth is represented by a dotted line. The intersection of dotted altitude circles and dotted azimuth arcs are marked with the symbol X.

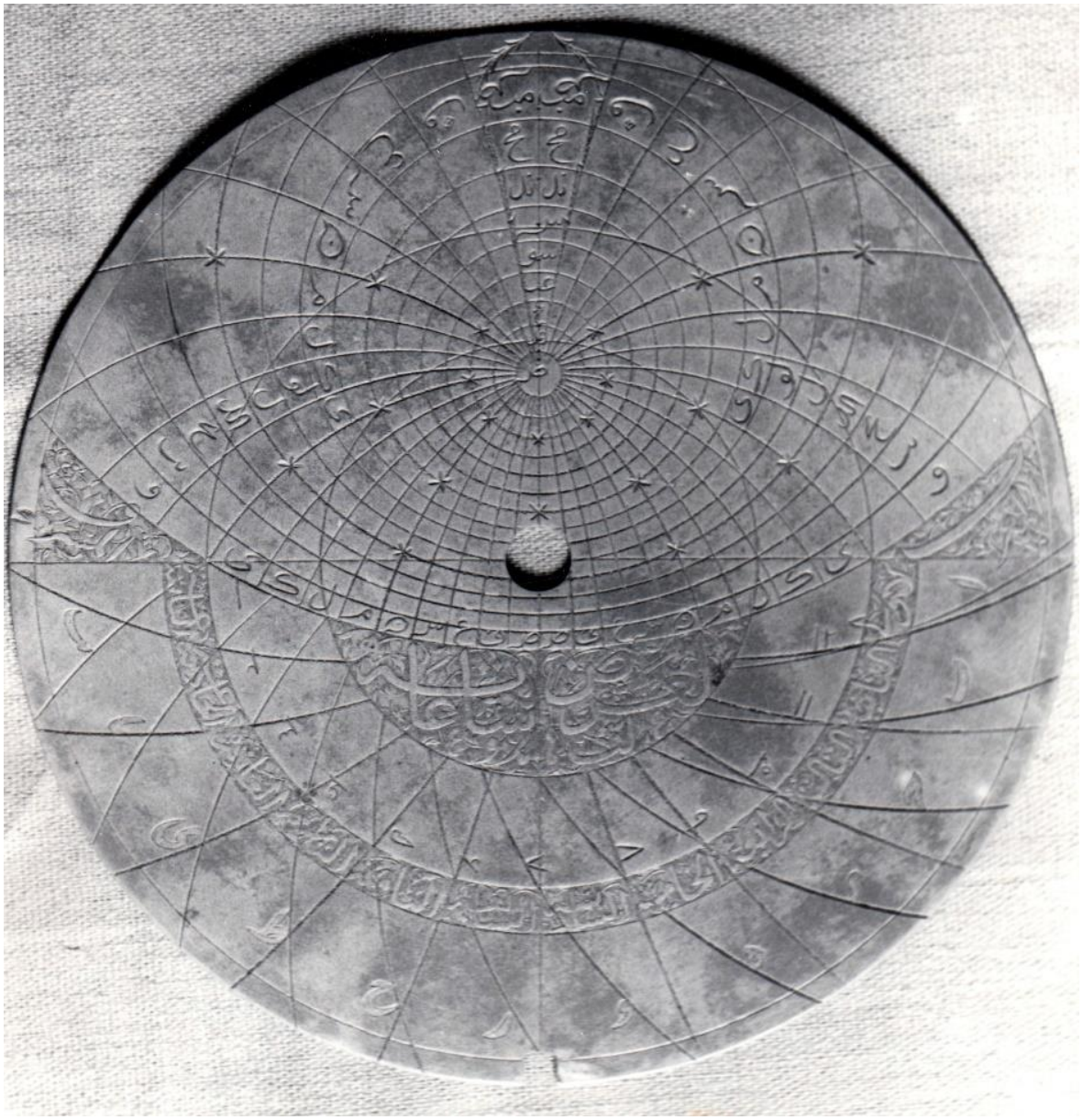


Figure Y008.3 – Plate for the latitude of 32° (photo courtesy Bharat Kala Bhavan)

In the lower half are drawn plain lines for seasonal hours; equal hours are marked with dotted lines drawn from the western horizon. Seasonal hours are numbered in common Arabic/Persian numerals above the equator circle; they are numbered once again in ordinal numbers expressed by words in ornate panels along the equator circle. The seasonal hours are numbered in *Abjad* letters below the equator circle. On the plates for 22° and 24°, however, there are only lines for seasonal hours; these are numbered in ordinals expressed by words in ornate panels along the equator circle.

The horizon plate is engraved with quarter-horizons for every 3° between 18° and 72°. The declination scales on either side of the equatorial circle are divided in 3° and numbered 6, 12, 18, 24, with the usual label *al-mayl al-kullī* (the maximum declination).



Figure Y008.4 – Geographical Gazetteer (photo by S. R. Sarma)

GEOGRAPHICAL GAZETTEER

On the inner side of the mater is engraved a geographical gazetteer in two concentric lines, providing the longitudes, latitudes, *inḥirāf* and *jihat* for 46 localities, in an elegant spiral formation. The place names are written in large embossed letters against a hatched background. In the outer circle, in particular, the letters have become unreadable because of the patina that covers the hatched background.

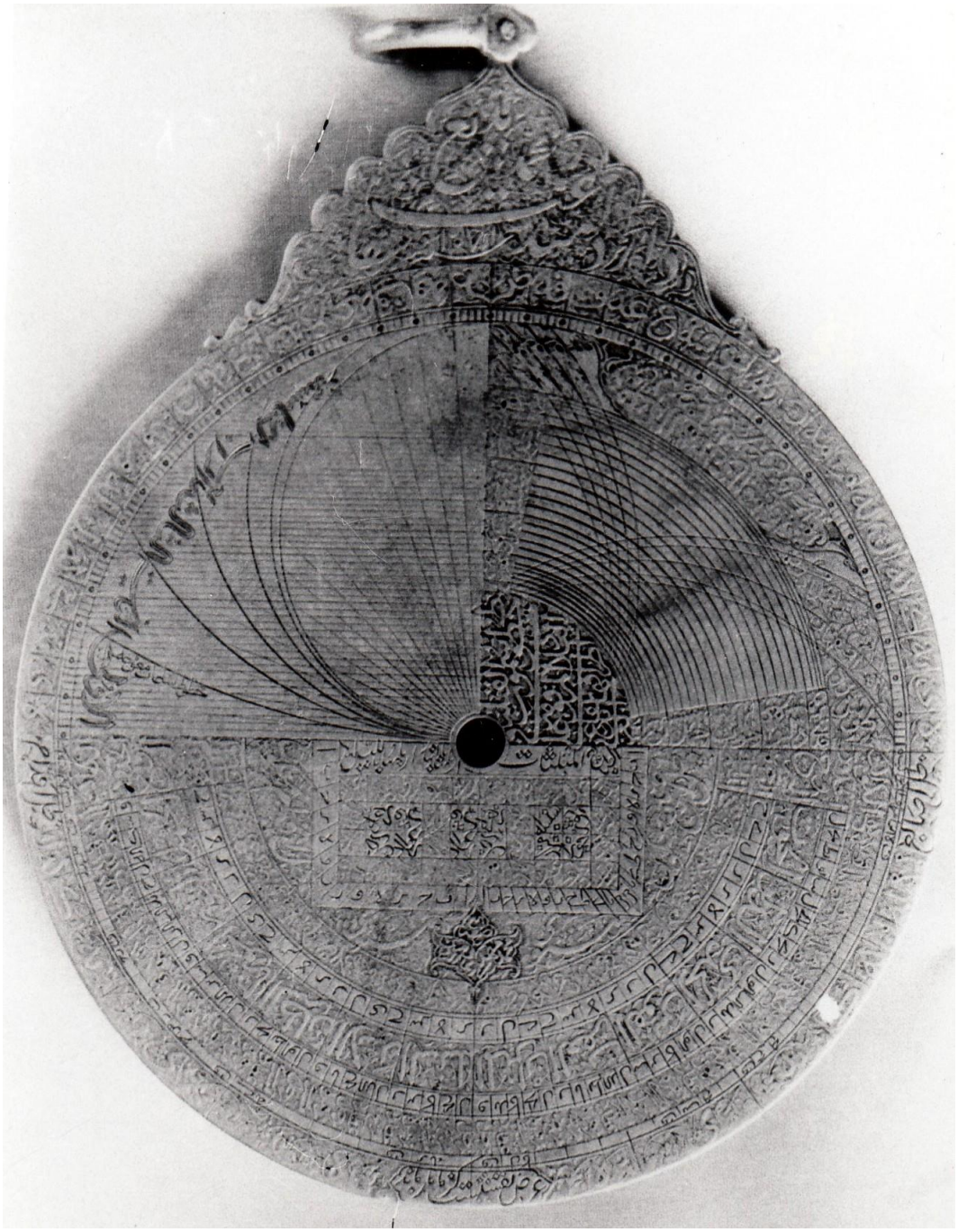


Figure Y008.5 – Back of the astrolabe (photo courtesy Bharat Kala Bhavan)

BACK

The rim of the upper half carries altitude scales in each quadrant; these are graduated in 1° with every fifth division marked by a thick dot, as in the front. Groups of 5° are numbered in *Abjad* notation as 5 —90; 90—5.

The upper left quadrant is filled with 90 horizontal lines which are stereographically projected. Radial lines are drawn from the centre to every fifth degree on the arc. Upon this grid are superimposed six arcs of seasonal hours, labelled as *khaṭūṭ sāᶜāt muᶜawwaiyah* (lines of unequal hours). The six arcs are labelled, starting from the

horizontal radius as the *al-awwal* (first [hour]), *al-thānī* (second), *al-thālath* (third), *al-rābiᶜ* (fourth), *al-khāmis* (fifth); the sixth one, for lack of space, is marked simply as 6 in *Abjad* notation. The ordinal names are in large letters and look as if they are painted and not engraved.

The upper right quadrant is filled with 60 stereographically projected declination arcs. The names of the 12 signs are written along the two radii in slanted columns, also in embossed letters.

Upon these declination arcs are superimposed five curves of solar meridian altitude; the latitudes for which these curves are meant are written at the top, but these are difficult to decipher. The label related to these curves is written in embossed letters in an arc below the altitude scale on the right: *dawā'ir inṣāf al-nahur fī al-ᶜurūḍ al-marqūmah ᶜalā aṭrāfahā* (circles of midday for the latitudes marked at their extremities).

There are also five arcs of azimuths of qibla for the cities of Ṭūs, Shīrāz (?), Iṣfahān, Baghdād and Kūfah (as read from the horizontal diameter). The inscription related to these arcs is written in embossed letters inside the innermost declination band in four lines: *khuṭūṭ sumūt al-qiblah fī al-bilād al-murqūmah ᶜalā aṭrafāhā bi-irtifaᶜ al-gharbī* (lines of *Qibla* directions in cities marked on the edges near the altitude scale in the west).

The rim of the lower half carries cotangent scales, on the left for feet with the label *ẓill aqdām* in embossed letters just below the horizontal diameter and on the right the cotangents in digits with the label *ẓill aṣābiᶜ* in embossed letters just below the horizontal diameter.



Figure Y008.6 – Lower half of the back (photo by S. R. Sarma)

Inside these cotangent scales, there are five semi-circular rows; what they contain is mentioned in the labels at both the ends of the semi-circles. The main one among these is the middle row; it carries the names of the 12 zodiac signs, in embossed letters, with the label *al-burūj,* also in embossed letters, at both ends of the semi-circle. Other rows are related to this one. Starting from the outside these are as follows.

1. The names of the planets related to the limits mentioned in the second row; the label is *al-kawākib* (planets).
2. The second row is entitled *al-ḥudūd* (the limits); here each zodiac sign is divided in five limits or intervals and each interval is assigned to a certain planet, other than the sun and moon (see Introduction to A-series, 2.6.4.2). The names of the planets are given in the first row, and the numerical strengths of the limits are mentioned in this second row.
3. The names of the 12 zodiac signs, as mentioned above.
4. The fourth row carries the label *al-wujūh* (decan or faces) on both ends. Here each sign is divided in three decans (i.e. 10°) and each cell is filled with the last letter of the name of the planet that governs the decan.
5. The names of the 28 lunar mansions with the label *al-manājil.*

These semi-circular tables enclose shadow squares, on the left for feet and on the right for digits. The vertical and horizontal scales on the left are marked from 1 to 7;

those on the right are marked from 1 to 12. The shadow squares are labelled in the usual manner in large embossed letters.

Inside the shadow squares is a rectangular table, containing the trigons and their regents, both diurnal and nocturnal.

INSCRIPTIONS[1708]

1. On the obverse side of the *kursī* is the well-known thrown verse (*āyat al-kursī*) from the Qur'ān.
2. On the reverse side of the *kursī* is engraved

   dārad ummīd shafāᶜt muḥammad [ibn] badīᶜ

   'Muḥammad [ibn] Badīᶜ hopes for intercession.'[1709]

This is followed by the year of production of the astrolabe, *sanah 1071,* which translates to AD 1660-61. This Muḥammad [ibn] Badīᶜ must be the patron who commissioned this astrolabe.

3. Immediately below the shadow squares is an ornate rhomboid cartouche which carries the name of the astrolabe maker

   muḥammad mahdī al-khādim al-yazdī

   'Muḥammad Mahdī al-Khādim of Yazd.'

The phrase *al-khādim* (the servant [of God]) may have been added as a mark of humility.

4. At the middle of the cotangent scales at the bottom is engraved a line from the *Gulistān* of the poet Shaykh Saᶜdī:

   gharaḍ nakshīst kaz mā bāz mānad

   'The intention of this drawing is that it should remain after us'[1710]

5. Moreover, on the Capricorn ring in the rete is engraved a Persian poem which begins with 'This bowl of Jam (= Jamshid) which is the mirror of the spheres and

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[1708] Professor Mohammad Bagheri has very kindly deciphered and translated all the inscriptions on this astrolabe, for which I am highly indebted to him.

[1709] Professor Bagheri notes that 'ibn' is needed for the prosody.

[1710] As translated by Rehatsek 1875, p. 328.

stars....' and concludes with 'it is the mirror of Alexander and the bowl that shows the world.'

6. Finally, on the thick edge of the astrolabe all around are engraved greetings to the Prophet and the to the twelve Imāms who followed him:

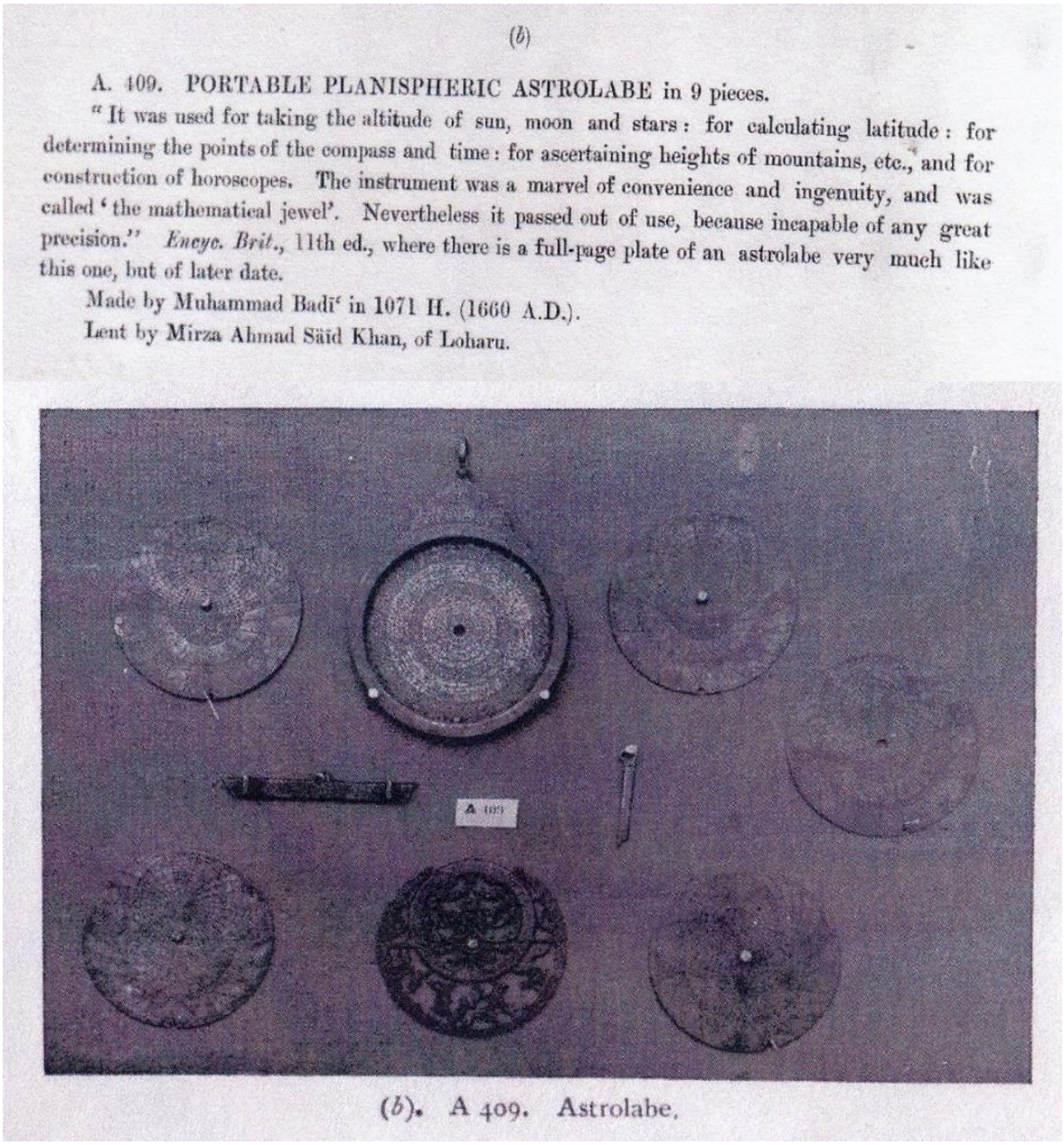
> 'O God! Send greetings to the prophet Mohammad and ᶜAlī and the sons of Fāṭimā, Ḥasan and Ḥussayn, and send greetings to the ornament of the worshippers (title for the fourth Imām), and to Muḥammad al-Bāqir and Jaᶜfar al-Ṣādiq and Mūsā al-Kāẓim and ᶜAlī al-Riḍā and Muḥammad al-Taqī and ᶜAlī al-Naqī and Ḥasan al-ᶜAskarī and Mahdī al-Muntaḍar (who is expected to return) or al-Ghāyab (who disappeared).'

PROVENANCE

1. At the beginning of the twentieth century, the astrolabe was in the possession of Mirzā Aḥmad Saᶜīd Khān of Loharu (small princely state now in Haryana). When George V, after becoming the king of England and Emperor of India, visited India, a Coronation Durbar was held at Delhi in 1911. On this occasion, the Delhi Museum of Archaeology hosted a 'Loan Exhibition of Antiquities' where this astrolabe was displayed. It the catalogue of this exhibition, it is stated that the astrolabe was made by Muhammad Badīᶜ in 1071 H (1660 A.D.).[1711]

Subsequently, it was acquired by the Bharat Kala Bhavan, the art museum of the Banaras Hindu University. It is not known precisely when the museum acquired the astrolabe; since the museum was founded in 1920, the astrolabe must have been acquired after this date.

[1711] Accordingly, CCA listed it under M Badiᶜ with the serial number 3711.



(*b*)

A. 409. PORTABLE PLANISPHERIC ASTROLABE in 9 pieces.

"It was used for taking the altitude of sun, moon and stars: for calculating latitude: for determining the points of the compass and time: for ascertaining heights of mountains, etc., and for construction of horoscopes. The instrument was a marvel of convenience and ingenuity, and was called 'the mathematical jewel'. Nevertheless it passed out of use, because incapable of any great precision." *Encyc. Brit.*, 11th ed., where there is a full-page plate of an astrolabe very much like this one, but of later date.

Made by Muhammad Badī' in 1071 H. (1660 A.D.).

Lent by Mirza Ahmad Sāid Khan, of Loharu.

(*b*). A 409. Astrolabe.

Figure Y008.7 – From the catalogue of 1911.

2. Later, in connection with the Festival of India in the US, an exhibition was organised under the title 'India: A Festival of Science, A Travelling Exhibition of Indian Science and Technology, presented by the Government of India's National Council of Science Museums and the Department of Science and Technology'. The exhibition was shown at various places like Chicago, Los Angeles, Portland, Seattle, Charlotte and Boston, from June 1985 to August 1987. The present astrolabe was included in that exhibition, as if it was an Indian artefact. The exhibition catalogue (p. 25) carries the photos of the front and back of this astrolabe with the caption 'The "Astrolabe" made by Md. Mahndi Ashahani (sic!) was used for observing the position of stars and planets.'

3. The records of the Bharat Kala Bhavan describe the astrolabe thus: 'Made in 1070 / 1660 by Malik Muhammad Isfahani, dedicated to Mohammad Badi ibn Khuso Sultan ibn Nazir Muhammad Khan, ruler of Balkh.' The person who was responsible for this description must have misread the name *Muḥammad Mahdi al-Khādim al-Yazdī* engraved in the cartouche on the back, but correctly assumed that the astrolabe was dedicated to Muḥammad Badīʿ; however, it is not known on what basis he concluded that Muḥammad Badīʿ was the son of 'Khuso Sultan ibn Nazir Muhammad Khan, ruler of Balkh.'

BIBLIOGRAPHY

Delhi Museum of Archaeology, Loan Exhibition of Antiquities: Coronation Durbar, 1911: An Illustrated Selection of the Principal Exhibits, published by the Archaeological Survey of India, Calcutta (?), 1911.

Michel 1936; see also Michel 1976, Pl. XV.

Gibbs & Saliba 1984, no. 25, pp. 65-68; no. 44, pp. 79-82.

Turner 1985, no. pp. 86-91.

India: a Festival of Science, A Travelling Exhibition of Indian Science and Technology, presented by the Government of India's National Council of Science Museums and the Department of Science and Technology, New Delhi 1985 (?).

Y009 ASTROLABE BY ᶜABD AL-A'IMMA, NOT DATED[1712]

Diameter 135 mm

Hyderabad, Saidiya Library



Figure Y009.1 – Front of the astrolabe (photo by Ahmed Athaullah)

[1712] Grateful thanks are due to Ahmed Athaullah for the detailed photographs and for the relevant information.

ᶜAbd al-A'imma ibn ᶜAbd al-Ḥussayn (*fl.* 1100/1688-1132/1719) is the most well-known and very prolific astrolabe-maker of Safavid Iran.[1713] About three dozen richly decorated astrolabes by him are extant in all major collections.[1714] Aside from producing many astrolabes on his own, he also collaborated with Muḥammad Amīn (Y011), Khalīl Muḥammad and others in producing astrolabes jointly. The inscriptions on their joint astrolabes state 'made' (*sanaᶜah*) by Amīn or Khalīl and 'decorated' (*namaqah*) by ᶜAbd al-A'imma. It is not clear what the terms 'made' and 'decorated' exactly mean in this context. The letters and numbers on the one hand and the decorations on the other on the surfaces of the *kursī,* the rim, the rete and the gazetteer in these astrolabes are so intricately mixed that one cannot think of one man doing the embossed letters and numbers and another adding the decorations. Does this then mean that Amīn or Khalīl made just the skeleton of the astrolabe and ᶜAbd al-A'imma did the entire engraving on the surface?

Unlike Muḥammad Muqīm and Ḍiyā' al-Dīn Muḥammad of Lahore who never repeat the same design in their *kursīs,* retes or gazetteers, ᶜAbd al-A'imma repeats the same designs often. In particular, the type of rete used in the present astrolabe is found in several of his astrolabes.[1715] It is even borrowed by other Safavid astrolabe makers like ᶜAbd al-ᶜAlī (see Figure Y011.2), ᶜAlī ibn Sādiq,[1716] and Muḥammad Mu'min,[1717] and also by Ḥāmid of the Lahore family (A109). In some astrolabes, there is a variation: the tracery between the two rings is the same, but inside the ecliptic ring, there is no

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1713 He signs his name usually as *ᶜAbd al-A'imma*; but in two astrolabes (Museum of the History of Science, Oxfor, # 33739; Adler Planetarium, Chicago # W-89) which he made jointly with Khalīl Muḥammad, the inscription reads 'made by poor man Khalīl Muḥammad ibn Ḥasan ᶜAlī, decorated by ᶜAbd al-A'imma ibn ᶜAbd al-Ḥussayn.

1714 Because of his fame, there exist some fake astrolabes carrying his name; cf. Gingerich, King & Saliba 1972; Gingerich 1982b.

1715 For examples, in the following four astrolabes in the Museum of the History of Science at Oxford: # 40744 of 1124/1712-13; #46681 of 1132/1719-20; 37321, nd; and #48701, nd, are equipped with the same style of retes; so also the astrolabes at the Adler Planetarium, Chicago, # A-74 (cf. Pingree 2009, no. 27); # A-88 (cf. Pingree 2009, no. 28).

1716 Adler Planetarium, # W-151 (cf. Pingree 2009, p. 30, pp. 138-142).

1717 Adler Planetarium, # A-146 (cf. Pingree 2009, no. 31, pp. 143-147).

tracery to join the star pointers; instead there is the equinoctial bar with counter-changes; star pointers are joined to this bar, as well as the ecliptic ring and the central ring.[1718]

ᶜAbd al-A'imma's astrolabes are much smaller, as compared to the Lahore astrolabes. The present astrolabe with a diameter of 135 mm is one of his largest specimens. It has close similarities with another astrolabe by him, which is in the Adler Planetarium at Chicago (# A-90)[1719]: they are both of the same size, the arrangement, decoration and the contents of the geographical gazetteer are the same; the *kursī* has the same shape and carries the same design on the reverse side, both have the same cartouche on the front, but it is blank in the present astrolabe, while the one at the Adler is filled with an inscription.

COMPONENTS

Body (d. 135, h. 180, t. 7) with *kursī,* rete (d. 118) for 30 stars, 6 plates (d. 118), alidade, pin and washer; no information is available about the wedge; the shackle and ring are lost and replaced by a strange apparatus for suspension.

FRONT

The *kursī* is high and lobed with a trifoliate finial. At the base on either side, there are two incisions separated by a tulip flower, its two outstretched petals forming the profile of the *kursī.* On the obverse side there is a large cartouche which is blank; it is surrounded by many tiny floral decorations. On the reverse side, there is a large flower in the centre, surrounded by many decorative curves representing vines with small flowers and leaves. [1720] To the finial is attached a small shackle; its upper part is circular with a hole at the centre, through which passes a longish rod for suspension. These appear to have been added later.

[1718] For example, Museum of the History of Science, # 54193 of 1115/1703-4; # 40833, nd; # 43739, nd; Adler Planetarium, # A-74 (cf. Pingree 2009, no. 27) and # A-28 (cf. Pingree 2009, no. 28); see also CCA 37, 39 and 40, in the National Museum of American History, Washington, D.C. (cf. Gibbs & Saliba 1984, pp. 69-77).

[1719] Adler Planetarium, # A-90 (Pingree 2009, no. 26, pp. 120-123). In this astrolabe, the original rete and plates are lost and replaced by fake substitutes; cf. Gingerich 1982b.

[1720] *Kursīs* with exactly the same decorations can be seen in his undated astrolabes in the Museum of the History of Science, Oxford (# 37321 and # 48701).

The rim of the main body is graduated in single degrees and numbered clockwise in 5s from 5 to 360. The numbers are represented by *Abjad* symbols which are embossed and embellished with small floral decorations.



Figure Y009.2 – Rete (photo by Ahmed Athaullah)

RETE

The rete is the most characteristic feature of ᶜAbd al-A'imma's astrolabes. It consists of a narrow ring of Capricorn and a wider ring of ecliptic; these two are held together by the floral tracery that joins the star pointers. The ecliptic ring is divided into the twelve zodiac signs; their names are written in large embossed letters against a background filled by small leaves and circles. Each sign is subdivided into five parts which are numbered anti-clockwise as 6, 12, 18, 24, 30. The Capricorn ring is decorated with a floral pattern.

There are 30 star pointers which are shaped like stylized leaves with claw-like tips with sharp ends. These are joined by a tracery of vines. One vine arises from the north point on the Capricorn ring and branches off to the left and right, spreading in the space between the Capricorn ring and the ecliptic ring. Inside the ecliptic ring, the vines form two ‘figures-of-eight’ on the left and right.

Table Y009-1 Stars on the Rete

	Star Names	Identification
1	*Dhanab Qayṭus*	β Ceti
2	*Fam Qayṭus*	γ Ceti
3	*Ṣadr Qayṭus*	π Ceti
4	*Ghūl*	β Persei
5	*Masafat al-Nahr*	γ Eridani
6	*ᶜAyn Thawr*	α Tauri
7	*ᶜAyyūq*	α Aurigae
8	*Rijl al-Jawzā’ Yusrā*	β Orionis
9	*Yad* ---	γ Orionis
10	*Shiᶜrā Yamānīyah*	α Canis Majoris
11	*Shāmīyah*	α Canis Minoris
12	*Fard Shujāᶜ*	α Hydrae
13	*Qalb al-Asad*	α Leonis
14	*Ẓahr Dubb*	α Ursae Majoris
15	*Qāᶜidah*	α Crateris
16	*Janāḥ al-Ghurāb*	γ Corvi
17	*Simāk Aᶜzal*	α Virginis
18	*Simāk Rāmiḥ*	α Bootis
19	*Nayyir Fakkah*	α Coronae Borealis

	Star Names	Identification
20	*Unuq al-Ḥayyā* (?)	α Serpentis
21	*Qalb al-ᶜAqrab*	α Scorpii
22	*Rās al-Ḥawwā*	α Ophiuchi
23	*Nasr Waqiᶜ*	α Lyrae
24	*Dhanab al-Dulfīn*	ε Delphini
25	*Nasr Tā'ir*	α Aquilae
26	*Dhanab al-Dajājah*	α Cygni
27	*Fam al-Faras*	ε Pegasi
28	*Sāq Sākib al-Mā'*	δ Aquarii
29	*Mankib al-Faras*	β Pegasi
30	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are six plates with notches at the north points.

Table Y009-2 Plates

	φ	The longest day
1a	22°	13;21 hours
1b	29	13;52 hours
2a	31°	14;1 hours
2b	32°	14;4 hours
3a	33°	14.12 hours
3b	34°	14;15 hours
4a	35°	14;27 hours
4b	36°	14;28 hours

	φ	The longest day
5a	37°	14;38 hours
5b	38°	14;39 hours
6a	40°	14;51 hours
6b	Tablet of Horizons	

On all plates, except 6b, altitude circles are drawn for every 2°; these are numbered in *Abjad* on both sides of the meridian. Azimuth arcs are drawn above the horizon for every 10°. These are numbered also in *Abjad* on both sides of the meridian, partly along the horizon curve and partly along the periphery above the horizon.

On 1a, there are lines only for seasonal hours; these are numbered in Arabic ordinal numbers from the first to the twelfth, starting from the western horizon; the words are engraved under the circle of equator. On the rest of the plates (1b to 6a) lines are drawn for both seasonal and equal hours and numbered from the western horizon. The seasonal hours are numbered under the circle of equator, sometimes in *Abjad* numerals (1b, 3a, 4a, 5a, 6a), sometimes as Arabic ordinals in feminine form (2a, 3b, 4b, 5b) and once both in Arabic ordinals and in common Arabic numerals (2b). In general an attempt seems to have been made to write *Abjad* numerals on one side of the plate and the words on the other side. The Arabic ordinals in feminine form are: *al-’ūlā, al-thāniyah, al-thālithah, al-rābiᶜyah, al-khāmisah, al-sādisah, al-sābiᶜah, al-thāminah, al-tāsiᶜah, al-ᶜāshirah, al-ḥādiyah ᶜāsharah, al-thāniyah ᶜāsharah.*

The lines of equal hours, on the other hand, are numbered just above the periphery sometimes in *Abjad* (2a, 2b, 5b), but more often in common Arabic/Persian numerals (1b, 3a, 3b, 4a, 4b, 5a, 6a).

The arguments, *al-ᶜarḍ* and *al-sāᶜātah* under the horizon at the centre and *al-maghrib* and *al-mashriq* at the western and eastern ends are written in large letters. On two plates there are decorations. 1a (for 22°, obviously for Mecca) and 2b (for 32°, probably for Bayt al-Maqdis = Jerusalem) the central segment between the horizon and the circle of Cancer, the words *al-ᶜarḍ* and *al-sāᶜātah* are written in embossed and ornate letters and the background chased with fine dots and filled with small flowers and

leaves. Likewise the two segments between the horizontal diameter and the horizon in the west and in the east, the words *al-maghrib* and *al-mashriq* are written in embossed letters and the background chased with fine dots. In addition, on 2b the ordinal words are written in embossed letters and their background constituting a wide band under the circle of equator is chased with fine dots.

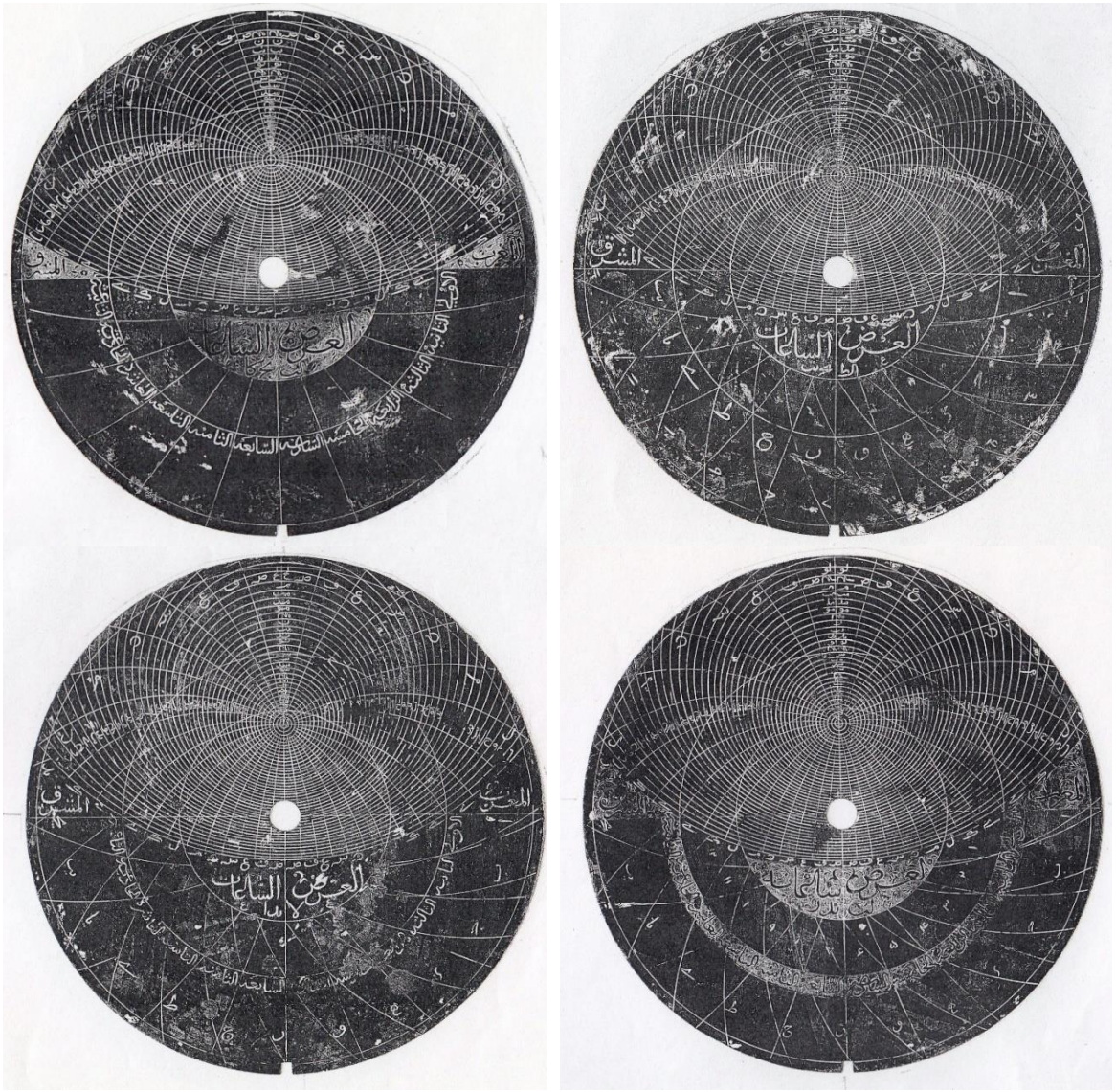


Figure Y009.3 – Plates 1 (for latitudes 22° & 29°) and 2 (for latitudes31° & 32°)
(photos by Ahmed Athaullah)

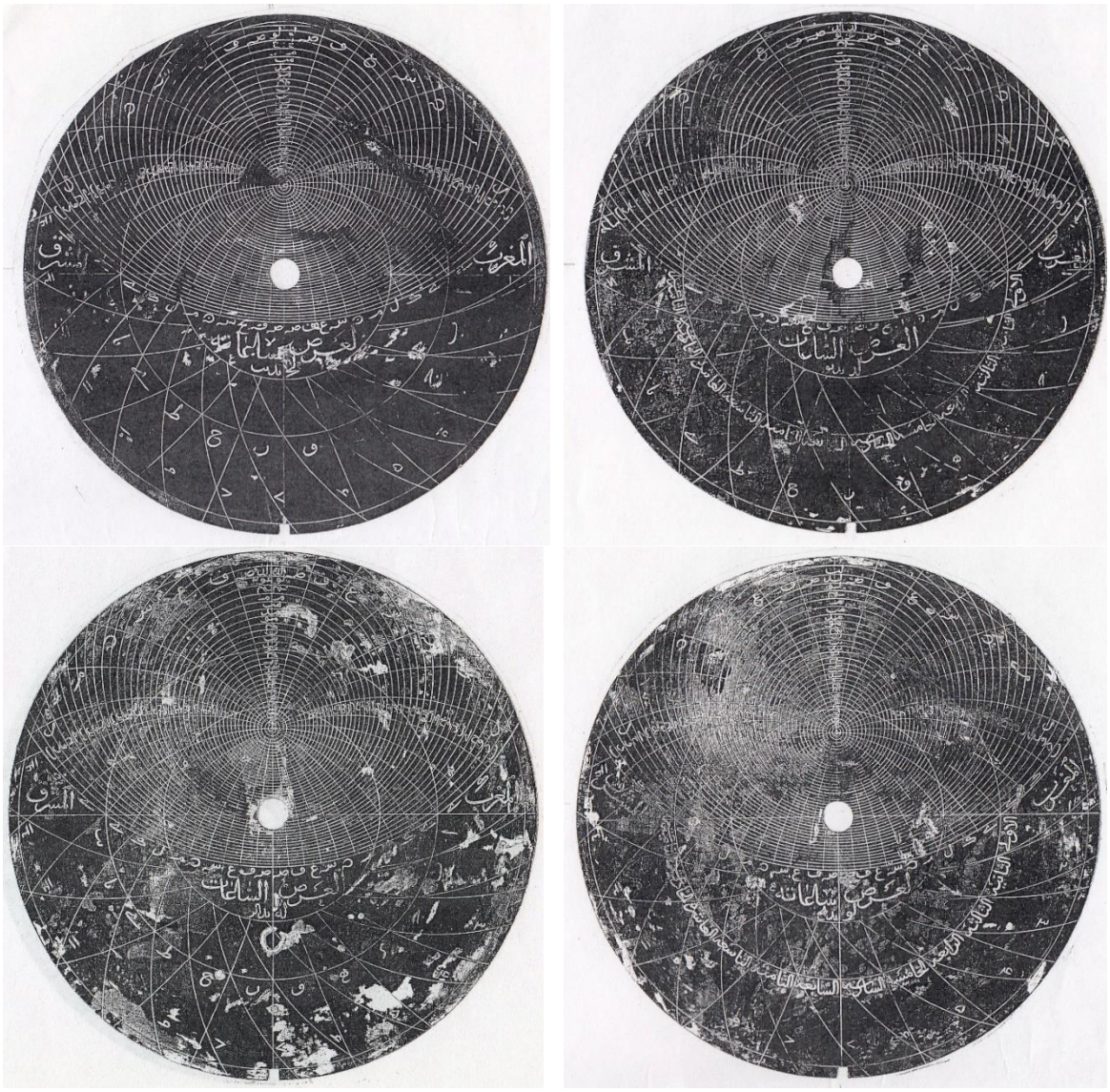


Figure Y009.4 – Plates 3 (for latitudes 33° & 34°) and 4 (for latitudes 35° & 36°)
(photos by Ahmed Athaullah)

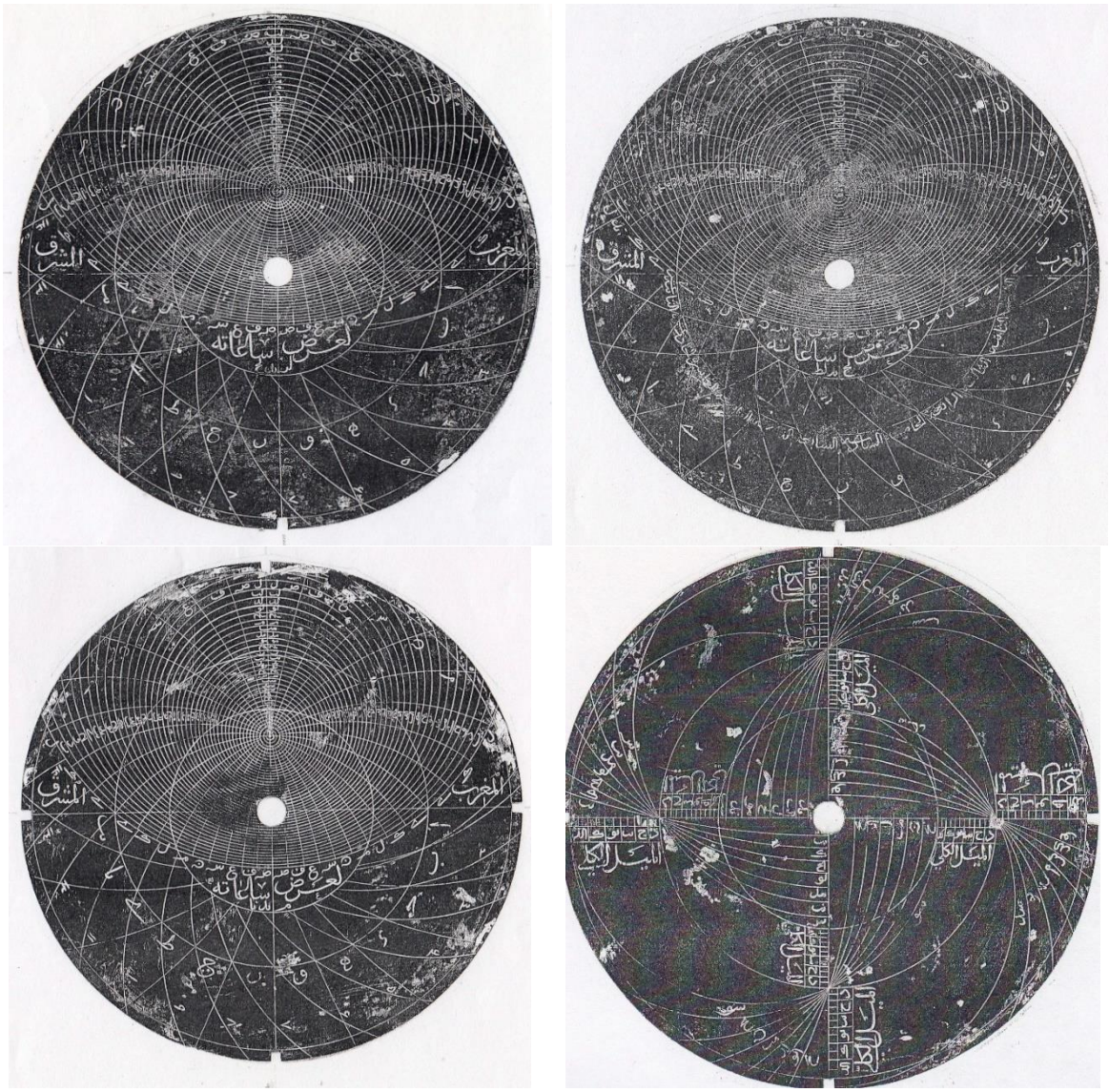


Figure Y009.5 – Plates 5 (for latitudes 37° & 38°) and 6 (for latitude 40° & horizons)
(photos by Ahmed Athaullah)

GEOGRAPHICAL GAZETTEER

In the geographical gazetteer, engraved on the inner side of the main body, the names, longitudes, latitudes, *inḥirāf* and *jahat* of 46 localities are displayed in two sets of five concentric circles. In the both sets, in the upper circle, the place names are in embossed letters against a chased background. Likewise, in the alternative radial segments, the *Abjad* numbers are written in embossed letters against a chased

background. In the only available photo of the gazetteer, some parts are not distinct enough and cannot be deciphered; therefore the gazetteer is not copied.[1721]



Figure Y009.6 – Geographical Gazetteer (photo by Ahmed Athaullah)

[1721] As mentioned above, this gazetteer is identical in design and in contents to the gazetteer in the astrolabe made by A’imma in 1127/1715, now in Adler Planetarium, # A-90; cf. Pingree 2009, no. 26, pp. 120-123; the gazetteer is copied on p. 122 and illustrated on p. 123.

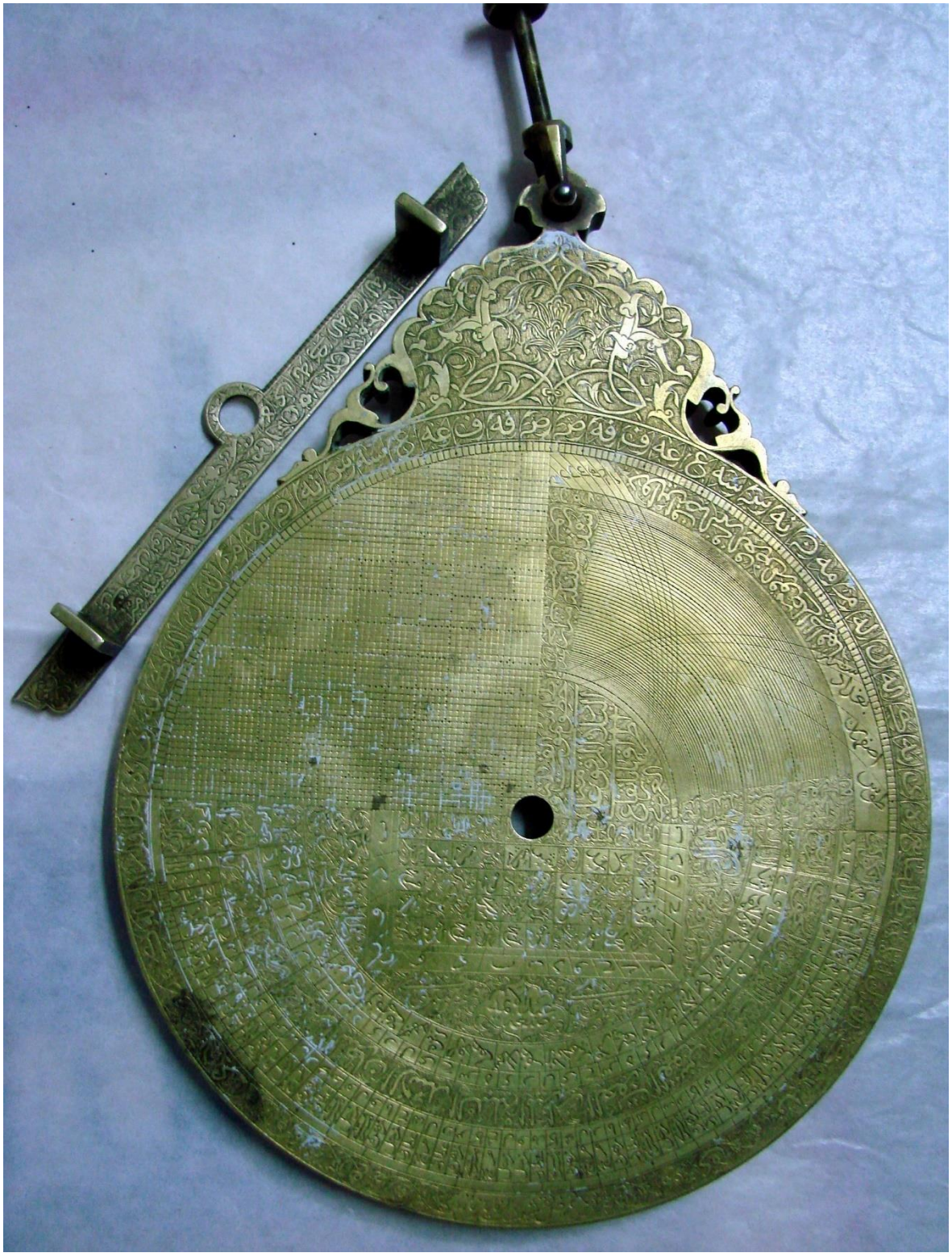


Figure Y009.7 – Back of the astrolabe and the alidade (photo by Ahmed Athaullah)

BACK

The rim of the upper half is graduated in single degrees and numbered in 5s, from 5 to 90, separately in each quadrant. The *Abjad* numerals are embossed and their cells

are decorated with some embossed lines. The upper left quadrant contains a sine-cosine graph with 60 equi-distant horizontal and vertical parallels, with every fifth highlighted.

The upper right quadrant is filled with 60 declination arcs projected stereographically. The names of the 12 signs are written along the two radii in slanted columns, also in embossed letters.

Upon these declination arcs are superimposed seven curves of solar meridian altitude for the latitudes of 28°, 30°, 32°, 34°, 36°, 38° and 40°. The label related to these is written in embossed letters in an arc below the altitude scale on the right: *dawā'ir inṣāf al-nahur fī al-ᶜurūḍ al-marqūmah ᶜalā aṭrāfahā* (circles of midday for the latitudes marked at their extremities).

There are also four arcs of azimuths of qibla for the cities of Ṭūs, Baghdād, Iṣfahān and Shīrāz. The inscription related to these arcs is written in embossed letters inside the innermost declination band in four lines: *khuṭūṭ sumūt al-qiblah fī al-bilād al-murqūmah ᶜalā aṭrafāhā bi-irtifaᶜ al-gharbī* (lines of Qibla directions in cities marked on the edges near the altitude scale in the west).

The rim of the lower half carries cotangent scales, on the left for feet with the label *ẓill aqdām* in embossed letters just below the horizontal diameter and on the right the cotangents in digits with the label *ẓill aṣābiᶜ* in embossed letters just below the horizontal diameter.

Inside these cotangent scales, there are five semi-circular rows; what they contain is mentioned in the labels at both the ends of the semi-circles. The main one among these is the middle row; it carries the names of the 12 zodiac signs, in embossed letters, with the label *al-burūj,* also in embossed letters, at both ends of the semi-circle. Other rows are related to this one. Starting from the outside these are as follows.

1. The names of the planets related to the limits mentioned in the second row; the label is *al-kawākib* (planets).
2. The second row is entitled *al-ḥudūd* (the limits); here each zodiac sign is divided in five limits or intervals and each interval is assigned to a certain planet, other than the sun and moon (see Introduction to A-series, 2.6.4.2). The names of the planets are given in the first row, and the numerical strengths of the limits are mentioned in this second row.
3. The names of the 12 zodiac signs, as mentioned above.

4. The fourth row carries the label *al-wujūh* (decan or faces) on both ends. Here each sign is divided in three decans (i.e. 10°) and each cell is filled with the last letter of the name of the planet that governs the decan.
5. The names of the 28 lunar mansions with the label *al-manājil.*

These semi-circular tables enclose shadow squares, on the left for feet and on the right for digits. The vertical and horizontal scales on the left are marked 2, 4, 6, 7; those on the right are marked 2, 4, 6, 8, 10, 12. The shadow squares are labelled in the usual manner in embossed letters. Inside the shadow squares is a rectangular table, containing the trigons and their regents.

ALIDADE

The sloping upper edge of the alidade on the left is divided into 60 parts to match with the divisions on the upper left quadrant on the back; groups of 5 units are numbered on the upper register of the surface from the centre towards the left in embossed *Abjad* numerals from 5 to 60. The lower register carries the scale of unequal hours to be used when the alidade is employed as a sundial with the sighting plate on the left as the gnomon.

The right half of the alidade is divided into zodiac signs to match with the same on the upper right quadrant on the back and are filled with the names of the signs on the lower and upper registers.

All the empty spaces on the alidade are filled with pleasing floral decorations.

INSCRIPTIONS

In a small cartouche below the shadow squares on the back is the signature of the astrolabe maker which reads

sanaᶜah ᶜabd al-a'imma

'Made [by] ᶜAbd al-A'imma'.

In a longer cartouche at the bottom of the rim is the quotation from the Persian poet Shaykh Saᶜdī:

gharaḍ naqshīst kaz mā bāz mānad

'The intention of this drawing is that it should remain after us.'

This is indeed the most appropriate quotation to engrave on the astrolabe, to express the hope that the astrolabe may last long even when the astrolabe maker is no

more. ᶜAbd al-A'imma engraves it on the back of several of his astrolabes; [1722] sometimes just this one line and some other times the following two lines:

gharaḍ nakshīst kaz mā bāz mānad

kah hastī rā namī binam baqāyī

'The intention of this drawing is that it should remain after us;

for I see no permanence of life.'[1723]

BIBLIOGRAPHY

Gingerich, King & Saliba 1972.

Gingerich 1982b.

Gibbs & Saliba 1984 carries descriptions of these four astrolabes by ᶜAbd al-A'imma: CCA 31 (nd, d. 74, pp. 68-69, Fig. 41), 37 (nd, d. 93.5 mm, pp. 69-71, Figs. 42-43), 39 (nd, d. 92.5, pp. 72-74, Fig. 44) and 40 (nd, d. 93.5, pp. 74-77, Figs. 45-46).

Pingree 2009 contains full descriptions, with illustrations, of four astrolabes signed by ᶜAbd al-A'imma: no. 26 (1127/1715, pp. 120-123); no. 27 (nd, pp. 124-127); no. 28 (nd. pp. 128-132); one astrolabe attributable to him: no. 24 (nd, pp. 110-115); one astrolabe made by Khalīl Muḥammad and decorated by ᶜAbd al-A'imma (nd, pp. 104-109).

[1722] E.g., Oxford, Museum of the History of Science, (#35313, # 48701, # 40833# 46681); Chicago, Adler Planetarium (# A-88, A-90); Washington, National Museum of American History (# 32).

[1723] As translated by Rehatsek 1875, p. 328.

Y010 ASTROLABE MADE BY MUḤAMMAD AMĪN IBN MUḤAMMAD ṬĀHIR AND DECORATED BY ᶜABD AL-A'IMMA, NOT DATED [1724]

Diameter 186 mm

Kolkata, Indian Museum (# A 24.431)

CCA 32 Répertoire 2

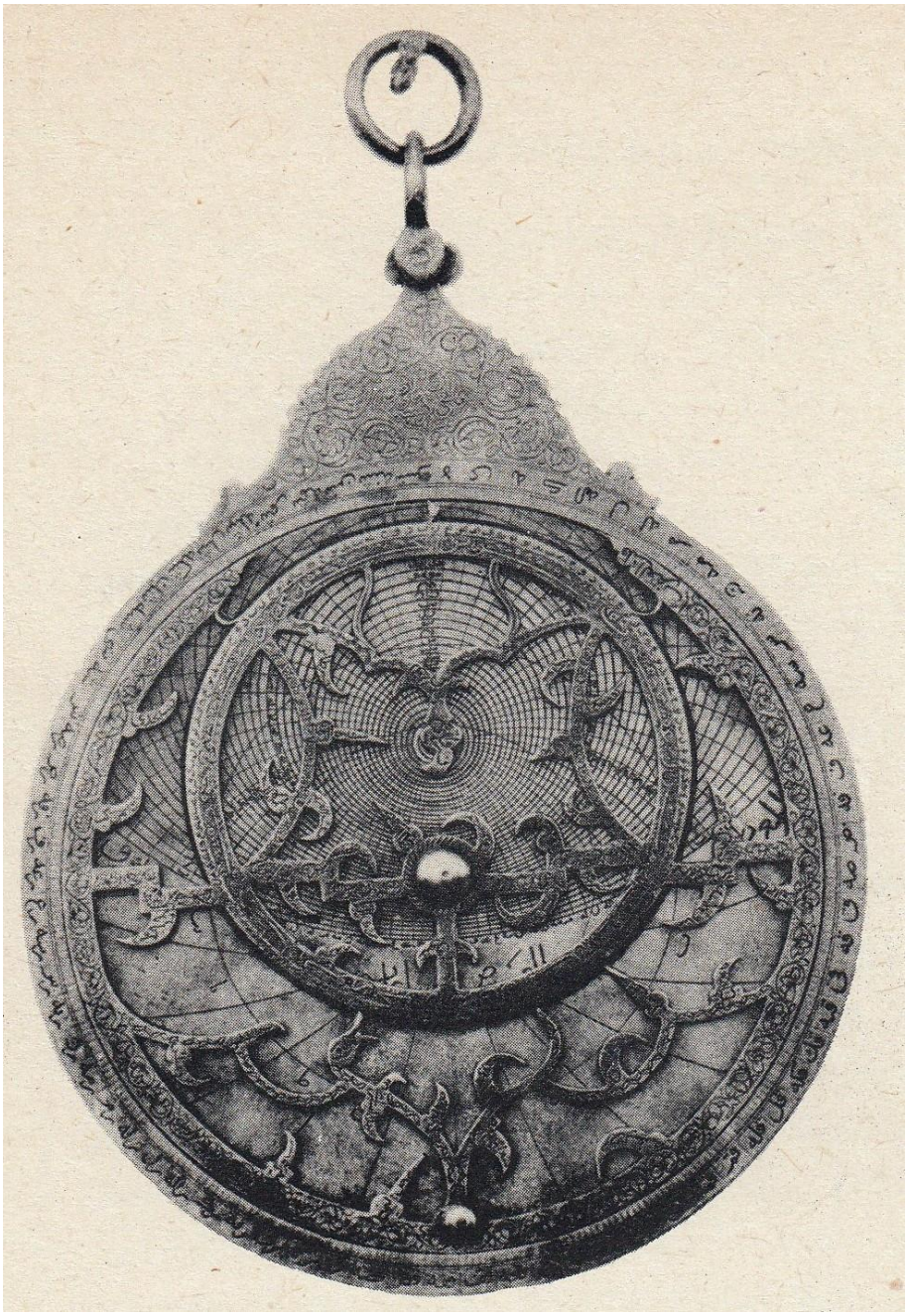


Figure Y010.1 – Front of the astrolabe (from Kaye 1918)

[1724] Entry based primarily on Govind 1979, p. 15.

This astrolabe has not been very lucky with the modern studies it has generated. It was acquired from Herat by a certain Major Pottinger who presented it to the Asiatic Society at Calcutta. J. Middleton, Principal of the Government College at Agra, published a description of it in 1841.[1725] William Morley remarks that 'the description itself, derived chiefly, as Mr. Middleton informs us, from two intelligent Pandits, is extremely inaccurate.'[1726] It is also extremely long-winded, full of platitudes, but without a mention of the maker of the astrolabe; it gives a list of 44 stars marked on the rete, but does not say much about the plates. By the time G. R. Kaye published his well-known *The Astronomical Observatories of Jai Singh* in 1918, the astrolabe was moved to the Indian Museum, Calcutta. In his book, Kaye lists this astrolabe among 'the metal instruments actually examined, most of them at Jaipur,' as follows:

> 'C.— Astrolabe. Designed by Muḥammad Amīn bin Muḥammad Ṭāhir and engraved by 'Abdul Aimmah. From Herāt. Diameter 7.3 inches. Indian Museum, Calcutta. Figures 9, 12, 15 and 16.'

Kaye states that the astrolabe was 'from Herat', but does not add that it was acquired at Herat by Major Pottinger, nor does he mention Middleton's article. He does not provide any description of the astrolabe, but reproduces four photos of the astrolabe.[1727]

In Gunther's *Astrolabes of the World*, this astrolabe becomes two separate entities: no. 32: 'Muḥammad Amīn's Astrolabe, *'Herat C' c.* 1700' on the basis of Kaye's book mentioned above, and no. 43. 'Major Pottinger's Astrolabe' on the basis of Middleton's description.[1728] The CCA follows suit and lists it as 32 (CIM= Calcutta, Indian Museum) and 43 (POT = Major Pottinger Collection). The only account which is somewhat coherent is by Govind.[1729]

1725 Middleton 1841.

1726 Morley 1856, p. 4.

1727 Kaye 1918, p. 16, Figs. 9 (front), 12 (back), 15 (plate of horizons, wrongly captioned 'Venter of Astrolabe') and 16 (Venter of the astrolabe engraved with a geographical gazetteer, wrongly captioned as 'tablet of Horizons'); all the four figures are identified as 'Herat C'.

1728 Gunther 1932, no. 32, pp. 146-147, Figs. 71-72; no. 43, p. 156, Fig. 76.

1729 Govind 1979, p. 15.

Muḥammad Amīn ibn Muḥammad Ṭāhir (*fl.* 1085/1674-1097/1685) is known by three astrolabes which he produced on his own; four others are said to have been made (*sanaᶜah*) by him and decorated (*namaqah*) by ᶜAbd al-A'imma.[1730] The astrolabe made alone by Muḥammad Amīn in 1086/1675, which is now in the Museum of the History of Science at Oxford, is so exquisitely decorated that it is difficult to say in the three astrolabes he produced in collaboration with ᶜAbd al-A'imma which tasks were performed by whom.

COMPONENTS

Body (d. 186) with *kursī,* shackle and ring, rete (d. 167) for 44 stars, 6 plates (d. 167) , alidade (length 173), pin and horse. One of the sighting plates on the alidade is broken and lost.

FRONT

The *kursī* is very high with several small lobes on each side and a trifoliate finial at the top. The front of the *kursī* is decorated with an arabesque design. On the back there is a circular cavity, which may have contained a gem or a compass. There are floral decorations around the cavity. The shackle has circular bases and a circular cross-section; the ring also has a circular cross section.

The rim of the main body is graduated in 1° and 5° and numbered from 5 to 360.

RETE

The rete has almost the same design as the rete in the astrolabe no. 31 at the National Museum of American History at Washington.[1731] The narrow ring of Capricorn and the broader ring of the ecliptic are held together by the equinoctial bar which is counter-changed four times. There are 44 star pointers, 22 to the north of the ecliptic and the same number to the south. The traceries joining these star pointers to the main

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[1730] Those made by him are CCA 3710, 1085/1674, formerly Paris, Landau Collection, PLU; CCA 1020, 1086/1675, Oxford, Museum of the History of Science (# 35565); CCA 3659, 1095/1683, formerly Paris, Alain Brieux, PLU; CCA 3693, 1097/1685, Long Island City, PC; PLU. The three made by Amīn and decorated by A'imma are CCA 31, nd, Washington, D.C., National Museum of American History; CCA 32, the present specimen; CCA 1171, nd., St. Louis, City Art Museum. CCA 31 is described in Gibbs & Saliba 1984, no. 31, pp. 68-69, Fig. 41.

[1731] See Gibbs & Saliba 1984, no. 31, pp. 68-69, Fig. 41.

frame as well as the outer ring of Capricorn are decorated with minute engravings. The ecliptic ring is divided into the 12 zodiac signs and their names are written with embossed letters. Each sign appears to have been divided in groups of 2° and numbered anti-clockwise as 2, 4, 6, … 30.

Plates

No details are available of the six plates. The plate visible below rete in Figure Y011.1, appears to carry altitude circles for every 2°, azimuths arcs drawn above the horizon for every 5°, and lines for seasonal hours numbered from the western horizon.

Geographical Gazetteer

The gazetteer carries the names, longitudes, latitudes, *inḥirāf* and *jihāt* of 44 localities in two concentric circles.

Back

On the back, the rim of the upper half is graduated in 1° and 5° and numbered 5—90; 90—5. The upper left quadrant carries a sine graph with 60 equi-distant horizontal parallels. In the upper right quadrant, declination circles are stereographically projected, upon which are drawn five arcs of the solar meridian altitudes for latitudes 24°, 26°, 33°, 36°, 37° and azimuths of *qibla* for the cities of Shīrāz, Baghdād, Iṣfahān, Qazwīn, Yazd and Ṭūs.

The rim of the lower half bears cotangent scales, in feet and in digits. Within these scales are three semi-circular scales containing respectively the 28 lunar mansions, the 12 zodiac signs, the decans and their lords. These semi-circular scales enclose shadow squares in feet and in digits. Within the shadow squares is engraved a table of trigons and their lords.

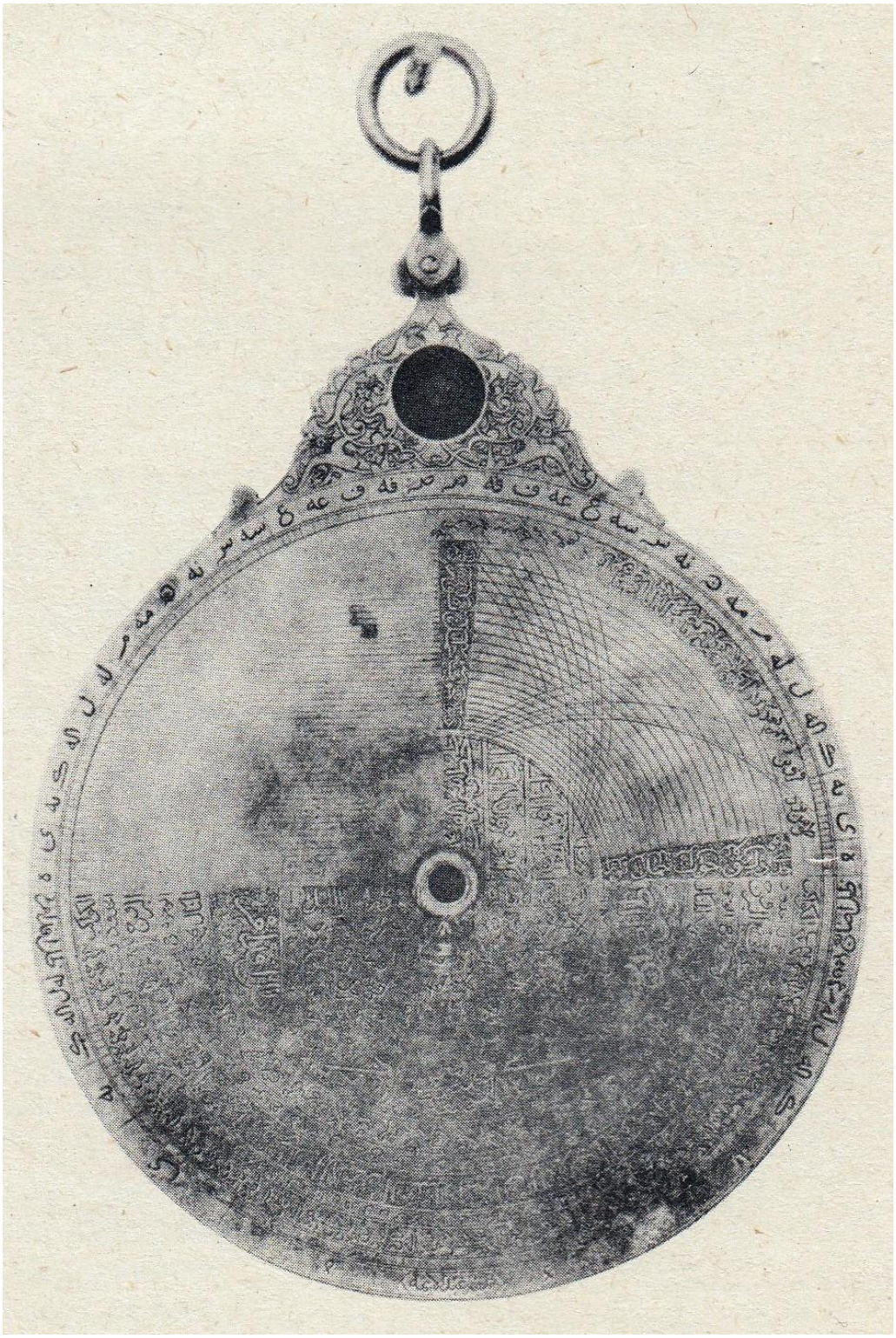


Figure Y010.2 – Back of the astrolabe (from Kaye 1918)

INSCRIPTIONS

Below the shadow squares is the following inscription, engraved inside a cartouche:

sanaᶜah muḥammad amīn ibn muḥammad ṭāhir namaqah ᶜabd al-a'imma

‘Made by Muḥammad Amīn ibn Muḥammad Ṭāhir, decorated by ᶜAbd al-A’imma.’

At the very bottom of the back, in the middle of the two cotangent scales, is engraved a line from Shaykh Saᶜdī’ *Gulistān:*

gharaḍ nakshīst kaz mā bāz mānad

‘The intention of this drawing is that it should remain after us.’[1732]

BIBLIOGRAPHY

Middleton 1841.

Morley 1856, p. 4.

Kaye 1918, p. 16, Figs. 9, 12, 15, 16.

Gunther 1932, no. 32, pp. 146-147, Figs. 71-72; no. 43, p. 156, Fig. 76.

Govind 1979, p. 15.

Gibbs & Saliba 1984, nos. 31, pp. 68-69, Fig. 41.

Répertoire, s.v. Muḥammad Amīn b. Muḥammad Ṭāhir, 2.

[1732] As translated by Rehatsek 1875, p. 328.

Y011⊙ ASTROLABE BY ᶜABD AL-ᶜALĪ, [1]119 AH (AD 1707-08)[1733]

Diameter 132.5 mm

Mumbai, K. R. Cama Oriental Institute

CCA 1157



Figure Y011.1 – Front of the astrolabe (photo by S. R. Sarma)

[1733] Entry based on Khareghat 1950, pp. 55-74, Figs. 10-15.

ᶜAbd al-ᶜAlī (*fl.* 1119/1707-1126/1714) was one of the leading astrolabe makers of Iṣfahān. He is well known for the very large and very splendid astrolabe, with a diameter of 402 mm and a height 609 mm, which he made for Shāh Ḥussayn Safāvī in 1124/1712. The description of this astrolabe by William Morley has become a classic in the literature on the astrolabe.[1734] The CCA lists ten astrolabes made by ᶜAbd al-ᶜAlī.[1735]

Unfortunately the date of the present astrolabe is not certain. There is a large cartouche on the front side of the *kursī* and a smaller one below the shadow squares on the back. Rehatsek, who was the first to study this astrolabe, notes that the larger cartouche on the front of the astrolabe contains a quotation from the *Gulistān* of the great Persian poet Saᶜdī and that the smaller cartouche on the back contains the signature of the astrolabe maker and the date, which he deciphers as *sanaᶜah fī 119,* and adds that 'the date, no doubt, standing for A. H. 119, A.D. 1707.'[1736]

M. P. Khareghat, who examined this astrolabe on 22.9.1925, also deciphered the smaller cartouche in the same manner, but interpreted 119 as 1190, because 'as it sometimes happens, the last cypher of the year is not given here.'[1737]

Dinshaw D. Kapadia, who edited Khareghat's work, notices below the quotation from Saᶜdī in the larger cartouche a date '1160'; he goes on to add that because Khareghat read 119 in the smaller cartouche, 'the date, therefore, could not be definitely fixed.[1738]

1734 Morley 1856.

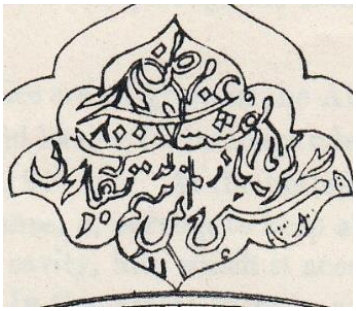
1735 Chronologically, these are CCA 10, 1119/1707, Oxford, Museum of the History of Science (# 40330); CCA 1157, 1119/1707 (?), the present astrolabe; CCA 33, 1124/1712, made for Shāh Ḥussayn Safāvī, London, British Museum; CCA 1158, 1126/1714, Tehran, Museum of Archaeology; CCA 1020, nd, Oxford, Museum of the History of Science (# 36247); CCA 1159, nd, Vienna, Kunsthistorisches Museum; CCA 2536, nd, Oxford, Museum of the History of Science (# 37940); CCA 3554, nd, Cairo, formerly Harari Collection, now probably in Cairo, Museum of Islamic Art; CCA 3685, nd, Newport News, Virginia, Maritime Museum; CCA 3740, nd, Newport News, Virginia, Maritime Museum. Not listed in CCA is an eleventh specimen: Chicago, Adler Planetarium (# A-69); cf. Pingree 2009, no. 29, pp. 133-137.

1736 Rehatsek 1875, p. 328.

1737 Khareghat 1950, p. 59.

1738 Khareghat 1950, p. 61.

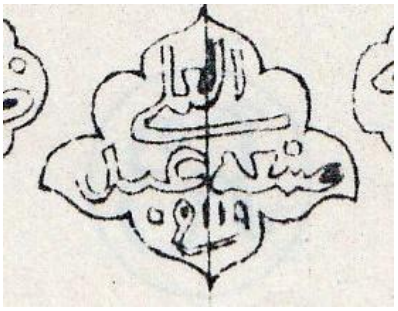
To add to the confusion, the drawings of the two cartouches printed in Khareghat's work show both the dates: the larger cartouche in Figs. 11 and 12 has 1160 and the smaller cartouche in Fig. 10 has 119. It is most probably Kapadia who was responsible for these drawings. Rehatsek's sketch of the front (Fig. 2 printed 326) does not show any date below Saᶜdi's quotation.


Rehatsek, Fig. 2


Khareghat, Fig. 11


Khareghat, Fig. 12

Figure Y011.2 – Cartouche on the front of the Kursī


Rehatsek, Fig. 3

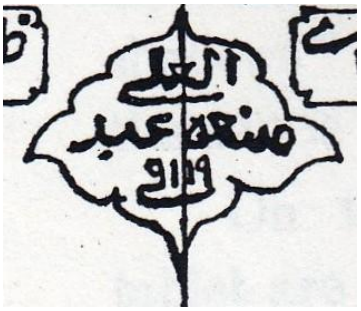

Khareghat, Fig. 10

Figure Y011.3 – Smaller cartouche on the back

Of the two dates 1119 and 1160, the former appears to be the more likely one, because it is closer to the other known dates of ᶜAbd al-ᶜAlī's astrolabes, namely 1124 and 1126.

Components

Body (d. 132.5) with *kursī,* shackle and two rings, rete (d. 116), 5 plates (d. 116), alidade, pin and horse

Front

The *kursī* is high and lobed, with a fig-leaf-shaped finial. The shackle has simple bases and a diamond cross section; passing through this shackle are two small rings, both with diamond cross-sections. The back of the *kursī* is blank, but on the front is

engraved a rhomboid cartouche, in which a very appropriate passage from Shaykh Saᶜdī's *Gulistān* is written, which translates thus:

'The intention of this drawing is that it should remain after us;
for I see no permanence of life.'[1739]

The rim of the main body is graduated in 1° and 5° and numbered in 5s as 5, 10, 15, … 350, 355, 360.



Figure Y011.4 – Rete (from Rehatsek 1875)

RETE

The rete is constituted by a narrow Capricorn ring and a much wider ecliptic ring, both held together by the third tracery that joins the star pointers. The equator is not represented, nor the equinoctial or solstitial bars. The ecliptic is divided into the 12

[1739] As translated by Rehatsek 1875, p. 328.

zodiac signs; the names of the signs are written in embossed letters; each sign is divided into groups of 6° and numbered accordingly in anti-clock direction. The sloping edge is divided in 2°. A decorative pattern is engraved on the Capricorn ring. There are 24 leaf-shaped star pointers, 11 inside the ecliptic circle and 13 outside. These are joined by a thin wire-like tracery.

Interestingly the same design of the tracery is repeated in two of his astrolabes which are now with the Museum of the History of Science at Oxford (# 40330 of 119/1707-8 and 36247, nd.). Obviously this design is borrowed from his more famous contemporary ᶜAbd al-A'imma who uses it in several of his astrolabes (see for example, Figure Y009.2).

Table Y011-1 Stars on the rete

	Star Names	Identification
1	*Dhanab Qayṭus* [*Janūbī*]	β Ceti
2	*ᶜAyn al-Thawr*	α Tauri
3	*Rijl al-Yusrā*	β Orionis
4	*Yad Yumnā*	α Orionis
5	*Shiᶜrā Yamānīyah*	α Canis Majoris
6	*Shiᶜrā Shāmīyah*	α Canis Minoris
7	*Fard al-Shujāᶜ*	α Hydrae
8	*Qalb al-Asad*	α Leonis
9	*Ẓahr al-Dubb*	α Ursae Majoris
10	*Qāᶜidah*	α Crateris
11	*Janāḥ al-Ghurāb*	γ Corvi
12	*Simāk al-Aᶜzal*	α Virginis
13	*Simāk al-Rāmiḥ*	α Bootis
14	*Nayyir Fakkah*	α Coronae Borealis
15	*ᶜUnuq al-Ḥayyah*	α Serpentis

	Star Names	Identification
16	*Qalb al-ᶜAqrab*	α Scorpii
17	*Rās al-Ḥawwā*	α Ophiuchi
18	*al-Nasr Wāqiᶜ*	α Lyrae
19	*al-Nasr Ṭā'ir*	α Aquilae
20	*Ridf*	α Cygni
21	*Fam al-Faras*	ε Pegasi
22	*Sāq Yamānī*	γ Aquarii
23	*Mankib* [*al-Faras*]	β Pegasi
24	*Kaff al-Khaḍīb*	β Cassiopeiae

PLATES

There are five plates, with notches at the north point.

Table Y011-2 Plates

	φ	Longest Day
1a	18°	13;12 hours
1b	horizons	
2a	22°	13;22 hours
2b	32°	14;7 hours
3a	25°	13;? hours
3b	36°	14;? hours
4a	29°	?? hours
4b	34°	14;22 ? hours
5a	38°	14;40 hours
5b	40°	14;51 hours



Figure Y011.5 – Plate of Horizons (photo by S. R. Sarma)

The plates do not carry any decorations; in the plate of horizons, however, the argument *mayl kullī* is written in embossed letters and enclosed in a crown-like cartouche with a trifoliate finial; this is repeated eight times all over plate.

GEOGRAPHICAL GAZETTEER

On the inner side of the main body is engraved a geographical gazetteer of 43 localities with their names (*al-bilād*), longitudes (*al-ṭūl*) and latitudes (*al-ʿarūḍ*), in two concentric circles. The arguments and the place names are written in embossed letters.



Figure Y011.6 – Geographical gazetteer (photo by S. R. Sarma)

Table Y011-3 Geographical Gazetteer

	Place Names	L	φ
	Outer Circle		
1	Makkah	77;10	21;40
2	Madīnah	75;20	25;0
3	Kāshān	86;0	34;0
4	Iṣfahān	86;40	32;25
5	Qazwīn	85;0	36;0
6	Sāvah	85;8	35;8
7	Hamadān	83;0	35;10
8	Zangān	83;40	36;30

	Place Names	L	φ
9	Nihāwand	83;15	34;20
10	Iṣṭakhr	88;30	35;0
11	Shīrāz	83;0	29;36
12	Kāzrūn	87;0	29;15
13	Baṣrah	84;0	30;0
14	Baghdād	82;0	3325
15	Ardabil	82;30	38;0
16	Tabrīz	82;0	38;0
17	Marāghah	82;0	37;20
18	Nakhchiwān	81;15	38;40
19	Dimashq	70;0	33;15
20	Astarābād	89;35	36;50
21	Sārī	88;0	36;0
22	Āmul	88;20	36;15
23	Rayy	86;20	35;0
	Inner Circle		
24	Kāshghar	106;30	44;0
25	Khujand	104;35	41;55
26	Samarqand	69;15	39;37
27	Balkh	21;0	36;41
28	Qā'in	93;20	33;40
29	Tūn	92;30	34;30
30	Ṭūs	92;30	36;8
31	Sabzwār	91;30	36;50

	Place Names	L	φ
32	Āstarābād[1740]	89;35	36;50
33	Kashmīr	108;0	35;0
34	Ahmadābād Gujarāt	108;40	22;52
35	Kambāyāt	109;20	26;20
36	Sūrat	110;5 (?)	20;15
37	Brūj (Broach)	110;5 (?)	21;20
38	Chotpur (Jodhpur)	119;16 (?)	26;36
39	Dākah Bangāl	104;0	25;0
40	Mainī	---	---
41	Badakhshān	84;24	37;10
42	Bukhārā	97;30	39;50
43	Khutan	---	---

Nos. 34 Ahmadābād Gujarāt and 38 Dākah Bangāl occupy two cells each; strangely, Lahore, Delhi and Agra are not mentioned. The coordinates of 40 Mainī and 43 Khutan are not filled in.

BACK

The back is divided into four quadrants by the vertical and horizontal diameters. The rim of the two upper quadrants is calibrated in 1° and 5° and numbered in 5s as 5—90; 90—5. The upper left quadrant is engraved with 60 equidistant horizontal parallels, every fifth is highlighted. The upper right quadrant, surprisingly, is completely blank.

[1740] Occurs already at 20; here repeated by mistake.

There are shadow squares in the lower half, on the left for 12 digits and on the right for 7 feet, with the usual labels. The rim carries cotangent scales, on the left for digits and on the right for feet.

ALIDADE

The alidade is 115 mm long; its sides are sloped ornately. On the upper surface are marks showing tangent scales. There is a pin with round head. The wedge is horse-shaped and long.

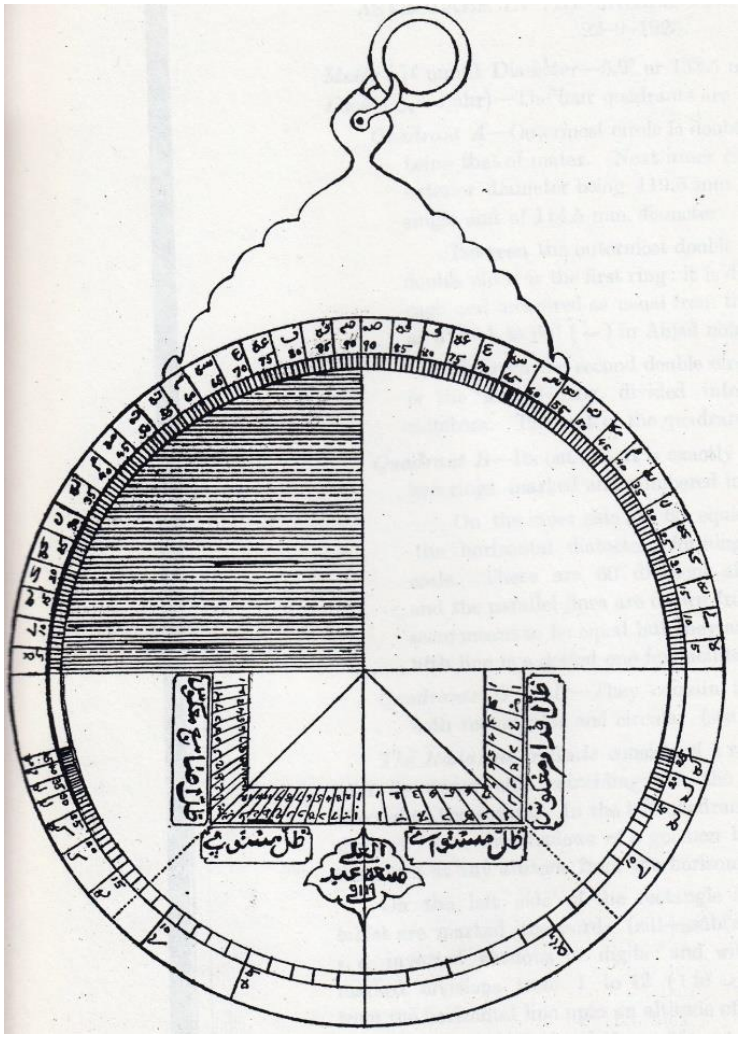


Figure Y011.7 – Back of the astrolabe (drawing from Khareghat 1950)

INSCRIPTIONS

1. On the front of the *kursī,* the following from the *Gulistān* of Shaykh Saᶜdī is engraved in a large cartouche:

   gharaḍ nakshīst kaz mā bāz mānad

   kah hastī rā namī binam baqāyī.

   ‘The intention of this drawing is that it should remain after us;

for I see no permanence of life.'[1741]

2. On the back, below the shadow squares is again a similar cartouche in which is engraved

sanaᶜah ᶜabd al-ᶜalī fī 119

'Made [by] ᶜAbd al-ᶜAlī in [the year] 119.'

PROVENANCE

The astrolabe was in the Mulla Feeroze Library, Mumbai, when Khareghat examined it on 22.9.1925. Subsequently this library was merged with the K. R. Cama Oriental Institute and the astrolabe is now with this institute.

BIBLIOGRAPHY

Morley 1856.
Rehatsek 1875, pp. 327-329, Figs. 3-11.
Khareghat 1950, pp. 55-74, Figs. 10-15.

[1741] As translated by Rehatsek 1875, p. 328.

Y012⊙ MARINER'S ASTROLABE, NOT SIGNED, NOT DATED

French or Portuguese, ca. AD 1575

Diameter 187 mm

Rampur, Rampur Raza Library (# 430)

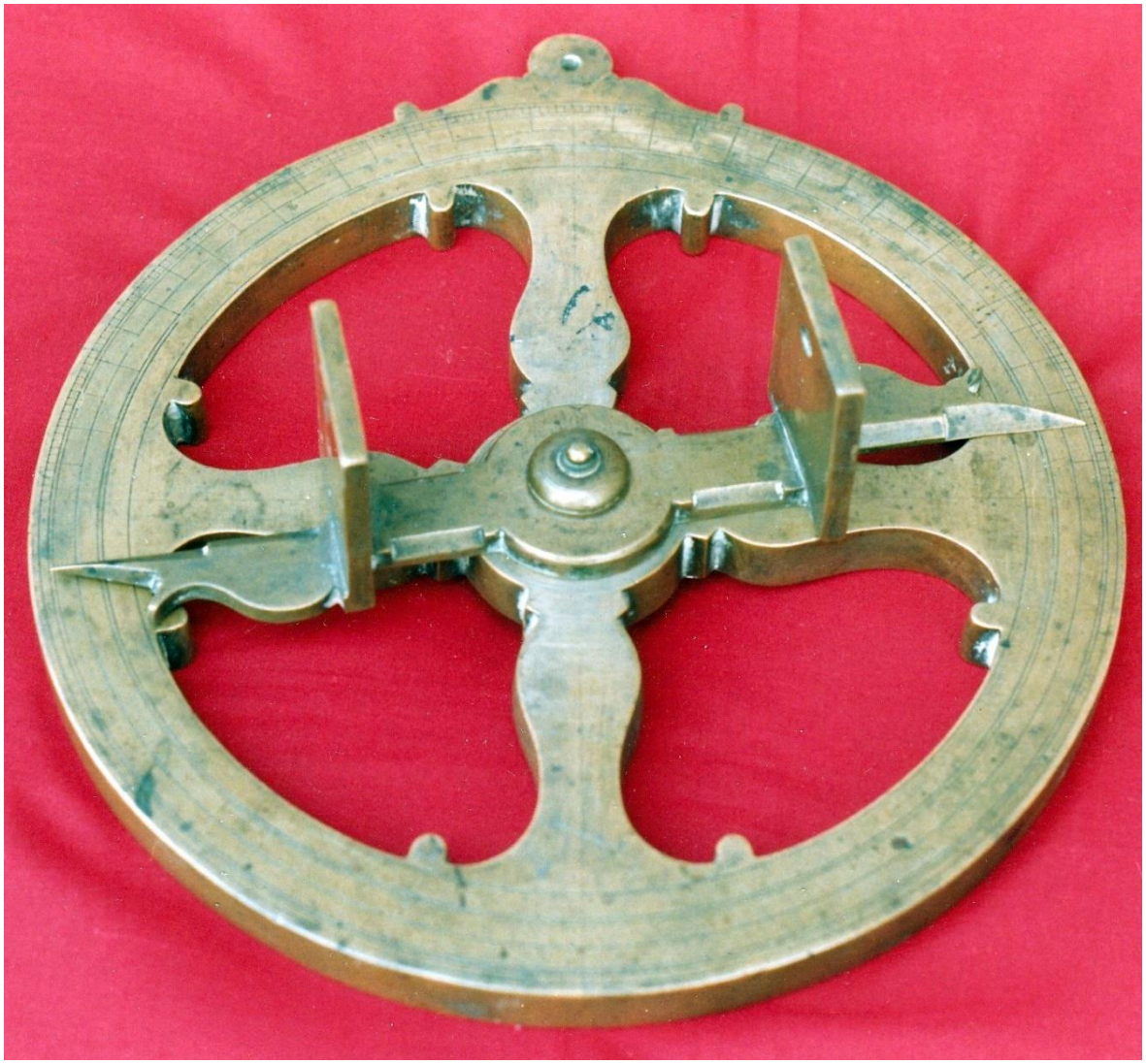


Figure Y012.1 – Front of the Mariner's Astrolabe (photo courtesy Rampur Raza Library)

The Mariner's astrolabe is a substantially modified version of the standard astrolabe for measuring the solar altitude on the high seas. The present specimen is made of brass. It is quite massive with a weight of about 1.87 kg. It carries no signature or date. Aside from the degree scale in front, there is absolutely no writing. The back is totally blank. It is in mint condition; it does not appear to have been used at the sea at all.

Mr Alan Stimson, the leading authority on Mariner's astrolabes and the author of *The Mariner's Astrolabe: A Survey of Known, Surviving Sea Astrolabes*, confirms that it

is a genuine Mariner's astrolabe. According to him, the size of the instrument and its style indicate that the astrolabe is either French or Portuguese, and that it was manufactured about the year 1575. He has assigned to this astrolabe the number NMM 80 in his inventory.[1742] No other collection in India is known to have another Mariner's astrolabe. Therefore, the present Mariner's astrolabe at the Rampur Raza Library is a unique item.

COMPONENTS

Main body, alidade with two sighting vanes, washer, pin and nut. The ring is missing. The astrolabe measures 187 mm in diameter and has a thickness of 11 mm. Though the thickness is uniformly the same, the lower half of the astrolabe appears to be considerably heavier than the upper half. This would ensure that the astrolabe hangs in a perfectly vertical plane.



Figure Y012.2 – Detail of the degree scale (photo courtesy Rampur Raza Library)

[1742] Letter dated 14 October 1997.

FRONT

The circular body is surmounted by a low suspension bracket, to which a circular disc with a hole in the middle was joined. There must have been a ring that passed through the hole of this disc, but it is now missing. On the limb circles are engraved forming three concentric bands of scales. These are graduated only in the upper half, successively in single degrees, groups of 5° and 10°, but not numbered. Through constant use, one would easily know where the 30° mark is or the 45° mark, just as one reads today the dial of a watch or that of a clock where the hours are not numbered but indicated by simple marks.

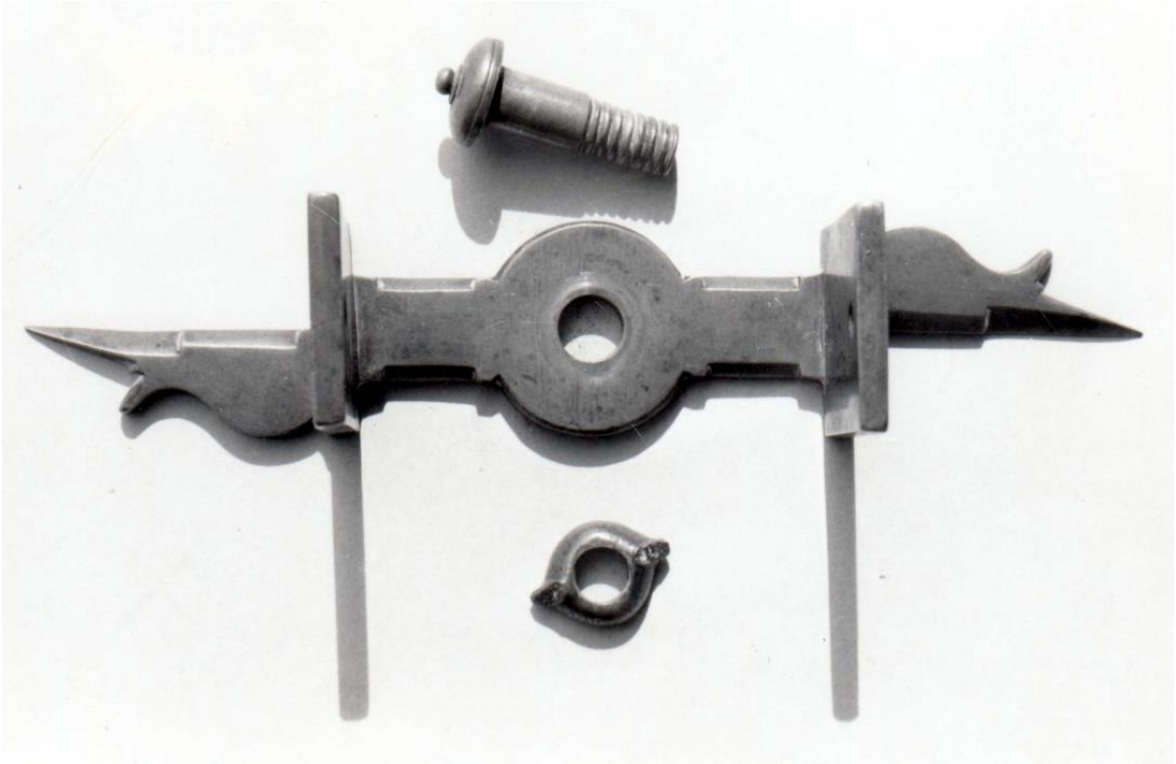


Figure Y012.3 – Alidade, washer and pin (photo courtesy Rampur Raza Library)

ALIDADE

A heavy alidade (length 176 mm) with elegantly tapered ends is attached to the front of the astrolabe. Two large sighting plates are affixed to the alidade, each measuring 42 x 33 x 4 mm. These are placed rather close to the centre at a distance of 50 mm on either side. There are two holes in each sighting vane, one large and the other very fine.

The alidade is held in position by means of a broad-headed heavy pin with screw-thread at the other end. The pin is 33 mm long. It is secured at the back with a circular nut having two grips.

BIBLIOGRAPHY

Stimson 1988.

Sarma 2003, no. 4, pp. 58-59.

Y013⊙ KUFIC CELESTIAL GLOBE BY MUḤAMMAD IBN JAʿFAR, AH 834 (AD 1430-31)[1743]

Diameter of the globe ca. 80 mm; height of the stand 117 mm

Rampur, Rampur Raza Library



Figure Y013.1 – Celestial Globe with Stand (photo courtesy Rampur Raza Library)

[1743] I am highly obliged to the late Akbar Ali Khan Arshizada for deciphering and translating the Kufic inscriptions on this globe.

Muḥammad ibn Jaᶜfar ibn ᶜUmar ibn Dawlatshāh al-Kirmānī (*fl.* 796-834 / 1393-1431) belongs to an important family of instrument makers from Kirmān in south-eastern Persia. His grandfather ᶜUmar is known by a single astrolabe which he made in AH 726. Only the mater of this astrolabe survives.[1744] Of Muḥammad's father Jaᶜfar (*fl.* 751-790 / 1349-1389), two globes and six astrolabes are extant. Two astrolabes survive of his son Maḥmūd ibn Jalāl al-Kirmānī. Of Muḥammad himself, two astrolabes and two celestial globes were known until now.[1745] The present celestial globe is the third extant globe made by him. His five instruments are listed below in chronological order.

1. Astrolabe, 796 / 1393-94, Kasbah of the Oueaia, Rabat, Morocco. CCA 2710.
2. Celestial Globe, 813 / 1410-11, diameter 67.5 mm, 35 stars, no constellation figures; only the globe survives but not the stand, Institut du Monde Arabe, Paris.[1746] ESS 61.
3. Astrolabe, 830 / 1426-27, diameter 250 mm, Kunstindustrimuseet / C. L. David Collection, Copenhagen.[1747] CCA 3595.
4. Celestial Globe, 834 / 1430-31, diameter 105 mm, ca. 60 stars, no constellation figures. British Museum, London. ESS 62, fig. 10.
5. Celestial Globe, 834 /1430-31, diameter 80 mm, 110 stars, no constellation figures. Rampur Raza Library, Rampur.

Muḥammad's father Jaᶜfar made two celestial globes, both with the full set of 48 constellation figures and about 1020 stars. The son Muḥammad, however, did not follow the father's footsteps. Instead he chose a simpler model with a small number of stars and without constellation figures in all the three globes known to us, including this one at Rampur.[1748]

The present globe is in good state of preservation. It is one of the few celestial globes with the original stand and the meridian ring fully intact. In the celestial globes,

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1744 Linton 1980, no. 163, pp. 90-91.

1745 Linton 1980, p. 90.

1746 Mouliérac 1989, pp. 80-81.

1747 *The Catalogue of C. L. David Collection, Copenhagen*, No. 361: 'Astrolabe of brass, incised and inlaid with silver, made by Muhammad ibn Jafar ibn Umar al-asturlabi, H. including suspension: 33.5 cm. Iran, AH 830 = 1427. D 25/1986.'

1748 For a comparison of the globes by the father and the son, cf. Savage-Smith 1985, p. 32.

the loose parts such as the meridian ring, the axis and even the stand tend to get misplaced or lost. A globe with an adjustable meridian ring and with a fully intact stand is rather rare. Towards the end of the eighteenth century, this globe was owned by a man called Al-Ḥāj Aḥmad Āghā who got his name engraved on the base ring of the stand in 1213 / 1798-99.

GLOBE

The globe has a diameter of about 80 mm. It was cast as two hollow hemispheres which were joined together at the ecliptic. The northern half is much darker than the southern hemisphere. The equator and ecliptic are marked with double bands and calibrated as in the horizontal ring. On the ecliptic, each sign is numbered separately as 5, 10, 5, 20, 5, 30. On the equator, however, groups of five degrees are numbered continuously from the vernal equinox onwards as 5, 10, 5, 20, … 100; … 200, … 300, 5, 10, … 5, 60. Six single lines cut the ecliptic perpendicularly, marking a separate segment for each sign. These are the ecliptic latitude circles. Some 110 stars are marked by inlaid silver nails of three magnitudes. There are no constellation figures. The zodiac signs are named along the ecliptic. Also the names of some prominent stars are engraved. The *Abjad* numerals on the horizon ring and on the meridian ring are more ornate with flourishes than on the globe.

Holes are bored at the two equatorial poles and also at the two poles of the ecliptic. The globe, however, is mounted on the meridian ring with an axis passing through the two equatorial poles.



Figure Y013.2 – Globe with the meridian ring (photo courtesy Rampur Raza Library)

STAND

The globe is mounted on a stand (height 117 mm) consisting of two horizontal rings joined by four ornate pillars. The two horizontal rings have a diameter of 110 mm, width of 15 mm and thickness of 7 mm. In the upper horizontal ring, there are notches through which the meridian ring passes, rather tightly. This enables the meridian ring to be adjusted for any desired terrestrial latitude. At 90° on the meridian ring, there is a short handle which facilitates the adjustment of the meridian ring. Perhaps it also functions as a movable gnomon.

The upper horizontal ring is graduated on the inner side in single degrees. Groups of five degrees are marked on the outer side and numbered separately for each quadrant, in *Abjad* notation as 5, 10, 5, 20 … 80, 5, 90. The four cardinal points are labelled. The meridian ring is also calibrated in the same manner. On the horizontal ring, there is an additional scale running from the east point and reaching up to 11° S, thus forming an

arc of 79°. This scale is divided into unequal units and labelled clockwise from the east point as (5), 10, (5), 20, 5, 30, 5, 40, 5, 50, (5), (60). Thus it resembles the circular cotangent scale for 12 digits on the rim on the back of the astrolabe. It can be seen in the upper right in the figure below.



Figure Y013.3 – Horizon ring of the stand (photo courtesy Rampur Raza Library)

MOVABLE GNOMON

There is one feature which distinguishes this globe. Attached to the meridian ring at 90° is a short handle-like projection. This is probably the movable gnomon (*muwirī*) mentioned by Al-Battānī in the ninth century.[1749] It has been mentioned that there is an

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[1749] Savage-Smith 1985, p. 88 ff.

additional scale engraved on the horizontal ring which looks like a cotangent scale. The shadow of the gnomon cast on the cotangent scale may facilitate the determination of the solar altitude. However, the cotangent scale starts from the east point and reaches up to 11° S only. The scale being thus on the eastern side, the shadow of the gnomon can fall on it only in the afternoon. In any case, this feature needs further investigation as it does not occur in any other extant Islamic celestial globe.



Figure Y013.4 – Maker's signature (photo courtesy Rampur Raza Library)

INSCRIPTIONS

There are three major inscriptions on the globe. The first one is engraved in three lines in the lower segment constituting the southern half of the sign Virgo and reads as follows:

ṣanaᶜah muḥammad ibn jaᶜfar
ibn ᶜumar al-asṭurlābī
al mulaqqab ba jalāl

'Made [by] Muḥammad, son of Jaᶜfar, son of ᶜUmar the astrolabist, who is known as Jalāl."



Figure Y013.5 – Inscription on the lower half of the globe
(photo courtesy Rampur Raza Library)

The second inscription is longer; it is engraved in five lines on the lower half of the globe, spanning across the signs of Pisces to Scorpio. It reads as follows:[1750]

rusimat hazahu al-kawākib b'ad ziyādah itwāleha
7;5 alī ṣāfi ṣuwar abil ḥasan ᶜabd al-rahmān
al-ṣūfī fī sanah 834 al-hijriyah wa 805
al-yajdjardiyah wa 1733
al-iskandariyah.[1751]

'These stars were placed (*rusimat*) after increasing their longitude [by] 7° 5′ according to the *Ṣuwar* [*al-Kawākib al-Thābitah*] of Abū al-Ḥusayn ibn ᶜAbd al-Rahmān al-Ṣūfī in the year 834 H, 805 Yazdijird, or 1733 of the Alexandrian Era.'

1750 This inscription is identical with an inscription on his globe at the British Museum; cf. Savage-Smith 1985, no. 62, p. 249.

1751 Muḥammad adopted this inscription from his father Jaᶜfar who engraved the same wording on his two globes. The amount of precession added to the longitudes is, of course, different. See Savage-Smith 1985, nos. 7 and 8, pp. 221-223.



Figure Y013.6 – Inscription on the stand (photo courtesy Rampur Raza Library)

The third inscription is in Naskh characters; it was caused to be engraved by an owner on the lower ring of the stand, between two legs:

ṣāhib-i sābiq bustānjī bāshī

al-ḥāj aḥmad āghā, sanah 1213.

'The first owner is Bustānjī, titled al-Hāz, Aḥmad Āghā, year 1213 [Hijrī].'

The year corresponds to AD 1798-99.'

Finally, on the bottom side of the lower ring there are two short inscriptions recording the names of two stars: *Rukbat al-Ḥawwā* (Knee of the Serpent Charmer; η Ophiuchi) and *Ra's al-Jāthī* (Head of the Kneeling Man; α Herculis). It is not clear why these names are written here.

BIBLIOGRAPHY

Sarma 2003, no. 5, pp. 60-64.

Y014⦿ SMITH'S CELESTIAL GLOBE, ENGLISH, 19TH CENTURY

Diameter 477 mm

Rampur, Rampur Raza Library



Figure Y014.1 – Globe with stand (photo courtesy Rampur Raza Library)

This English celestial globe, styled 'Smith's Celestial Globe,' was produced, probably in a large number, for the Astronomical Society of London. The date cannot be deciphered completely, but the globe appears to have been manufactured in the nineteenth century.

GLOBE

The globe is made of papier-mâché upon which is pasted a paper printed with a full complement of constellation figures. The surface of the globe has faded and the figures and legends are barely visible.

STAND

The globe is mounted on a wooden stand, consisting of a wooden horizontal ring supported by four carved legs. The legs are joined below by two cross-pieces. The junction of the cross-pieces supports the brass meridian ring which is graduated in 1/3°, 1°, 5° and numbered in 10s. Probably there was also a similar brass horizontal ring attached to the wooden horizontal ring, but it is now missing.



Figure Y014.2 – Maker's inscription (photo courtesy Rampur Raza Library)

Inscription

There is a long inscription, mentioning the year of manufacture in Roman numerals, only the first two of which (MC) are legible. The inscription reads as follows:

Smith's
Celestial Globe
Containing all the principal stars
compiled from the Works of
M[e]la[nch]thon, Flamsteed, De la Caille,
Havelius, Mayor,
Bradley, Herschel, Maskelyne,
the production of the
Astronomical Society, London,
MC ****,
Sold by J. **YLD, Charing Cross, East

Bibliography

Sarma 2003, no. 8, pp. 74-75.

Y015⊙ OTTOMAN ASTROLABIC QUADRANT, NOT SIGNED, 1136 AH (AD 1723-24)

Radius 93 mm

Mumbai, K. R. Cama Oriental Institute



Figure Y015.1 – Astrolabic quadrant on the obverse (photo by S. R. Sarma)

The astrolabic quadrant (*rubᶜ al-muqanṭarāt*) is a starkly simplified form of the astrolabe plate (*ṣafīḥah*) made for a particular latitude. Since stereographic projections on the astrolabe plate are symmetrical on either side of the meridian line, the astrolabe plate, together with the ecliptic circle, is folded along the meridian line and folded once again below the horizon.[1752] A cord attached to the centre of the quadrant with a movable bead functions as the rete. The bead indicates the position of the sun at the time of observation.

[1752] See Michel 1976, Fig. 8, and Morrison 2007, Figs, 17.1-3, which show how the plate is folded twice.

It is not known who invented this quadrant. The invention is usually attributed to the Jewish astronomer Jacob ben Mahir ben Tibben (ca. 1236 – 1304), better known by his Latin name Profatius Judaeus.[1753] But David King states that this quadrant was already described in the twelfth century in an Arabic manuscript of Egyptian origin, which was discovered in Istanbul.[1754] The author of this manuscript, however, does not claim the invention of this quadrant for himself; therefore, its invention must have taken place even earlier in the Islamic world.

This quadrant became very popular in Turkey from the seventeenth century onwards. Although there are a few brass specimens produced elsewhere, the majority of the surviving pieces are of Turkish provenance. These are made of light wood with lacquer coating. Sighting vanes are created by cutting a recess in one of the radii, leaving the two extremities which function as the sighting vanes. There are provisions to store the cord and bead in these sighting vanes.

The obverse side is prepared as the astrolabic quadrant and the reverse side as the sine quadrant. On both sides, lines and curves are drawn in red and black colours, so also the numbers and legends. Intersections of lines are marked with inlaid brass pins or with points in gold colour. These points sparkling under the coat of varnish make the quadrants very attractive.

The present specimen has a radius of 93 mm. The cord is missing. It was made for the latitude of 41° which is the latitude of Istanbul.[1755]

Astrolabic Quadrant on the Obverse Side

Since the photo is not sharp enough, the obverse side of the present specimen will be described with the help of the following two diagrams. The first is a sketch of the present specimen published by Khareghat and the second a diagram of the Profatius Quadrant drawn by Morrison.

1753 Michel 1976, pp. 117-122; Morrison 2007, pp. 235-238.

1754 King 1987b, pp. 9-10; King 2005, pp. 78-79.

1755 Unaware of its Turkish origin, Khareghat 1950, p. 76, assumes that it may have been made for Samarqand.

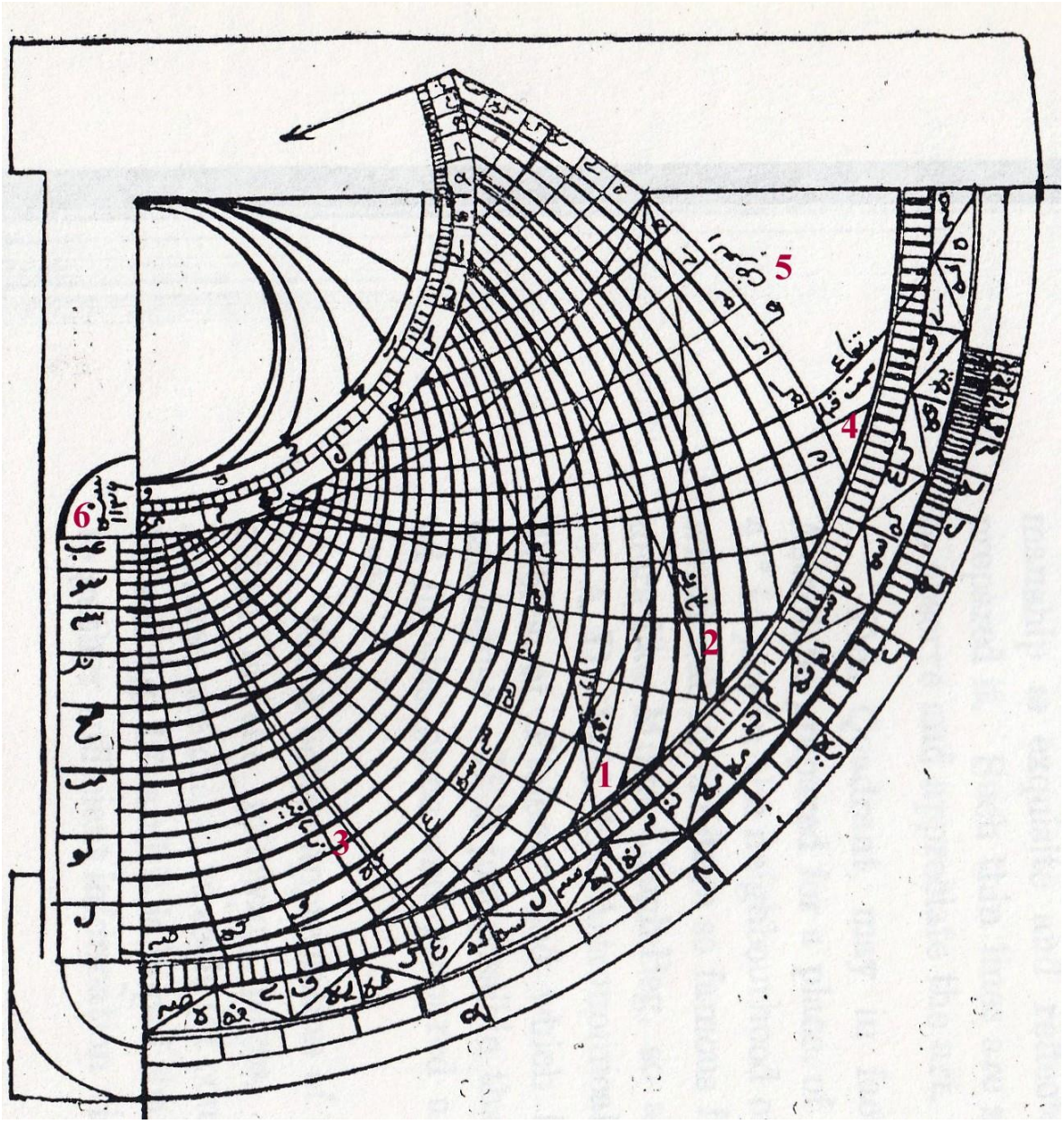


Figure Y015.2 – Astrolabic Quadrant (from Khareghat 1950, Fig. 17)

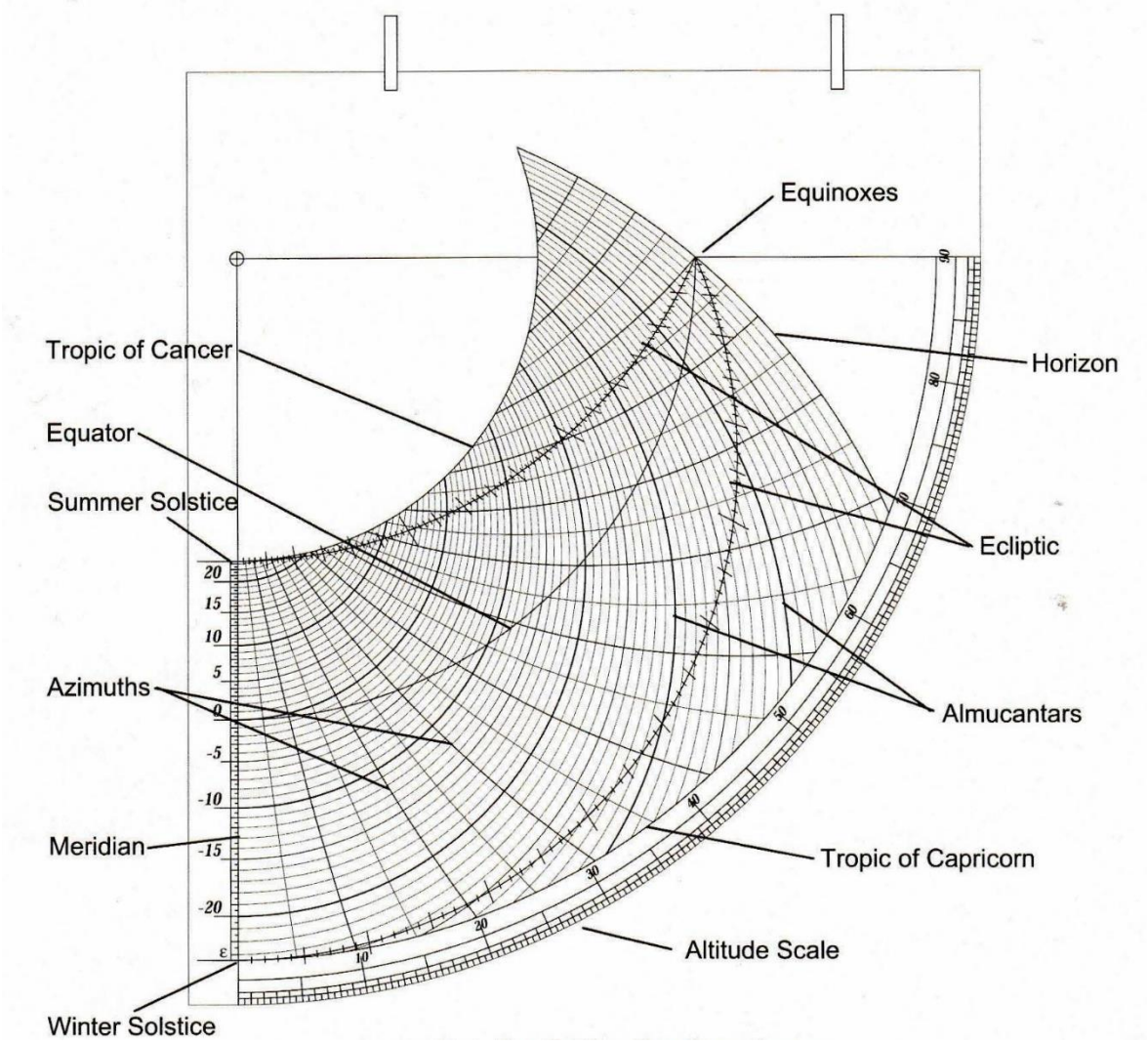


Figure Y015.3 – Astrolabic quadrant (diagram from Morrison 2007, Fig. 18-2)

The vertical radius on the left is the meridian; the line perpendicular to it is the east-west line; the last arc on the right is the horizon. The projections between the meridian and the horizon are bounded by the two tropics; the outer arc constitutes the Tropic of Capricorn and the inner arc near the apex is the Tropic of Cancer; between these is situated the celestial equator. A smaller quadrant is created within the larger quadrant at the apex by the Tropic of Cancer with a radius of about 26 mm. This smaller quadrant contains a universal horary quadrant with six arcs to represent the seasonal hours, which are numbered from 1 to 6. These are drawn in read colour which has faded; therefore not clearly visible in the photo. On the arc of this smaller quadrant is a degree scale, divided in 1° and numbered in 5s.

Beyond the Tropic of Capricorn, there are four more concentric bands. The innermost one is divided in single degrees. In the next band, groups of 5° are numbered from 5 to 90 in both directions; the *Abjad* numbers in one direction are written in black

and in the other direction in red. The next two bands are filled with the scale of cotangents in digits (*ẓill aṣābiᶜ*) and their subdivisions.

The point where the line of horizon intersects the east-west line represents the vernal as well as the autumnal equinox. Three arcs radiate from the point. The middle arc is the celestial equator; the two outer arcs (shown with slashed lines in Morrison's diagram) are the segments of the ecliptic circle. Here each segment contains two quarters of the ecliptic circle, superimposed one upon the other. Thus the inner segment from the vernal equinox to the summer solstice on the Tropic of Cancer, represents the three signs Aries, Taurus and Gemini; the same segment in the reverse direction represents the three signs Cancer, Leo and Virgo. Likewise, the outer segment, from the [autumnal] equinox to the winter solstice situated on the Tropic of Capricorn represents the three signs Libra, Scorpio and Sagittarius; the same segment in the reverse direction represents the three signs Capricorn, Aquarius and Pisces.

Upon this frame are drawn almucantars or equal altitude circles. They appear to have been drawn for each 2°. Azimuth arcs are drawn for each 5° and numbered; every third of these representing 15° is in black and the others in red.

The altitude circles and azimuth arcs which are extended beyond the east-west line are equipped with a scale to measure the excess of the half day light over 90°.

Prayer lines

Three arcs are drawn between the tropics. In Figure Y015.2, these are numbered as 1, 2 and 3 in red. Arcs 1 and 2 represent the beginning and end of the afternoon prayer *ᶜaṣr*; these carry the labels *ᶜaṣr awwal* and [*ᶜaṣr*] *thānī* respectively. The label of arc 3 is difficult to decipher; probably it indicates a twilight prayer, either *fajr* at the daybreak or *shafaq* at nightfall.

There is also an arc to indicate the direction of the *qibla.* It is drawn between the azimuth arcs for 25° and 30°, i.e., roughly at 27°, and labelled as *irtifāᶜ samt qiblah* (elevation of the azimuth of qibla). The horizon is labelled (5) as *al-ᶜarḍ hā* (zero altitude). The year of manufacture (6) is written above the meridian as *sanah 1136,* which corresponds to AD 1723-24.

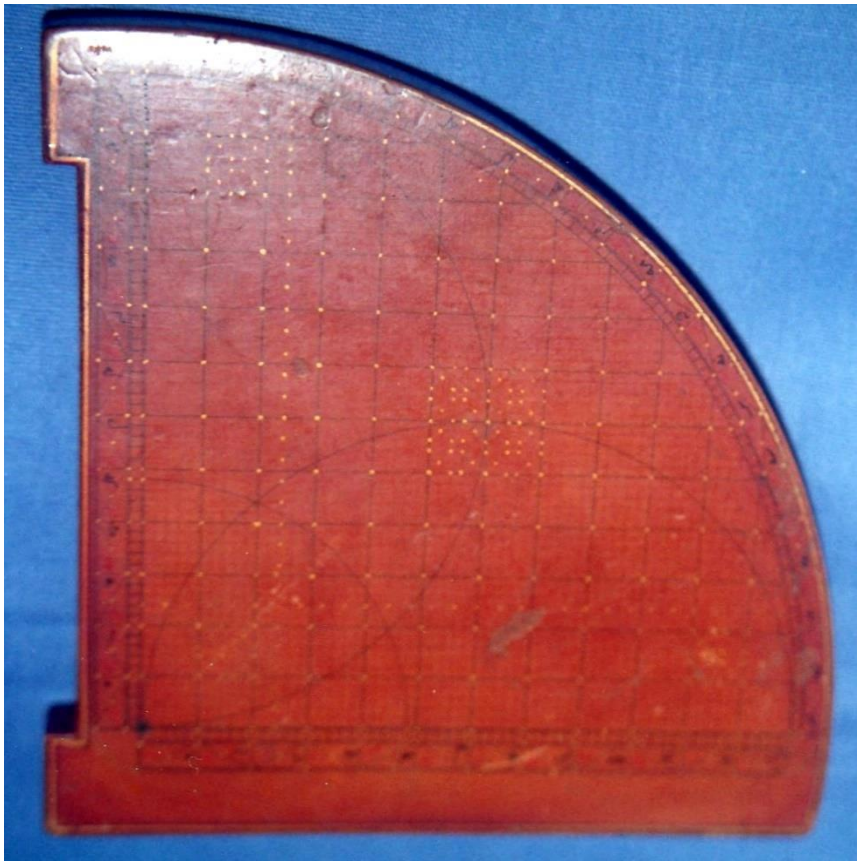


Figure Y015.4 – Sine Quadrant on the reverse (photo by S. R. Sarma)

SINE QUADRANT ON THE REVERSE SIDE

The reverse side shows a common sine-cosine quadrant with 60 horizonal and 60 vertical lines, both sets of lines being are drawn at equal distances. The lines are drawn in red colour, but every fifth is in black. Along the two radii, the lines are numbered in 5s in both directions; the numbers in one direction are coloured black and the other direction red.

The arc is divided into 1° and 5°; groups of 5° are numbered from 5 to 90 in both directions; the numbers in one direction are coloured black and the other direction red.

Semicircles are drawn along the two radii to facilitate the determination of sines and cosines. With the apex of the quadrant as the centre, a quarter circle is drawn with a radius of 24 of the 60 parts of the radii of the main quadrant; this is the circle of obliquity.

The points of intersection of the horizontal and vertical black lines are marked in golden ink or with inlaid brass pins; these points sparkle against the red background. Similar gold points are marked along the vertical and horizontal lines of 12 units as

counted from the apex. Moreover, the 6th and 7th cells in the 6th and the 7th rows as also the 2nd cell in the 11th row are filled with gold points.

BIBLIOGRAPHY

Khareghat 1950, pp.75-82, Figs. 16-17.
Michel 1976, ch. XVI, pp. 117-120 (Profatius' Astrolabe Quadrant).
Morrison 2007, chs. 17 (Astrolabe Quadrant) and 18 (Profatius Quadrant), pp. 221-238
.

Y016 OTTOMAN ASTROLABIC QUADRANT, NOT SIGNED, NOT DATED

Radius ?

Hyderabad, Saidiya Library

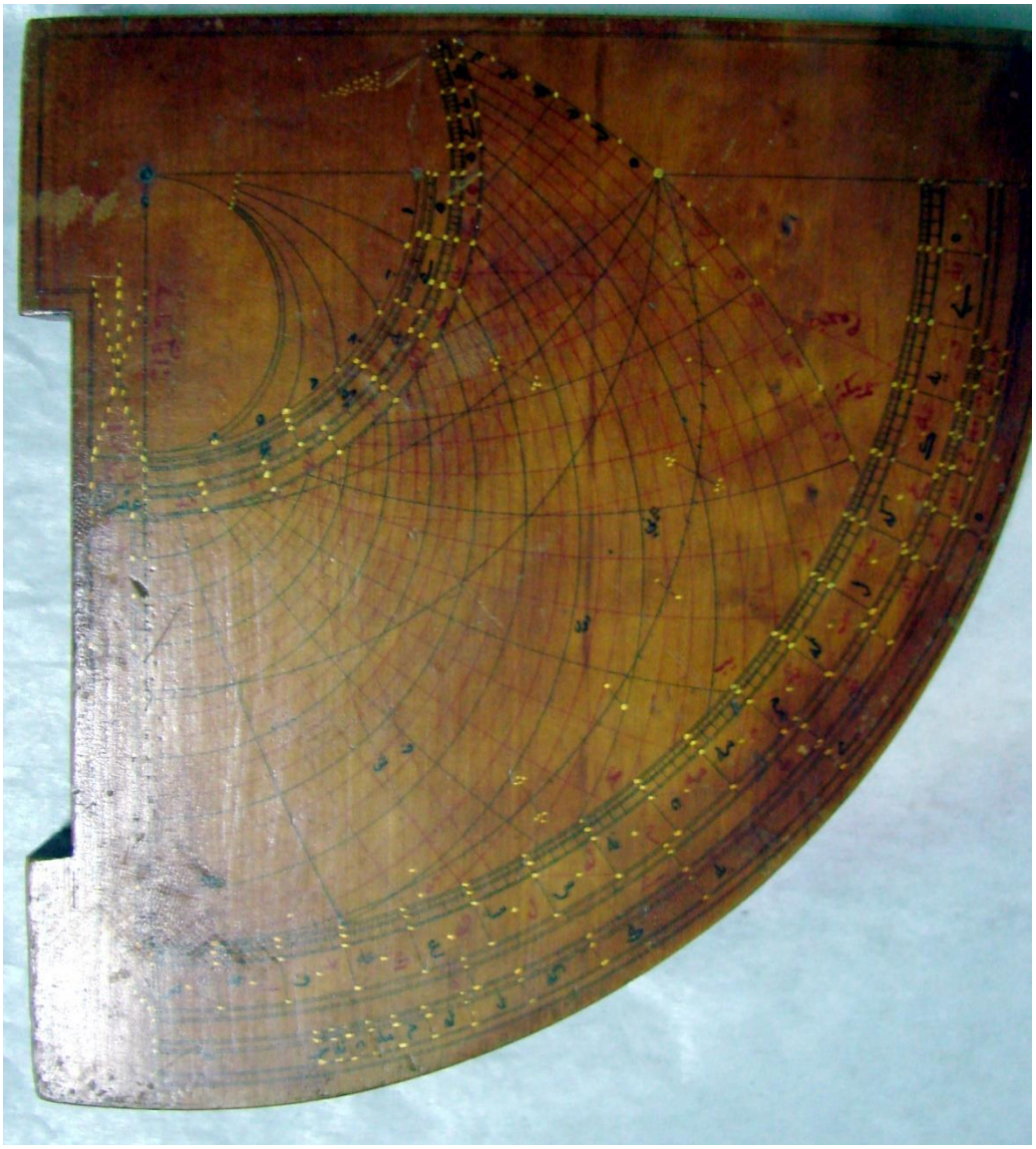


Figure Y016.1 – Astrolabic quadrant on the obverse (photo by Ahmed Athaullah)

This astrolabic quadrant also appears to have made for the latitude of Istanbul at 41°. The design is substantially the same as in the previous specimen, with three prayer lines and an arc to indicate the direction of the *qibla.*

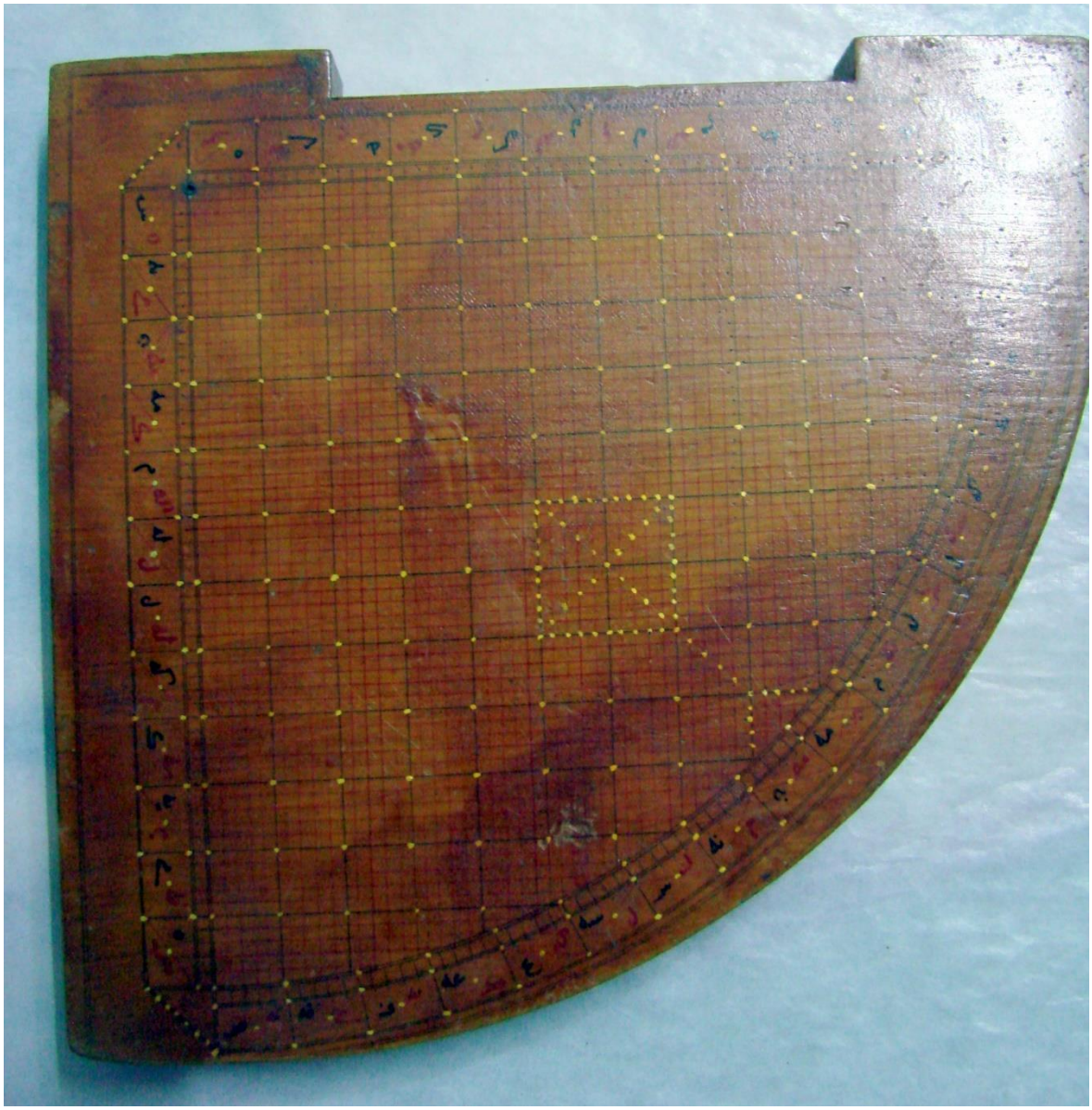


Figure Y016.2 – Sine quadrant on the reverse (photo by Ahmed Athaullah)

As in the previous specimen, here also the quadrant is filled with 60 horizontal and 60 vertical lines exactly in the same manner. However, there are no semicircles on the two radii and no quarter circle of obliquity. But the 6th and 7th cells in the 6th and the 7th rows are filled with gold points as in Y015.

Y017⊙ GUNTHER'S QUADRANT, AD 1768 (?)

Radius 112 mm

Varanasi (= Benares), Sampurnanand Sanskrit University, Sarasvati Bhavan Library



Figure Y017.1 – Gunter's Quadrant (photo by S. R. Sarma)

This type of quadrant was designed by Edmund Gunter (1581-1626), who taught mathematics and astronomy at Gresham College, London. He published the description of the quadrant in his *The Description and Use of the Sector, Cross-Staff and other Instruments.* Jim Morrison describes, with detailed diagrams, its construction and use; he also discusses a number of problems which can be solved with this quadrant.[1756]

[1756] Morrison 2007, ch. 19, pp. 239-250.

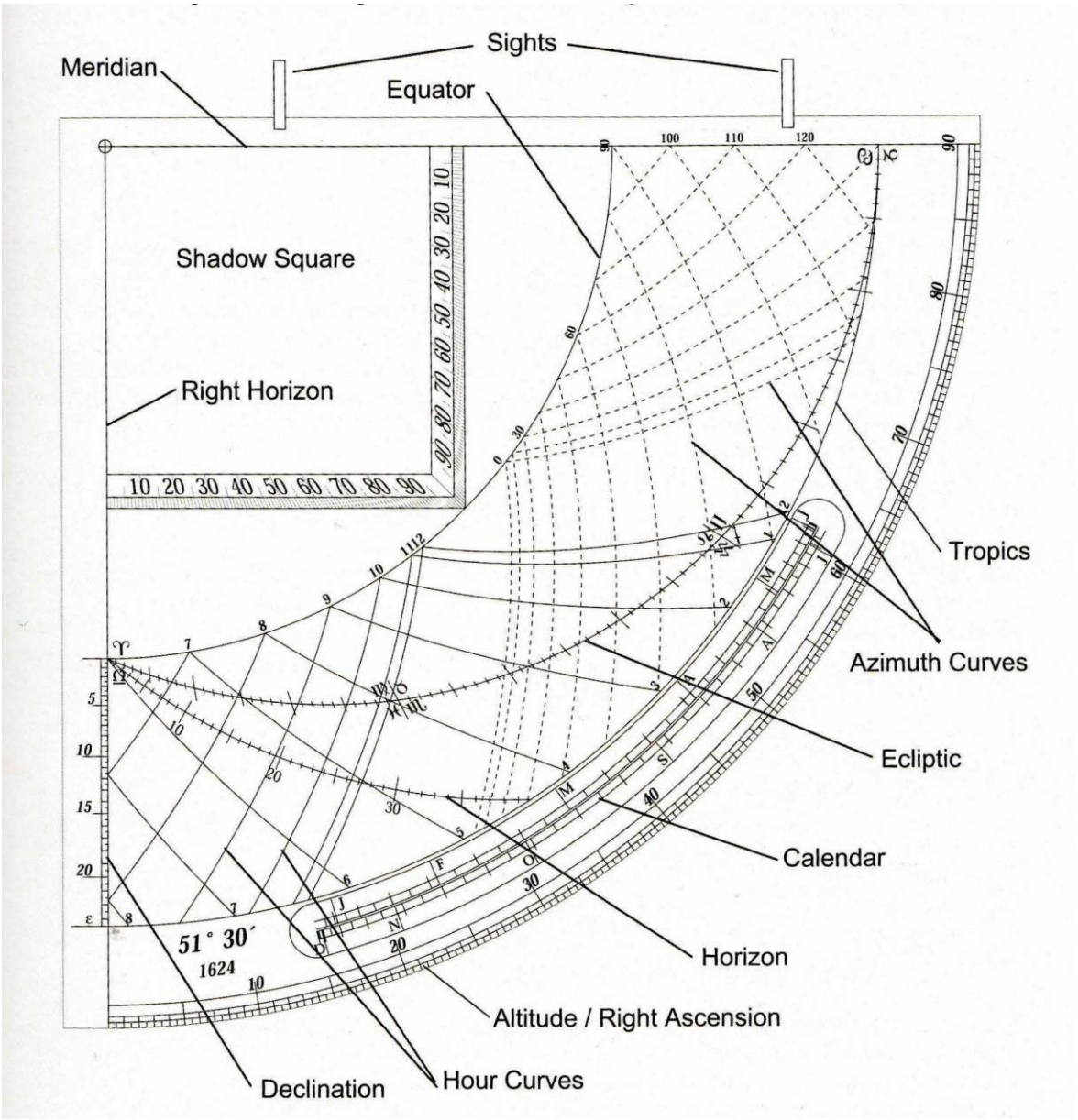


Figure Y017.2 – Gunter's Quadrant (diagram from Morrison 2007, Fig. 19-2.

This quadrant is not constructed by folding the astrolabe as in the astrolabic quadrant, but in a different manner. The disposition of the circles on this quadrant can best be understood from the diagram given above (Figure Y017.2).

Here the horizontal radius forms the meridian and the vertical radius the right horizon. The inner arc represents the equator. The ecliptic and the horizon are shown as slashed arcs. They meet the equator at the vernal equinox. The outer arc represents the tropics. Beyond the outer arc is a calendar scale, divided in months and days, and the degree scale. The vertical radius carries a declination scale. Between the two arcs which represent the equator and the tropics are the stereographic projections of azimuth curves (dotted) and hour lines. Between the inner arc and the apex is a shadow square.

The present specimen at Varanasi has a radius of 112 mm. Its construction follows, more or less, Morrison's diagram reproduced above; but it does not contain the shadow square at the apex. The reverse side is blank. Here the year 1768 is scratched with a sharp object; it can be the year of its manufacture.

The Sampurnanand Sanskrit University was originally a college founded by the British Colonial administration, and several Englishmen were associated with this college. The Gunter's quadrant must have been brought by one of these Englishmen.

At a later point, a Brahmin assistant of the library wrote in ink on the back of the quadrant *om | śrī-saṃkaṭā-devyai namaḥ* (salutation to the glorious Saṃkatā-devī).

BIBLIOGRAPHY

Morrison 2007, ch. 19, pp. 239-250.

Y018⊙ GEOCENTRIC MODEL OF THE SOLAR SYSTEM BY FRANÇOIS LE MARIÉE, PARIS

Not dated, early eighteenth century

Diameter of the base plate 328 mm

Jaipur, Jai Singh's Observatory



Figure Y018.1 – Model of the Solar System (photo by S. R. Sarma)

This is a simple device to demonstrate the geocentric or Ptolemaic solar system with the orbits of the planets and their epicycles. It carries the name of a French instrument-maker François le Mariée, Paris. It may have been brought to Sawai Jai Singh by one of the Jesuit astronomers who visited his court.

The model consists of a circular base plate with a low suspension bracket to which is added a small shackle and a large ring, as is done in an astrolabe. The periphery of the base plate is graduated in ½ degrees and marked with the names of the twelve zodiac signs and the twelve month names in French. Upon this base plate are arranged six discs of gradually diminishing diameters to represent the orbits of the six planets; they are arranged in such a manner that each disc rotates around a different axis. To each disc is attached a smaller disc which represent the epicycle of the respective planet.



Figure Y018.2 – Five upper discs (photo by S. R. Sarma)

On all the six discs, the names of the planets are engraved. Starting from below, these names are ‘Saturn En Son Epicycle’ (Saturn in its epicycle), ‘Jupiter En Son Epicycle’, ‘Mars En Son Epicycle’, ‘Le Soleil En Son Epicycle’, ‘Venus En Son Epicycle’, and ‘Mercur En Son Epicycle’.

When I saw the device in 1991, the pin joining the base plate and the disc of Saturn with the rest was broken and two parts are kept separately. The Figure Y018.2 shows the five discs of Jupiter to Mercury.

BIBLIOGRAPHY

Sharma 2016, p. 189.

Y019 PORTABLE ORRERY MADE BY W. JONES AND SOLD BY HIM AT HOLBORN, LONDON, W & S. JONES

Not dated, early nineteenth century

Dimensions ?

Hyderabad, Saidiya Library



Figure Y019.1 – Orrery (photo by Ahmed Athaullah)

The orrery is a mechanical model for demonstrating the motion of the planets around the sun, and the movements of the satellites around the planets. It is moved by hand or driven by clockwork. It was very popular in England in the eighteenth and the early nineteenth centuries. The name ‘Orrery’ is derived from one of the early specimens made for Charles Boyle, the fourth Earl of Orrery by John Rowley around 1712.

The present specimen is made by William Jones, who also published a book describing its construction and use. Except the photo, no other information is available

about it. Therefore, we quote the description of the base plate from William Jones' work (p. 20) to give the period flavour:

> 'The board on which the Machines turn, has pasted on it a new printed paper, coloured and varnished ; near the outward edge of which are several circles: The first or outward circle is divided into twelve months of the year, and the next into their respective days ; the two inmost circles have the twelve signs of the Zodiac, with their proper characters and names, each sign containing 30 degrees, or the whole of 360° […].
>
> 'It has also four divisions made by lines drawn from the first degree of Cancer, the first degree of Capricorn, the first degree of Aries, and the first degree of Libra ; between these four lines are written the four Seasons of the Year, the lines denoting their Beginning, Duration, and End, and along these four lines are written the length of the day and night, and the distinction of the Equinoxes.
>
> 'The inner circle contains a view of the diameters of the Planets, in proportion to each other, and to that of a Globe the diameter of the board for the Sun: among them is the new discovered Planet, the Georgium Sidus,[1757] of the comparative size now estimated […] and a small representation of the appearance of a Comet.'

BIBLIOGRAPHY

William Jones, *The Description and Use of a New Portable Orrery…,* 2nd edition, London 1784;
https://ia802608.us.archive.org/35/items/descriptionandu00jonegoog/descriptionandu00jonegoog.pdf
[also https://goo.gl/9SfLiM, last accessed in November 2017]

Holbrook, Anderson & Bryden 1992, pp. 63-64, Fig. 104.

[1757] William Herschel, who discovered the planet, named it 'Georgium Sidus' (Georgian planet) after his patron George III, but later the name was changed to Uranus.

Z. FAKE ASTRONOMICAL INSTRUMENTS

INTRODUCTION

Since scientific instruments fetch fabulous prices in the international antique market, there is now a growing industry that fabricates fake astrolabes, celestial globes and other instruments for the tourist market. This section is concerned with fakes instruments with Arabic/Persian engravings. There does not seem to be any demand for Sanskrit items; I am aware of just one fake Sanskrit astrolabe (Z004).

FAKE ASTROLABES

The majority of fake astrolabes with Arabic/Persian engravings found in museums were manufactured in Iran, in particular in Isfahan, and imitate the style of astrolabes produced by ᶜAbd al-A'imma and his contemporaries. The Adler Planetarium in Chicago has as many as twelve such fake astrolabes. [1758]

In India, one of the centres where fake astrolabes and celestial globes are being produced is Moradabad (28;50° N and 78;49° E) in the state of Uttar Pradesh, which is famous for its brass industry. At one time, Bombay was supposed to be such a centre; I have heard that fake instruments are being produced in Jaipur as well. The fake astrolabes that are coming now from Moradabad can be identified by the following features.

Alidade

Generally these fake astrolabes are made without alidades at the back for quite practical reasons. If an astrolabe is equipped on the back with an alidade in which two sighting plates jut out, it is difficult to place the astrolabe on its back and it is even more difficult to stack several astrolabes one upon the other for transport. Therefore, alidades are avoided. But without an alidade, the astrolabe cannot be used for any observation, i.e., for measuring the altitude of the heavenly bodies.

[1758] Described and illustrated in Pingree 2009, nos. 36-47, pp. 172-195.

Degree scales

Quite often the fake astrolabes do not have degree scales on the rim in the front and on the back. Instead, they are occasionally filled with the anthropomorphic figures of the zodiac signs (Z001 and Z003). Sometimes the rims are engraved with scales divided in an arbitrary manner, not in conformity with the sexagesimal division of circle into 360°.

Abjad Notation

Wherever there are scales, attempts are made to number them in *Abjad* notation without any understanding of this notation; some pseudo Arabic alphabets are added arbitrarily. Even the common Arabic/Persian numerals are not always used correctly.

Rete

The rete is made with perforations as in a genuine astrolabe. In a genuine astrolabe the outer ring of Capricorn is not graduated, but it is often graduated in fake astrolabes, but not in correct sexagesimal division of the circle. In a genuine astrolabe, the ecliptic ring is divided into 12 zodiac signs, labelled with their names, and each sign is subdivided into 30 degrees. Sometimes fakes carry the names of the zodiac signs, written correctly, but their subdivisions are often very irregular. The tracery of the perforated part should contain star pointers with their names engraved upon them. In fake astrolabes, the star pointers are never placed correctly and the names engraved on them often make no sense.

Plates

The plates are invariably engraved only on one side. There is no mechanism to lock them in position so that they do not rotate around the pin. The altitude circles, azimuth arcs and lines of seasonal and equal hours are copied reasonably correctly, but these are not numbered properly. Often the names of Islamic lunar months, names of zodiac signs and other irrelevant material are engraved indiscriminately. In the three fake astrolabes Z001, Z002 and Z003, the main body and rete differ in each case, but the plates are exactly similar and must have been derived from a common source where originally all there insertions must have been made.

Back

The back is generally divided into four quadrants. But, the rim of the two upper quadrants either do not carry degree scales, or if they do, the scales are not correctly divided and numbered. In the trigonometric quadrant on the upper left, the radius is divided into 60 divisions, or into sub-multiples of 60, and from the marks of these divisions perpendiculars are drawn up to the arc. But fake astrolabes are engraved with any arbitrary number of horizontal and vertical parallel lines. Likewise, the zodiac quadrant on the upper right is engraved with an arbitrary number of quarter circles and labelled with meaningless scribbles.

In the lower half, the four scales in the shadow squares are divided arbitrarily and not into 7 feet and 12 digits. In the semi-circular scales which enclose the shadow squares, one of the scales is filled correctly with the names of the zodiac signs, but the other scales are engraved with meaningless writing.

Quality of engraving

The legends and numbers are engraved with irregular strokes of the chisel and not in fluid lines as in the medieval astrolabes and celestial globes.

A striking feature of these fake astrolabes is that all empty spaces are filled with decorative motifs of flowers and leaves.

Sometimes fake astrolabes carry the names of well-known instrument makers like ᶜAbd al-A'imma [1759] or even the names of great astronomers like Naṣīr al-Dīn al-Ṭūsī (Z001) , or just fictitious names. Sometimes they carry fictitious dates as well; the year 1142 Hijrī (AD 1729-30) occurs often in the fake astrolabes seen by me.

FAKE CELESTIAL GLOBES

No fake celestial globes produced in Iran or elsewhere have come to light; they all appear to be fabricated exclusively in India. Many of these are cast as single hollow spheres by the 'lost wax' process, a technique in which India specialized in the seventeenth century.

[1759] Cf. Gingerich, King & Saliba 1972.

In 1992, we saw at Bangalore two celestial globes which appeared to have been cast as single hollow spheres. One of these, with a diameter of 150 mm, carried the inscription stating that it was the work of Muḥammad Ṣāliḥ Tatawī with the date 1073 Hijrī (AD 1662-63). On this globe, the celestial equator and the ecliptic are represented by double bands of lines. The narrower band is graduated in single degrees, while on the broader band groups of 6° are marked and numbered correctly in *Abjad* notation. The tropics, polar circles and those around the ecliptic poles are marked by single lines. Likewise, the six ecliptic latitude circles and the solstitial and equinoctial colures are also represented by single lines. The 48 classical constellation figures are engraved and the positions of about 1020 fixed stars are indicated by dots enclosed within small irregular circles. There is a dark finish on the surface of the globe. Against this background, the engraved star points, constellation figures and circles stand out clearly.

The globe is mounted on a stand consisting of a horizontal ring supported by four baluster-like legs which are joined below by two cross-bars. Like the equator and the ecliptic on the globe, the horizon ring also has two bands of lines. The narrower band is graduated in single degrees and the wider band in groups of 6° which are, however, not numbered. The axis of the globe is permanently fixed to the horizontal ring, and there is no provision for a meridian ring.

The second celestial globe is much larger with a diameter of 210 mm and is not engraved with the maker's name and date. Otherwise it was identical with the first globe in all respects.

Therefore we assumed that we discovered an unrecorded celestial globe signed by Muḥammad Ṣāliḥ and another that could easily be attributed to him.[1760] But Emilie Savage-Smith argued convincingly that the iconography of the constellation figures on these globes starkly deviates from the standard iconography of Indo-Persian celestial globes and that these globes are modern fabrications.[1761] Indeed, several globes of this type came into the international market about that time. None of them carried the signature of Muḥammad Ṣāliḥ, but they displayed the same degenerate iconography,

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1760 Sarma, Ansari & Kulkarni 1993.

1761 Maddison & Savage-Smith 1997, part 2, pp. 406-408 (Appendix 1: Modern Indian Globes); see also the Introduction to the section G above.

and were mounted on the same type of stands, with the axis permanently affixed to the horizontal ring.[1762]

But the globes that are being produced in more recent times (e.g., Z005) not only deviate from the standard iconography of constellation figures, but they are also engraved with far more figures than the conventional 48, all placed at random according to maker's whim. The *Abjad* symbols that are used on these globes have hardly any relation to the standard notation.

COLLAGES

A new phenomenon of recent times are collages or rather monumental medleys of different astronomical instruments, such as globes imbedded inside astrolabes or astrolabe-like objects imbedded upon what look like celestial globes. [1763] Dr Owen Cornwall saw some specimens in New Delhi and sent me the following photos.

[1762] See, e.g., Christie's, London, auction catalogue of 25 June 1997, lot 19, p. 12 (d. 253 mm); auction catalogue of 24 June 1998, lot 80, p. 48 (d. 191 mm); lot 81, p. 49 (d. 114 mm); on the same p. 49 are to be found two other fake globes mounted on different types of stands: lot 82 (d. 124 mm); lot 83 (d. 203).

[1763] Savage-Smith 2017, pp. 7-8.



Figure Z1 – Collage of astrolabes and globes (photo by Dr Owen Cornwall)

Here the main body has the outline of an astrolabe, in which a globe is incorporated at the top and five openwork discs resembling astrolabe retes are affixed symmetrically on the body. The empty spaces are filled with diagrams of the terrestrial globe, the names and figures of the zodiac signs, the names of the Islamic lunar months and geometrical and floral patterns.



Figure Z2 – Detail of the Figure Z1 (photo by Dr Owen Cornwall)

Two extravagant specimens of this genre are Z006 and Z008 where uncommon talent in metalwork is wasted in creating pseudo-astronomical-astrological artefacts. But, of course, these are not the solitary examples. A piece almost identical with Z006 came up for auction in 1998 (Z007) and one similar to Z008 is said to be with the Osaka Science Museum in Japan. There may be many more this kind.

Z001 ⊙ MY *ASṬUL LOB*

Late 20th century

Diameter 228 mm, height 307 mm, thickness 10 mm

Düsseldorf, PC



Figure Z001.1 – Front of the astrolabe (photo by S. R. Sarma)

This item was on sale in the Tibetan Market on Janpath in New Delhi in 2001. I tried to bring down the price by mentioning all the faults in it, but the shop-keeper asked me to consider the weight of the piece and all the nice decorations on it. More than these, it was the amusing name *Asṭul Lob* engraved inside cartouches on both sides of the *kursī* which induced me to buy it for 2000 rupees. Since then, it has served me well as a didactic piece; whenever people show me what they think are genuine astrolabes, I tell them that they are fakes just like my own fake astrolabe.



Figure Z001.2 – Floral decoration on the edge (photo by S. R. Sarma)

The limb on the front and the rim at the back do not carry degree scales and no provision is made for the alidade at the back. The rete is perforated to look like a genuine rete, but does not contain any star pointers; the circular scales on it are inaccurate and the engraved names meaningless. Therefore, this piece cannot be used for measuring the angles of altitude of the sun in the daytime or of the stars at night which is the first task an astrolabe is expected to perform.

The artisan who made it tried to imitate copies of astrolabe parts without understanding their function or the sexagesimal notation employed in astrolabes. He is familiar with the Arabic names of the 12 zodiac signs and their figurative representations which he tried to incorporate in this specimen. He also added here and there the names of the cardinal directions and the names of the Islamic and English months.

The year *1142 h[ijrī]* (AD 1729-30) is engraved on the plate for 27°, on the plate for 0° + 90° and twice on the plate for multiple horizons. But below the shadow squares on the back is *sanah 1130 h[ijrī]* which translates to AD 1717-18. Both are fictitious dates; this fake astrolabe was produced sometime in 1990s.

Moreover, the plate of multiple horizons carries an absurd statement that this blessed astrolabe is the work of Naṣīr al-Ṭūsī in the year 1142 Hijrī, although the great Naṣīr al-Dīn al-Ṭūsī lived some five hundred years before this date.

Components

Main body (d. 228) with a high *kursī*, shackle and ring, rete (d. 194), 5 plates (all of different diameters 191, 189, 189, 190, 190), pin and wedge. No alidade. The wedge is securely attached to the ring by a chain.

Front

The limb, *kursī* and the back are made of one piece. The ring is quite large with a diameter of about 54 mm; the shackle is decorated with a floral design in low relief. The *kursī* is also adorned on both sides with a floral design; there is a floral decoration all along the edge. On the *kursī* is an outline image of the terrestrial globe and a cartouche which carries the name *asṭul lob,* a miswriting for *asṭurlāb.* These are repeated on the back of the *kursī* as well.

The limb on the front and the rim on the back do not carry degree scales, but are filled with twelve roundels containing the figures of the signs of the zodiac and twelve cartouches containing their names. The names and their sequence are correct on both the sides, but the images are crude approximations and sometime they do not match with the names. Thus the twins of Gemini are labelled as *Thawr* (Taurus) and the figure of the balance (Libra) carries the names *Sunbulah* (Virgo)! On both sides the empty spaces next to the roundels and cartouches are filled with floriate patterns.



Figure Z001.3 – Rete (photo by S. R. Sarma)

RETE

In the rete the two rings, the outer ring of Capricorn and the inner ring of the ecliptic, are both graduated. The outer ring is divided into 24 parts and each part is subdivided in 6 units. The inner ring is divided into 38 units which are numbered in an arbitrary manner. The east-west bar is also divided and numbered in an erratic style.

The tracery joining various star-pointers is crudely copied from some genuine astrolabe and filled with leaf patterns. There are four labels which make no sense; one of these reads *asṭul lob.*

PLATES[1764]

There are five plates, each of a different diameter. They are not equipped with lugs to ensure that they remain firmly in position. They are engraved only on one side, the other side is not even properly cleaned. Two plates are designed for use at latitudes 24° and 27°. One plate carries the double projections for 0° and 90°. The last two are for the ecliptic coordinates and multiple horizons. The circles and lines are drawn reasonably correctly; but on all plates, outside the peripheral circle of Capricorn, two other concentric circles are drawn with some pseudo-*Abjad* letters engraved between them. Moreover, the plates are not properly identified with appropriate labels. Instead they are filled unnecessarily with the names of the Islamic and English months. Since the cardinal directions *al-mashriq* (east) and *al-maghrib* (west) are normally written above the horizon, an attempt is made to do justice also to the other two directions *al-junūb* (south) and *al-shamāl* (north) by adding them inappropriately on some plates.

Interestingly, the next two specimens (Z002 and Z003) also are equipped with the same plates filled in the same manner with irrelevant material; I have also seen similar plates in some other spurious astrolabes. All these must be based on a common source, which again must have been a fake.

[1764] Mubashir Ul-Haq Abbasi has very kindly deciphered and translated some of the unusual engravings on the plates, for which I am highly grateful to him.

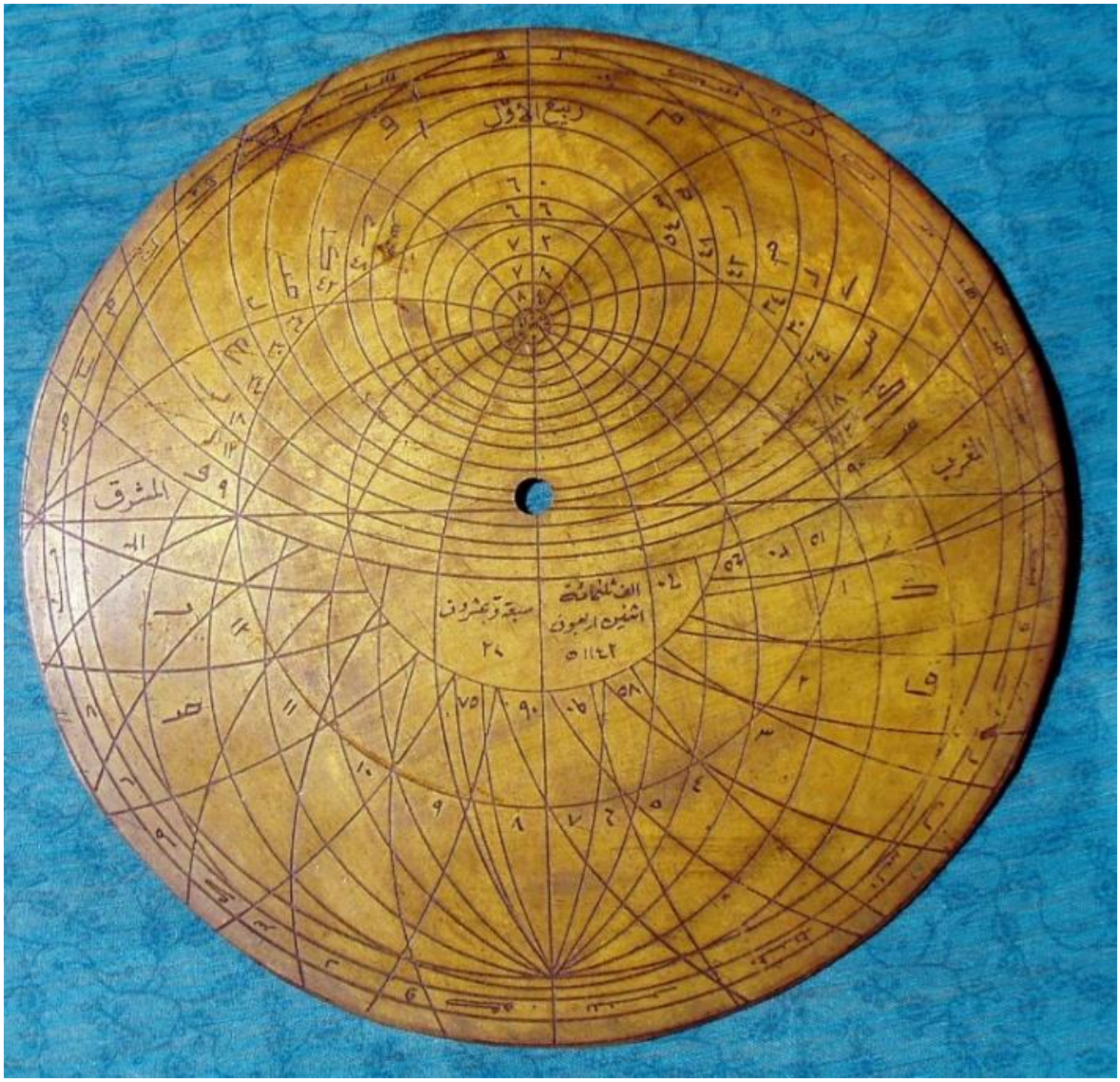


Figure Z001.4 – Plate for Lat. 24° (photo by S. R. Sarma)

This plate is engraved with the three concentric circles of Capricorn, equator and Cancer, and the arc of the oblique horizon with the labels *al-maghrib* on the west and *al-mashriq* on the east. In the centre, inside the circle of Cancer is written on the left *sabᶜah wa ᶜishrūn* (twenty-seven) and below it 27 in common Arabic/Persian numerals; on the right *'alf māi'ah ithnān 'arbaᶜūn* (one thousand one hundred forty-two) and below it *h[ijrī] 1142*. This implies that the plate is calibrated for the latitude of 27° and that it was produced in the year 1142 AH (AD 1729-30).

However, the configuration of the circles do not support the numerical value given to the latitude. Above the oblique horizon are drawn 14 altitude circles at uniform distances, roughly one for each 6°, with the circle for 24° passing through the centre. This shows that the plate is actually drawn for the latitude of 24°.

The altitude circles are numbered on both sides of the meridian line, once in common numerals and once in *Abjad*, both times very erratically. Azimuth circles are drawn for every 30° above the horizon and for every 10° below the horizon; the numbers are sporadic but not all are wrong. In the lower half are lines for seasonal hours and lines for equal hours drawn from the western horizon. The latter are numbered from the western horizon from 1 to 13 in common numerals, quite correctly. The month name *Rabīᶜ al-Awwal* is written at the top across the meridian line.

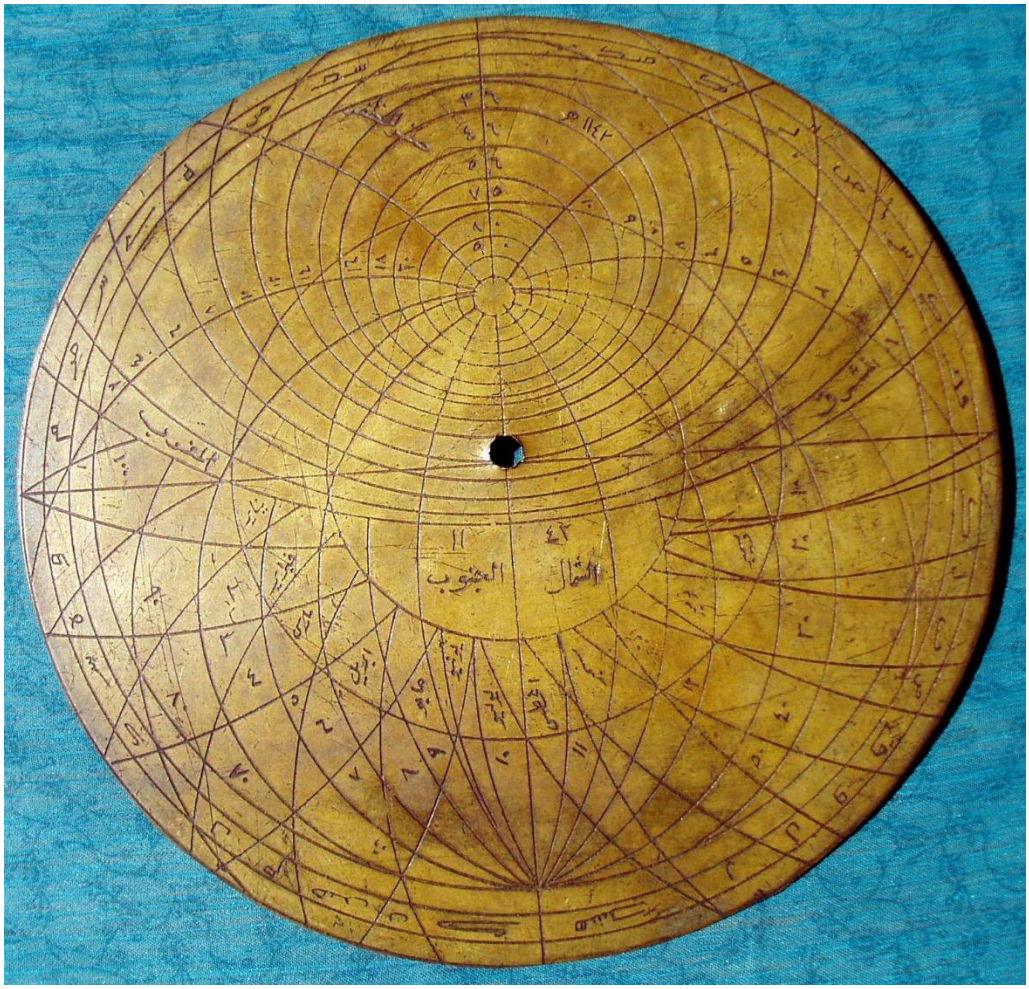


Figure Z001.5 – Plate for Lat. 27° (photo by S. R. Sarma)

This plate is also engraved with concentric circles of Capricorn, equator and Cancer, plus the arc of the oblique horizon with the labels *al-maghrib* on the west and *al-mashriq* on the east. Above the oblique horizon, 14 altitude circles are traced at uniform distances, roughly one for every 6°. The centre is roughly on 27°. The circles are numbered in common numerals erratically on both sides. Azimuth circles are drawn for every 30° above the horizon and for every 10° below the horizon, but without proper numbers.

In the lower half, lines for seasonal hours and lines for equal hours drawn from the western horizon; these are also not properly numbered.

In the upper part is written the month name *Ṣafar Muẓaffar* (victorious *Ṣafar*) on the left and the date *1142 h[ijrī]* on the right. The date is repeated in the centre with 11 on the left and 42 on the right. The cardinal directions *al-junūb* and *al-shamāl* are written, not quite appropriately, on either side of the meridian at the centre.

In the space between the circles of equator and Cancer, the names of the twelve English months are copied as they are pronounced by Arabic-speakers: *Yanāyir* (January), *Fibrāyir* (February), *Māris* (March), *Ibrīl* (April), *Māyū* (May), *Yūnyū* (June), *Yūlyū* (July), *'Aghusṭus* (August), *Sibtambir* (September), *Uktūbar* (October), *Nūfambir* (November) and *Dīsambir* (December). These too do not belong on an astrolabe.

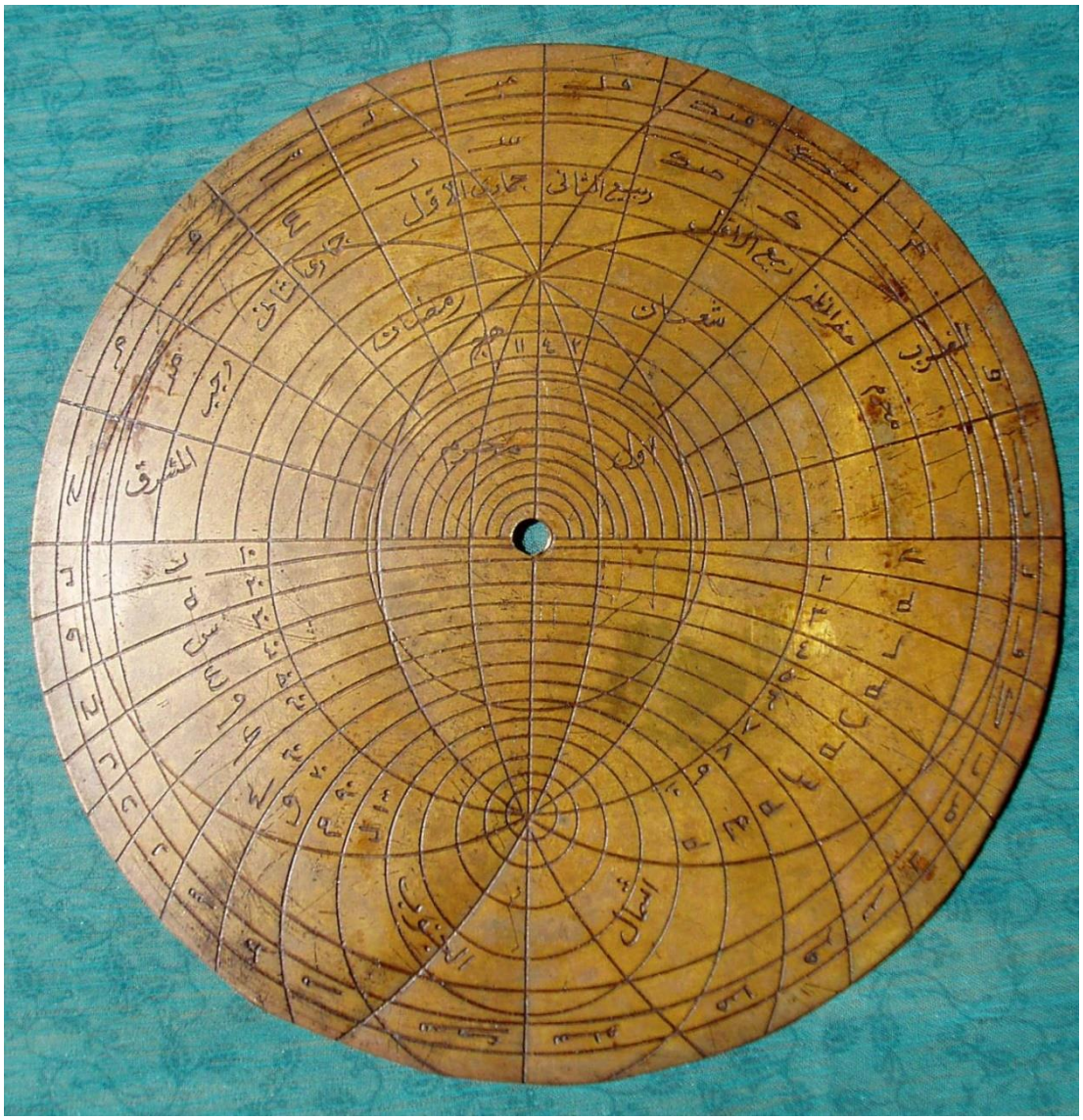


Figure Z001.6 – Plate for Latitudes 0° + 90° (photo by S. R. Sarma)

This plate is engraved with a double projection for 90° (north pole) in the upper half and for 0° (equator) in the lower half. Above the horizontal diameter, *al-maghrib* is written on the west and *al-mashriq* on the east; in the lower half *al-shamāl* and *al-janūb* added inappropriately on either side of the meridian at the bottom.

In the upper half, the names of Islamic months ae written in a semi-circle from right to left: *Muḥarram, Ṣafar Muẓaffar, Rabīᶜ al-Awwal, Rabīᶜ al-Thānī, Jamādā al-Ūlā, Jamādā al-Ākhirah, Rajab*; below the semi-circle are the two names *Shaᶜbān* and *Ramaḍān*; in the next line is written *hij[rī] 1142* at the centre; below this *awwal* on the right and some undecipherable word on the left. It is interesting that only the month *Ṣafar* is mentioned with the attribute *muẓaffar* (victorious). This expression is engraved on other plates as well. However, these month names have no relevance to this astrolabe plate.

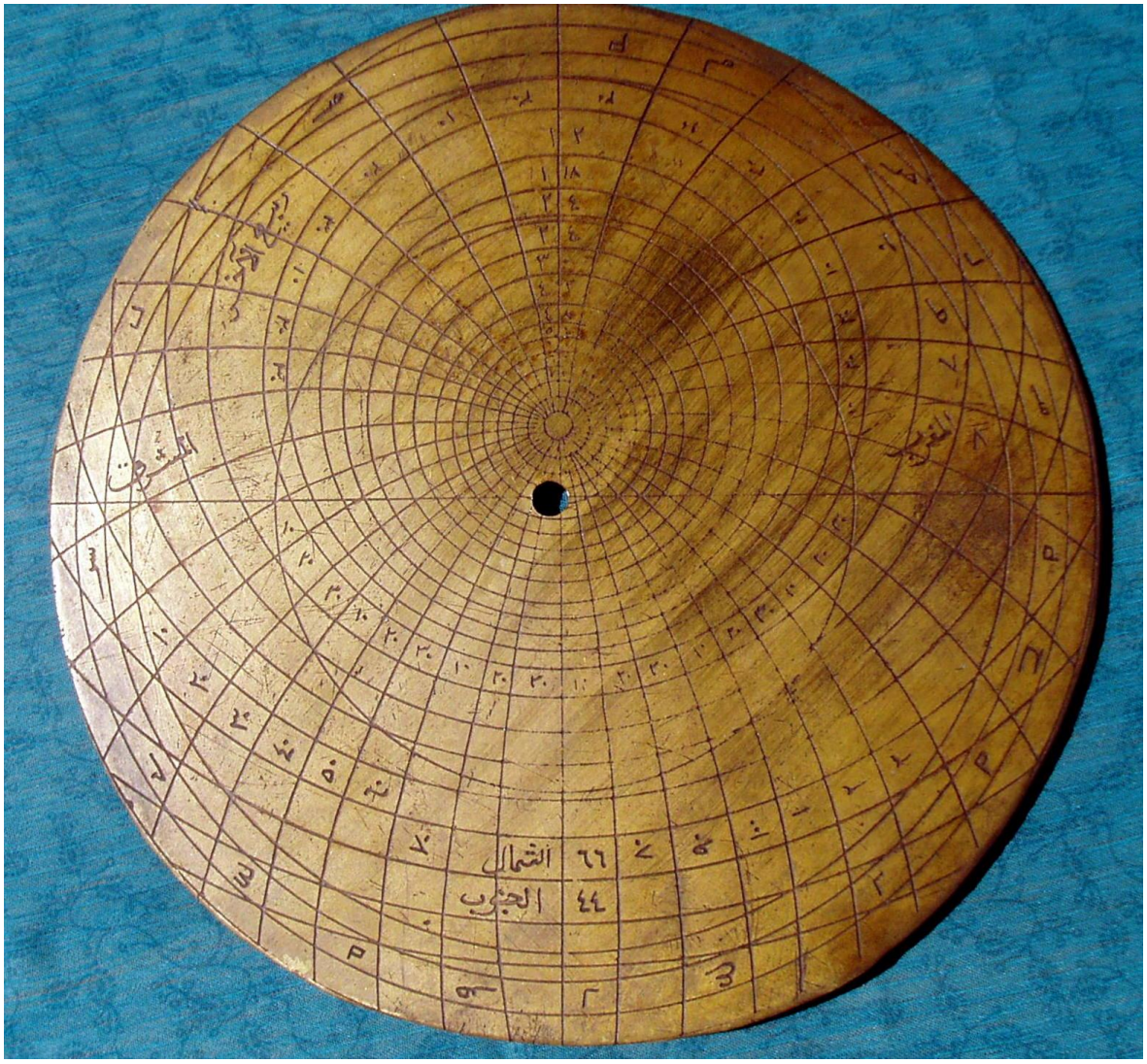


Figure Z001.7 – Plate for the ecliptic coordinates (photo by S. R. Sarma)

This plate is designed for the latitude of 66;30 which is the complement of the obliquity 23;30°. The ecliptic circle is drawn, but the names of the twelve zodiac signs are not written along the ecliptic circle. Azimuth circles are drawn for every 10° and these are numbered 10, 20, 30, separately in each zodiac sign. Altitude circles are drawn for every 6°, but these are not properly numbered.

Above and below the Capricorn circle are written *al-shamāl* and *al-janūb.* The name of the plate is not written, but the month name *Rabīʿ al-Ākhir* is engraved on the upper left.



Figure Z001.8 – Plate with multiple horizons (photo by S. R. Sarma)

On this plate, besides the three concentric circles of Capricorn, equator and Cancer, half horizons are drawn in four sets, together with the declination scales along

the four radii on either side of the equator. The numbers of the half-horizons and those on the declination scales are erratic.

The four quadrants are filled with the names of the cardinal directions, names of Islamic months, names of seasons and so on, none of which belong here. Thus the quadrant on the right carries the names *al-mashriq* (east), *Ramaḍān* (month name) and *al-harr* (summer). The upper quadrant has *al-Maghrib* (west), *Muharrum* (month name) and the year *1142 h[jrīī].* The quadrant on the left is engraved with *al-janūb* (south), *Shawwāl* (month name) and *al-shitā'* (winter). The lower quadrant has five lines of engraved text; the three on the right are *al-shamāl* (north), *Rajab al-Murajjab* (honoured *Rajab*) and *al-hawā'* (the air). On the left is a cartouche. Above the cartouche is written *asṭurlāb barak khairī* (the blessed astrolabe); inside the cartouche *ʿamal muḥammad naṣīr al-ṭūsī 1142 hijrī* (the work of Naṣīr al-Ṭūsī, 1142 Hijrī).



Figure Z001.9 – Inner surface of the mater (photo by S. R. Sarma)

On the inner surface of the mater is engraved what appears to be a geographical gazetteer, but which is actually a jumble of unconnected words and numbers in four circles. In the outer circle, above the horizontal radius on the right is *Ākrah* for Agra, but followed by the meaningless number 201918; there is also the month name *Muḥarram* followed by another meaningless number 21818 at the bottom.

Some of the cells are filled with floral pattern against a background. Most interesting is the pattern of the background caused by lathe marks in the shape of concentric circles.



Figure Z001.10 – Back of the astrolabe (photo by S. R. Sarma)

BACK

The back is divided in four quadrants by the vertical and horizontal diameters. The trigonometric quadrant on the upper left is filled with 21 horizontal parallels and 23 vertical parallels; both numbers are incorrect and the lines are not quite straight.

The upper right quadrant is divided by quarter circles into 6 segments; these are filled with floral patterns against a background which is alternately plain or dark.

In the lower half there are shadow squares. On the left the vertical and horizontal scale is divided in 9 divisions and numbered from 1 to 9 in common Arabic/Persian numerals. On the right, the vertical and horizontal scales are divided in five divisions and numbered as 1, 2, 3, 9, 7! The labels of the four scales are copied incorrectly from the source.

In the space below the square on the right is engraved a date *sanah 1130 h[ijrī]* which translates to AD 1717-18.

Z002 ⊙ FAKE ASTROLABE

Late 20th century

Diameter 172 mm, height 221 mm, thickness 8 mm

New Delhi, PC



Figure Z002.1 – Front of the astrolabe (photo by S. R. Sarma)

This fake astrolabe displays good workmanship with pleasant floral designs embossed on both sides of the *kursī* and all along the entire thickness, but all this is marred by highly idiosyncratic rendition of *Abjad* notation.

COMPONENTS

Main body (d. 172) with *kursī* and ring, rete (d. 150, t. 1.5), 5 plates (d. 151). There is no shackle; a ring is inserted in the hole at the top of the kursī, and another ring of the same size is joined to the first ring by a chain. There is a pin with a flat circular head, the wedge is equipped with a thick grip. No provision is made for the alidade.

FRONT

The limb, *kursī* and the back are made of one piece. Each quadrant of the limb is divided into 13 parts and each of these parts is subdivided in 4 units; thus the entire circle is divided in 208 units instead of 360 degrees! The 13 parts are numbered in *Abjad* notation somewhat erratically: 6, 12, 18, 24, 36, 42, 68, 66, 60, 72, ?, 44, 90. The numbering starts at the horizontal radii and reaches up to the vertical radii.



Figure Z002.2 – Rete (photo by S. R. Sarma)

RETE

The rete is a poor imitation of the rete in the well-known astrolabe made by Ḥāmid ibn Khiḍr al-Khujandī in 374 AH (AD 984-85) and the engravings do not make much sense.

PLATES

There are five plates; three are for latitudes 24°, 27° and for multiple horizons; two plates carry identical projections for 0°+90°; there is no plate for the ecliptic coordinates. The engravings are exactly as in the preceding specimen Z001, with a pair of concentric circles outside the peripheral circle of Capricorn, with the names of Islamic and English months and the wrongly placed labels *al-shamāl* and *al-janūb*.



Figure Z002.3 – Plates (photos by S. R. Sarma)



Figure Z002.4 – Inner surface of the mater (photo by S. R. Sarma)

The inner surface of the mater is engraved with what appears like a geographical gazetteer, but which is actually filled with a meaningless jumble of words and numbers.



Figure Z002.5 – Back view (photo by S. R. Sarma)

BACK

On the back, the rim of the two upper quadrants is divided in 6 units each, which are labelled with pseudo- *Abjad* symbols. The upper left quadrant is filled with 24 horizontal parallels, upon which is superimposed a universal horary quadrant with six arcs of seasonal hours, but without any labels.

The upper right quadrant is divided by quarter circles into 12 segments, which are labelled at both sides with meaningless scribbles. Upon these segments are superimposed two sets of curves; one is the azimuths of *qibla* for five cities which are not properly identified; the other is of sun's midday altitude throughout the year at seven terrestrial latitudes which are not identified.

In the lower half, immediately below the horizontal diameter is a crude imitation of double shadow squares, with identical numbered scales on both sides of the meridian. The horizontal scales are divided in 4 parts and the vertical scales in 5 parts. The numbers are imitation *Abjad.*

The shadow squares are enclosed by five semi-circular scales. The outer one is divided in 12 cells. The first cell at both ends is engraved with *ẓill asābiʿ* (shadows in digits) and the other cells with words of no significance. The second scale carries the names of the 12 zodiac signs which are correctly written. The other scales are filled with numbers and words of no significance.

Z003 ⊙ SPECTACULAR FAKE ASTROLABE

Late 20th century

Diameter 858 mm, height 1045 mm, thickness 30 mm

Lucknow, PC



Figure Z003.1 – Front of the fake astrolabe (photo by S. R. Sarma)

This spectacular fake astrolabe, lavishly decorated with beads of turquoise, adorns the wall behind the reception desk in a luxury hotel, which shall not be identified. It consists of a very large circular plate (diameter 858 mm) which is surmounted by a

triangular *kursī*. The circular body and the *kursī* are cut from a rather thin brass sheet.[1765] To the front side of this sheet is attached a thick circular rim (77 mm wide, 30 mm thick) by means of a series of brass nails, the tips of which have been hammered flush with the surface of the back. The rim extends over the entire surface of the *kursī*. The upper surface and the sides of the rim are decorated with ornamental patterns. There is no alidade at the back.



Figure Z003.2 – Zodiac sign Aries (photo by S. R. Sarma)

FRONT

The limb carries no graduations; instead, there are twelve brass roundels embedded at equal distances, containing embossed figures of zodiac signs, starting with Aries at the top and proceeding anti-clockwise. These figures are modelled after the *Art Nouveau* style of the early twentieth century. Next to the zodiac signs, their names in

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[1765] It has become somewhat wobbly; therefore it was difficult to photograph either the back or the inner surface.

Arabic language and script are engraved, apparently by workmen who are not quite familiar with the Arabic script. The spaces between these signs are decorated with geometrical patterns which extend to the surface of the crown as well. On the *kursī* is a cartouche on which is written *al-bashīr bijnūr*.



Figure Z003.3 – Rete (photo by S. R. Sarma)

RETE

The most impressive part of this astrolabe is the rete (d. 690 mm, t. 4 mm) which is modelled after the rete of the famous astrolabe made in brass and silver by as-Sahl al-Asṭurlābī al-Nīsābūrī in about 698 AH (AD 1298-99) for al-Mālik al-Muzaffar Taqui ad-Din, the ruler of the Syrian town of Hama. The astrolabe is now preserved in the

Germanisches Museum at Nürnberg, Germany.[1766] In this astrolabe, the rete contains 13 zoomorphic figures; certain projections jutting out of these 13 figures indicate the positions of 19 different stars.[1767]

These 13 figures are copied in the present astrolabe and in many cases the star positions are indicated by shining beads of Turquoise. In the lower half, below the ecliptic ring there are following five figures from left to right:

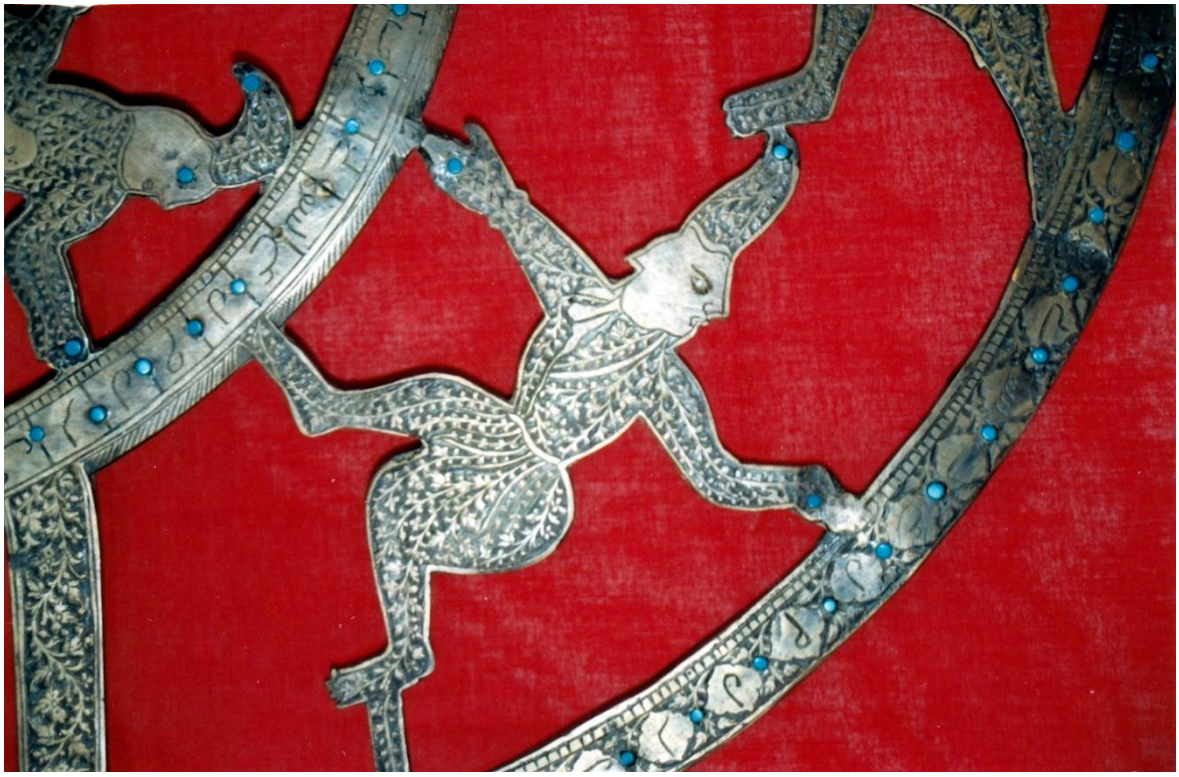


Figure Z003.4 – Acrobat pointing the finger of his right hand to the star α Tauri
(photo by S. R. Sarma)

1. A human figure, the finger of the hand touching the ecliptic ring points to the star *ᶜAyn al-Thawr* (α Tauri, Aldebaran).

2. Next to him is another human figure whose raised hand points to the star *Yad al-Jawzā' al-Yumnā* (α Orionis, Betelgeuse).

3. The outstretched hand of the next human figure indicates the star *Shiᶜrā Shāmīyah* (α Canis Minoris, Procyon).

1766 CCA 137, cf. Gerhard Bott (ed), *Treasures of Astronomy, Instruments of the German National Museum*, Nuernberg 1983, pp. 33-35; Gingerich 1987a, p. 97, plate 4; Stautz 1997, pp. 67, 205; Stautz 1999, figures on pp. 44 and 45.

1767 The stars are listed in Stautz 1997, p. 205.

4. His hand touches the head of the lion with a curved tail, which represents the constellation figure Leo; its paw where it touches the ecliptic ring points to the star *Qalb al-Asad* (α Leonis, Regulus).

5. The last figure is a crow, placed upside down; the turquoise bead on its eye indicates the position of the star *Janāḥ al-Ghurāb* (γ Corvi, Gienah).

Inside the ecliptic circle, there are eight figures. Starting from the right hand side and proceeding ant-clockwise, these are as follows:

6. The human figure, upside down, with a long lance in his hand is Bootes; the tip of the triangular projection between his legs is the position of the star *Simāk al-Rāmiḥ* (α Bootis, Arcturus); no turquoise bead is placed here.

7. The human figure perched on the circular disc at the centre and holding the lance is Hercules; in the original rete, he is shown as kneeling, here this detail is lost. The bead on his cap is the position of the star called *Ra's al Jāthī* (α Herculis, Rasalgethi).

8. Above him is another human figure, upside down. He represents the snake charmer Ophiuchus. The bead on his cap indicates the position of the star *Ra's al-Ḥawwā* (α Ophiuchi, Rasalhague).

9. With one hand he is holding the curved figure of the snake with its jaws wide open. The bead on the serpent's neck represents the position of the star *ᶜUnuq al-Ḥayyah* (α Serpentis, Unuk).

10. Next to it is a large bird with outstretched wings; the bead at its beak is the place of the star *al-Nasr al-Ṭā'ir* (α Aquilae, Altair).

11. The next figure is the horse Pegasus; the bead in its eye indicates the position of the star *Fam al-Faras* (ε Pegasi, Enif).

12. A bird is perched on the horse's back; the bead in its eye is the position of the star *al-Nasr al-Wakiᶜ* (α Lyrae, Vega).

13. Below the horse is the upside down figure of Cassiopeia; the turquoise bead on her hand touching the central disc indicates the position of the star *al-Kaff al-Khaḍib* (β Cassiopeiae, Caph).

While the acrobat figures in the Syrian original look austere with tight fitting clothes, here the human figures are draped in loose and flowing robes with intricate patterns. The most outstanding figures are the bird Corvus and the acrobat pointing to the star α Tauri.



Figure Z003.5 – Constellation figure of Corvus (photo by S. R. Sarma)

From the viewpoint of metal craft, this rete is superbly crafted, but as a scientific instrument, however, it violates all basic rules. In the original, inside the figures are engraved the names of the respective figures or the names of the stars to which the figures are pointing. What are written in the present copy are not the real names but mere scribbles.

The Tropic of Capricorn which forms the outer periphery is not graduated in a regular astrolabe. But here it is filled with 65 diamond-shaped cartouches with pseudo-*Abjad* symbols. The inner edge is subdivided into very small divisions, about 7 below each cartouche, totalling thus (65 x 7 =) 455 divisions instead of 360 divisions!

The ecliptic circle should be divided into 12 unequal parts to represent the zodiac signs. Here the entire circle is filled with 75 equal divisions, and labelled in pseudo-*Abjad* notation. These 75 divisions are further subdivided on the inner edge of the circular band, into 6 parts each. Thus there are (75 x 6 =) 450 equal divisions in this circle instead of 360 unequal divisions!

PLATES

There are five plates (d. 690, t. 1), all engraved only on one side, exactly in the same manner as the five plates of Z001, with the same circles and lines and the same engravings. The only difference is that on all plates outside the circle of Capricorn there is an ornate border with a chain design. On the inner surface of the main body, there are projections pertaining to one more terrestrial latitude. The plate is not labelled but it is calibrated for 36°. In the centre, in the place of the numerical value of the latitude, the date *1175 sanah* is engraved. Altitude circles are drawn for every 6°, azimuth circles are traced above and below the horizon and there are lines for the seasonal and equal hours in the lower half. Because of the wobbly nature of the brass sheet, it was not possible to photograph this sixth plate.

It is, however, not necessary to illustrate and describe all the five remaining plates. By way example, we show two plates.

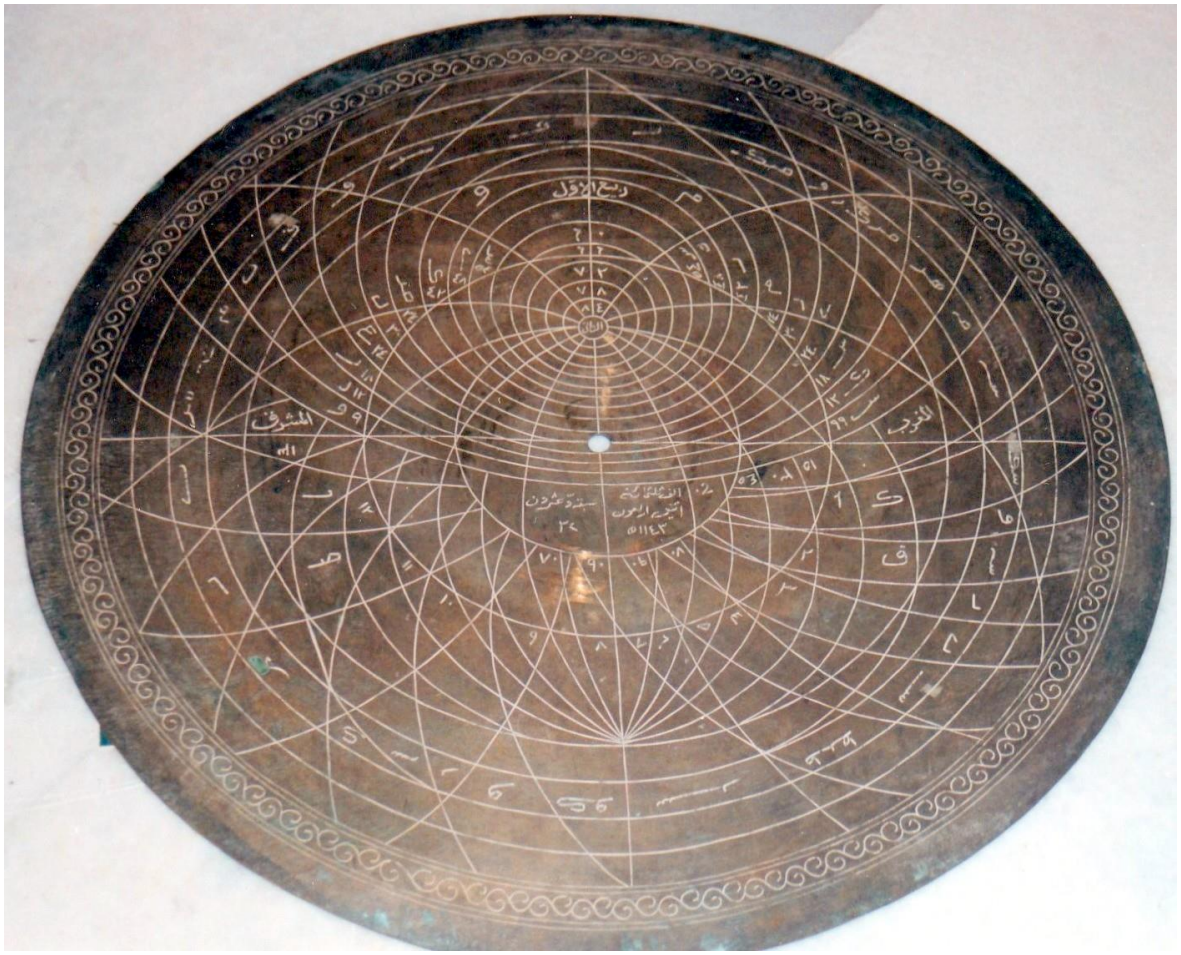


Figure Z003.6 – Plate for 24° (photo by S. R. Sarma)

This plate is exactly like Figure Z001.4. It is also calibrated for 24°, but labelled differently. In the centre, inside the Cancer circle, on the left is written *sabᶜah wa ᶜishrūn* (twenty-seven) and below it 27 in common Arabic/Persian numerals. On the right *'alf mā'iah ithnān 'arbaᶜūn* (one thousand one hundred forty-two) and below it *h*[*ijrī*] *1142*. This implies that the plate is calibrated for the latitude of 27° and that it was produced in the year 1142 AH (AD 1729-30).

But the plate is actually calibrated for the latitude of 24°, because above the oblique horizon are drawn 14 altitude circles at uniform distances, roughly one for each 6°, with the circle for 24° passing through the centre.



Figure Z003.7 – Plate for multiple horizons (photo by S. R. Sarma)

In the corresponding plate in Figure Z001.8, there is a long inscription attributing the production of the astrolabe to Naṣīr [al-Dīn] al-Ṭūsī; this inscription is omitted here. Otherwise, this plate is exactly like Figure Z001.8, with four sets of half-horizons and declinations scales along the four radii on either side of the equator. Here also numbers of the half-horizons and those on the declination scales are erratic. The names of the four cardinal directions are written on the four quadrants in a wrong sequence. Moreover, the names of different months like *Muḥarram* and *Shawwāl* are engraved here and there: next to *Muḥarram* occurs *h[ijrī] 1142*.



Figure Z003.8 – Back of the astrolabe (photo by S. R. Sarma)

BACK

On the back, the outer rim is divided into (19 x 4 =) 36 parts and each part is further subdivided into 6 divisions; thus there are (36 x 6 =) 216 divisions. These are neither numbered nor labelled. There is no provision for an altitude.

The engravings on the back have absolutely no relation to those found on the back of a regular astrolabe. First of all, the back is not divided into four quadrants as in a

genuine astrolabe. Here a large circle is drawn at the centre; and four circles of the same diameter all around. All these five circles are decorated with ornate borders and filled with various diagrams as one finds in school atlases about the theory of eclipses, longitudes and latitudes, etc. The space between these circles is filled with drawings of various constellation figures taken from the celestial globe. Neither these pictures, nor the diagrams, nor the clumsy inscriptions make any coherent astronomical or geographical statement.

Dates and Names

At three different places on the object, the name of a person and different dates in Hijrī era are engraved. Thus the cartouche on the front of the *kursī* carries the inscription in two lines: *al-bashīr, bijnūr.* On the horizon plate is the date *1142 h[ijrī].* On the inner side of the main body is the date *1175 sanah* (AD 1761-62). On the back of the crown, there is one more cartouche that contains three lines of inscription: *al-stulāb, al-bashīr, 1050 sanah*.

The three Hijrī dates 1050 (AD 1640-41), 1142 (AD 1729-30) and 1175 (AD 1761-62) are clearly fictitious; *al-stulāb* is one more miswriting for *asṭurlāb.*

On the other hand, al-Bashīr can be the name of the person who fabricated this splendid, but spurious, astrolabe and he may be from Bijnor (29;22° N - 78;8° E), a town in northern Uttar Pradesh.

Z004 ⊙ FAKE SANSKRIT ASTROLABE

Diameter 153 mm, height 189 mm, thickness 13 mm

Rampur, Rampur Raza Library

This is the only fake instrument with Sanskrit legends and Devanagari numerals that I have come across. Rampur Raza Library acquired this and the next piece (Z005) around 2003 just when I was completing my catalogue *Astronomical Instruments in the Rampur Raza Library.* At that time I was not aware that fake Sanskrit instruments were very rare; now I regret that I did not photograph this rare piece.

FRONT

The body and the *kursī* are made of a single piece. Several pieces of turquoise are inlaid on the rim of the *kursī* and on the limb of the main body, and a pearl-like substance is inlaid at the centre of the *kursī*.

This piece was partly copied from a genuine astrolabe. In other parts, the artisan did not understand the principles of construction and so he concocted his own legends. Thus, instead of calibrating the limb in single degrees and then in groups of 5° or 6° as is customarily done, he engraved on the rim the words *cakra naṃ 1, cakra naṃ 2*, etc., where *cakra* means 'circle' and *naṃ* is the abbreviation of the English word 'number'.

On the inner surface of the main body, there are some concentric circles; the spaces between these circles are filled with the words *cakra naṃ 1, dhruva naṃ* 1 and so on, repeated several times. Here *dhruva* means the 'pole'.

RETE

The outer form of the rete is correctly copied. The ecliptic band is divided into 12 zodiacal signs and labelled with their names correctly. But the signs are subdivided quite arbitrarily and numbered illogically as 25, 28, 24, 30, 62, 22 etc.

There are 10 star pointers outside the ecliptic and 15 inside the ecliptic. These are given absurd names.

PLATES

There are 5 plates, engraved only on one side, but the projections have been copied reasonably correctly from a genuine astrolabe.

BACK

On the back, the rim is graduated 1° and 6°; the groups of 6° are numbered anti-clockwise, which is not correct.

In the upper right quadrant there is a sine-cosine grid; in the two lower quadrants, there are shadow squares and the four scales are labelled as *cakra naṃ 1, dhruva naṃ 1; … … cakra naṃ 4, dhruva naṃ 4*.

Z005 ⦿ FAKE CELESTIAL GLOBE

Diameter of the globe ca. 180 mm; height of the stand 150 mm.
Rampur, Rampur Raza Library

The globe appears to have been cast as a single hollow sphere. It is mounted on a stand consisting of a horizon ring supported by four legs. The inner diameter is the horizon ring far exceeds the diameter of the globe with the result that the horizon is not at the same level as the centre of the globe.

The horizontal ring is not properly graduated; it is engraved with three different scales of no special significance. There is no vertical ring. The axis of the globe is permanently affixed to the horizontal ring. Therefore, the globe cannot be adjusted to the latitude of the place where it is used.

On the globe, the equator and the ecliptic are drawn with double lines, but these are neither labelled nor graduated properly. Even their location is not entirely correct.

The globe maker has seen some constellation figures on a genuine globe, but without understanding their iconography or location, he placed these arbitrarily all over the globe, and repeated some of them.

The South Pole is surrounded by the figures of Serpentarius, Sagittarius, Cancer, Pegasus, Leo, and others, whose actual location is far away from this thinly populated South Pole. Sagittarius should be located on the ecliptic, on this globe, there are at least three Sagittarius figures, all wrongly placed.

Centaurus, a prominent figure in the southern hemisphere, is placed once between ecliptic and equator and another time north of the ecliptic. There are several puppies, rabbits, and other small animals which are the maker’s own invention.

Thus, instead of the usual 48 figures, the globe is engraved with as many as 56 figures.

Z006 ⦿ ARMILLARY SPHERE WITH A CELESTIAL GLOBE AT THE CENTRE

Late 20th century

Diameter

Lucknow, PC



Figure Z006.1 – Armillary sphere upon an ornate table (photo by S. R. Sarma)

This object is placed upon an ornate round table, under the dome of the lobby of a luxury hotel as the chief attraction of the place. It is modelled after the traditional armillary sphere, which is discussed in section I above. The genuine armillary sphere

consists of several concentric rings of varying diameters, arranged around a common centre where a small globe is placed to represent the earth. The rings around the earth represent the various imaginary circles in the heavens, like the ecliptic, celestial equator, meridian, colures and the horizon. Sometimes there are also rings with different centres.



Figure Z006.2 – Fake armillary sphere (photo by S. R. Sarma)

But what is at the centre of the present object is not the terrestrial globe but the celestial globe engraved with the various constellation figures. In a genuine armillary sphere, the globe and the rings are mounted on an axis perpendicular to the plane of the celestial equator. Here the axis is vertical and the celestial globe is mounted on it upside down, its south pole pointing upwards and the north pole downwards.

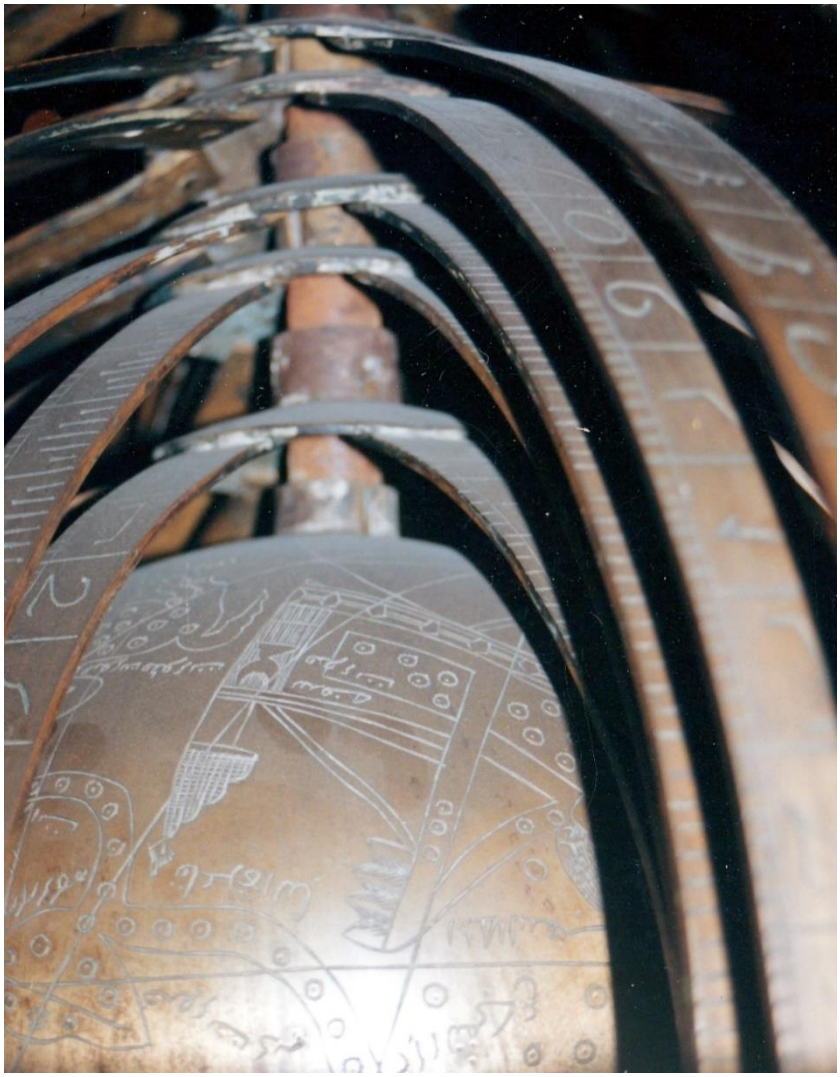


Figure Z006.3 – Figure of Argo Navis (photo by S. R. Sarma)

The globe is surrounded by seven sets of rings which rotate around the same vertical axis and each set consists of six rings. The rings are irregularly graduated and numbered with pseudo-*Abjad* symbols. The innermost rings are somewhat circular but gradually they become more and more elliptical. While the rings in the genuine armillary sphere represent various imaginary circles like the celestial equator, the ecliptic and others, the rings here have no astronomical or astrological significance.

These rings are enclosed by a thick and broad horizontal ring. This ring rests on four tapering legs which are joined by two cross bars at the bottom. On the junction of the two crossbars rests the vertical shaft to which the rings and globe are pivoted.

The horizontal ring contains twelve roundels in which the signs of the zodiac are engraved. The spaces between these are filled with floral decorations. However, the signs of the zodiac, being the division of the ecliptic, make sense only on the ecliptic; elsewhere (as in the present case) they merely serve as decorative elements.

The celestial globe in the centre is engraved with the various circles and constellation figures which are seen on genuine celestial globes; the positions of the stars are marked by dots enclosed within small circles, but the Arabic names are not accurately inscribed. Because of the plethora of rings which surround it, not much of the celestial globe can be seen from outside. Figure Z006.3 above offers a glimpse of the upper part of the celestial globe along with the surrounding rings. The divisions on the rings are numbered by pseudo-*Abjad* symbols and subdivided irregularly, into 6 units in a ring on the left and 7 units in a ring on the right.

In the middle is the celestial globe mounted upside-down with the south pole up and the north pole below. Consequently, the constellation figure of Argo Navis which is situated in the southern hemisphere, is also at the top and is upside-down. It is a somewhat crude imitation of the same figure on genuine celestial globes, such as the one shown in Figure F013.7.

Z007 ARMILLARY SPHERE WITH A CELESTIAL GLOBE AT THE CENTRE[1768]

Diameter ?

PLU; ex-Christie's



Figure Z007.1 – Armillary sphere (from Christie's catalogue)

[1768] Entry based on Christie's, London, auction catalogue of 25 November 1998, lot 38, p. 25.

This spurious armillary sphere is constructed in the same manner as the preceding specimen, but the rings are more ornately decorated. Under the heading ‘Provenance’, Christie’s catalogue states as follows:

> ‘Originally from the palace of the Maharajah Shri Tej Singhr (sic!) Shahib (sic!) from the state of Bikaner Rajputana.
>
> ‘According to the vendor, this armillary sphere probably dates from the middle of the last century, the celestial sphere having been made in Udaipur, and the whole constructed in Lahore. It was purchased from the family of the Maharajah several years ago. It would appear to have been used for casting horoscopes. ‘

This is pure fiction. First of all, there existed no Maharaja named ‘Tej Singh Sahib’ in the royal dynasty of Bikaner. Second, this celestial globe could not have been made in Udaipur in Rajasthan, because it is engraved with figures copied from Indo-Persian celestial globes which were produced mainly in Panjab and not in Rajasthan. Third, this object could not have been used for casting horoscopes. For this purpose, one needs the ascendant at the time of a person’s birth and three other points on the zodiac circle. These can be obtained from an astrolabe, but not from this object. In fact, this object serves no astrological or astronomical purpose. It is a mere decorative item.

Z008 ⦿ COLLAGE OF SPURIOUS INSTRUMENTS

Late 20th century

Height ca. 1.5 m; diameter of the upper part 828 mm

Lucknow, PC



Figure Z008.1 – Collage of spurious instruments (photo by S. R. Sarma)

This large object does not resemble any known astronomical instrument. It is a mere medley or collage of elements from different astronomical instruments. Starting from below, their sequence is as follows. There is a tripod stand, the three massive ornamental legs of which are joined above by a horizontal ring, and below by three strips which radiate from the centre. From this centre rises a vertical shaft which respectively passes through (i) a vase like object, (ii) a small celestial globe, (iii) a larger celestial globe and finally supports (iv) a circular plate which is surrounded by three broad rings. The circular plate together with the rings is inclined from the horizon by about 60°.



Figure Z008.2 – Stand (photo by S. R. Sarma)

From the horizontal ring at the tripod rise vertically two massive curved bars, which support a semi-circular arc, which further supports the circular plate surrounded by the three rings.



Figure Z008.3 – Larger celestial globe (photo by S. R. Sarma)

As in Z006 and Z007, here also the two celestial globes are also mounted on a vertical axis. The two globes are engraved with double bands of equator and ecliptic, which are divided in 1° and 6° and groups of 6° numbered in pseudo-*Abjad* notation. The larger globe also carries rather crude imitations of constellation figures, sometimes with correct labels. Thus in Figure Z008.3 can be seen the serpent Hydra, raising its neck above the circle of equator and carrying the label *ṣūrat shujā*^{c}. Near its mouth is engraved the star name *mankhar shujā*^{c} (nose of the serpent, σ Hydrae) and below the equator another star name *fard al-shujā*^{c} (the isolated one of the serpent, α Hydrae).

On the ecliptic band are the figures of Gemini, Cancer and Leo. At the very top can be seen the figure of the Great Bear.

Elsewhere on the globe is the figure of Auriga, with a long moustache spreading left and right far beyond the outlines of his face. Holding two rabbits, he looks like a magician pulling rabbits out of his sleeves.

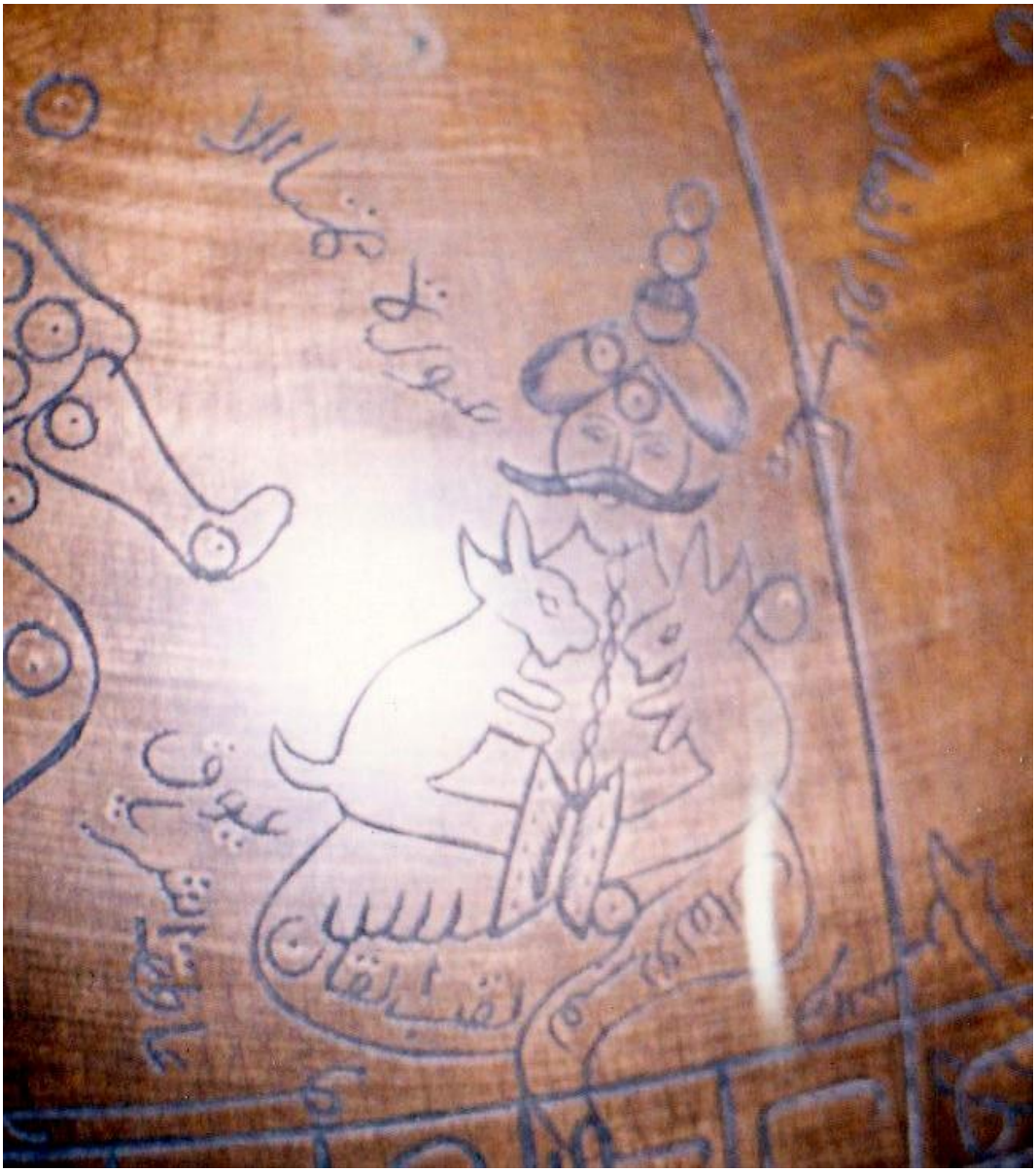


Figure Z008.4 – Auriga on the larger celestial globe (photo by S. R. Sarma)

On either side of the larger globe are suspended two objects that look like Mariner's astrolabes. These are decorated with two pretty figures of fish at the top, with floral decorations at the two ends of the vertical and horizontal diameters and with two figures of the moon at the bottom. Indeed, these are more beautiful than any of the eighty and odd genuine Mariner's astrolabes which are extant.



Figure Z008.5 – Mariner's astrolabe (photo by S. R. Sarma)

But as measuring instruments they are absolutely non-functional because the alidades are not equipped with sighting plates and because the altitude scales are not properly engraved on the rim of the astrolabe. In a genuine Mariner's astrolabe, the two upper quadrants are graduated in 90° each, the numbers beginning at the two ends of the horizontal bar and proceeding towards the top. But in the present case, an arc of about 60° at the top of the circle is not graduated. The remaining part is divided into 29 parts and numbered consecutively in clockwise direction in common Arabic-Persian numerals. These 29 parts are further subdivided, not very uniformly, into 4 or 5 divisions each. Here, as elsewhere, the basic principle of dividing the circle into 360 degrees is ignored.



Figure Z008.6 – Circular disc surrounded by three rings (photo by S. R. Sarma)

The top of the object consists of a circular disc, surrounded by three broad annular rings. The rings are held in position by four ornate knobs in each ring. The total diameter of the top including the rings is 828 mm. The rings are attached in such a manner that they can be rotated around the centre. To the centre of the circular disc is attached a dioptre which slides over all the three rings. But like the dioptres in the two Mariner's astrolabes, this too is without sights and is therefore non-functional.

In the outer ring, there are twelve roundels at equal distances. On these, zodiac signs are engraved and their Arabic names added. The iconography of these figures is rather idiosyncratic and the Arabic names are carelessly written. The second and third inner rings contain likewise twelve roundels each, which are filled with various kinds of diagrams taken from the school atlas, such as the sun, moon, names of zodiac signs, terrestrial globe, theory of lunar eclipses etc. The spaces between these roundels on all the three rings are filled with three or four bands of irregular scales with pseudo-*Abjad* symbols.



Figure Z008.7 – Two segments of the three outer rings (photo by S. R. Sarma)

The central disc contains various diagrams and constellation figures as they are drawn on the surface of the celestial globes. The figures are often crude, the labels are sometimes correct and sometimes highly corrupt.



Figure Z008.8 – Perseus on the central disc (photo by S. R. Sarma)

For example, in Figure Z008.8 can be seen an assemblage of diverse elements around the figure of Perseus. Above his head is the moon, on the upper left a fish and on the upper right a diagram of the terrestrial globe. The mighty warrior of Greek mythology is depicted like a street urchin, naked but for a short pair of pants; his ear is drawn so carelessly that it looks like a bulge in the head. The only the elements which are drawn well are the ghoul's head in his right hand an the sword in his left hand. To the right of the figure is the label: *ṣūtar sharshāūs* (! *parshāūs*).



Figure Z008.9 – Virgo holding Libra (photo by S. R. Sarma)

The most amusing rendition is that of the nude Virgo, her face in profile, her long hair flowing downwards, holding Libra in one hand and covering her shame with a twig of leaves in the other hand. Below Libra can be seen the Sagitta (in the form of bow and arrow) of Sagittarius. To her left is the serpent Hydra with the forked tongue. Here the labels are correctly engraved; Libra carries the label *mīzān* and Hydra *ṣūrat shujāʿ*. The star on its nose is not clearly marked, but the label is correctly written as *mankhar al-shujāʿ* (the nose of the serpent, σ Hydrae).



Figure Z008.10 – Signature (photo by S. R. Sarma)

Above the figure of Virgo is another diagram of the terrestrial globe on one side and a crab on the other. Above the crab is written *sarṭāt,* or *sarẓāt al-naqī sanah 1221 h[ijrī].* The first two words may or may not be the name of the person who fabricated this weird medley, but the Hijrī date which corresponds to AD 1806-07 is clearly fictitious. This object, like the preceding ones, was produced in the 1990s.

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* Except in a few cases, auction catalogues are not listed.

A

Abbasi forthcoming | Mubashir Ul-Haq Abbasi, 'An Embodiment of Cultural Synthesis: An Astrolabe by Lālah Bulhomal Lāhorī, dated 1841'

Abbasi & Sarma 2014 | Mubashir Ul-Haq Abbasi & Sreeramula Rajeswara Sarma, 'An Astrolabe by Muḥammad Muqīm of Lahore dated 1047 AH (1637-38 AD),' *Islamic Studies,* 53.1-2 (2014) 37-65.

Abbott 1937 | Nabia Abbott, 'Indian Astrolabe Makers,' *Islamic Culture*, 11 (1937) 144-146.

Abdi 1988 | Wazir Hasan Abdi, 'Enrichment of Mathematical Sciences in India through Arabic and Persian' in: B. V. Subbarayappa and S. R. N. Murthy (eds), *Scientific Heritage of India*, Bangalore 1988, pp. 63-77, esp. 69.

Abraham 1981 | George Abraham, 'The Gnomon in Early Indian Astronomy,' *Indian Journal of History of Science,* 16.2 (1981) 215-218.

Abū al-Faḍl 1 | Abū al-Faḍl, *Ā'īn-i Akbarī,* vol. 1, tr. H. Blochmann, Calcutta 1873; reprint: Institut für Geschichte der Arabisch-Islamischen Wissenschaften, Frankfurt 1993.

Abū al-Faḍl 2 | Abū al-Faḍl, *Ā'īn-i Akbarī,* vol. 2, tr. H. S. Jarrett, second edition, corrected and further annotated by Jadu-Nath Sarkar, Calcutta 1949, reprint: Institut für Geschichte der Arabisch-Islamischen Wissenschaften, Frankfurt 1993.

Abū al-Faḍl 3 | Abū al-Faḍl, *Ā'īn-i Akbarī,* vol. 3, tr. H. S. Jarrett, revised and further annotated by Jadu-Nath Sarkar, Calcutta 1948, reprint: Institut für Geschichte der Arabisch-Islamischen Wissenschaften, Frankfurt 1993.

Ackermann 1999 | Silke Ackermann, 'Islamic Globes' in: Elly Decker (ed), *Globes at Greenwich: A Catalogue of Globes and Armillary Spheres in the National Maritime Museum, Greenwich,* OUP and National Maritime Museum, London 1999, pp. 177-198.

Ackermann 2005 | Silke Ackermann, 'Astrological Scales on the National Maritime Museum astrolabes' in Cleempoel 2005, pp. 73-89.

Aga-Oglu 1947 | Mehmet Aga-Oglu, 'Two Astrolabes of the late Safavid Period,' *Bulletin of the Museum of Fine Arts, Boston*, XLV, 79 (December 1947) 988-993.

Akbarnāma | The Akbarnama of Abu-l-Fazl (History of the Reign of Akbar including an Account of his Predecessors), tr. H. Beveridge, 3 vols, Calcutta 1910.

Al-Daffa' & Stroyls 1983 | Ali A. Al-Daffa' & John J. Stroyls. 'The Art of the Astrolabe,' *Hamdard Islamicus*, 4.1 (Spring 1983) 15-36.

Ali 1974 | Mrs. Meer Hassan Ali, *Observations on the Mussulmauns of India,* edited with notes and an introduction by W. Crooke, Oxford University Press, Karachi 1974.

Anderson 1982 | R. G. W. Anderson, Science in India: A Festival of India Exhibition at the Science Museum, London, 24 March – 1 August 1982. Catalogue, Science Museum, London 1982.

Anderson 1993 | R. G. W. Anderson et al (ed), Making Instruments Count: Essays on Historical Scientific Instruments presented to Gerard L'Estrange Turner, Variorum, Aldershot 1993.

Anon 1898 | 'Die Uhren-ausstellung in der Urania' *Deutsche Uhrmacher-Zeitung*, 22.19 (1 October 1898) 472-473.

Anon 1899 | 'Pilgrim's Staff with Sun-dial,' *The Horological Journal*, January 1899, 69-70.

Anon 1984 | Le Mesure de Temps dans la Collections Belgiques. Exposition organisee par le Societe Generale de Banque, 26.1-7.4.1984, rue Ravenstein, 1000 Bruxelles, Catalogue, No. 17.

Anon 1985 | *The Unity of Islamic Art,* catalogue of an exhibition to inaugurate the Islamic Art Gallery of the King Faisal Center for Research and Islamic Studies, Riyadh, Saudi Arabia, 1405 AH/ !985 AD, The King Faisal Foundation.

Anon 1989 | *Islamic Science and Learning*, Washington D.C. July 1989, Exhibition Catalogue, High Commission for the Development of Arriyadh.

Ansari 2015 | S. M. Razaullah Ansari, 'Survey of *Zījes* Written in the Subcontinent,' *Indian Journal of History of Science,* 50.4 (2015) 576-601.

Ansari & Fatima 1984 | S.M. R. Ansari & Zia Fatima, 'An Essay Review on *Science and Technology in Medieval India*, by A. Rahman *et al.*', *Studies in History of Medicine* (New Delhi), Vol. VIII, No.1-2, pp. 67-87.

Ansari & Sarma 1999-2000 | S. M. Razaullah Ansari & S. R. Sarma, 'Ghulām Ḥussain Jaunpūrī's Encyclopaedia of Mathematics and Astronomy,' *Studies in History of Medicine and Science,* 16 (1999-2000) 77-93.

Archinard 1983 | Margarida Archinard, *Astrolabe*, Musée d'Histoire des Sciences de Genève, Genève 1983.

Armitage 1989 | A. Armitage, 'The Schlagintweit Collection,' *Indian Journal of History of Science,* 24.1 (1989) 67- 83.

Āryabhaṭa, *Āryabhaṭīya* | *Āryabhaṭīya of Āryabhaṭa,* critically edited with Introduction, English Translation, Notes, Comments and Indexes by Kripa Shankar Shukla, in collaboration with K. V. Sarma, Indian National Science Academy, New Delhi 1976.

Athar Ali 1985 | Athar Ali, *The Apparatus of Empire: Awards of Ranks, Offices and Titles to the Mughal Nobility (1574-1658),* Centre of Advanced Study in History, Aligarh Muslim University, and Oxford University Press, Delhi 1985.

B

Babur | *Bābur-Nāma (Memoirs of Bābur)*, tr. Annette Susannah Beveridge, Delhi 1979.

Bahura 1976 | Gopal Narayan Bahura, *Literary Heritage of the Rulers of Amber and Jaipur, with an Index to the Register of Manuscripts in the Pothikhana of Jaipur (1. Khasmohor Collection),* Maharaja Sawai Man Singh II Museum, City Palace, Jaipur 1976.

Balmer 1978 | R. T. Balmer, 'The Operation of Sand Clocks and their Medieval Development,' *Technology and Culture,* 19 (1978) 615-32.

Baloch 1979 | N. A. Baloch, 'Measurement of Space and Time in the lower Indus Valley of Sind' in: Said 1979, part I, pp. 168-196.

Bandyopadhyaya 1994 | Amalendu Bandyopadhya, 'Astronomical Instruments devised by Ancient Indian Astronomers,' *Journal of the Asiatic Society of Bengal.* 36.3 (1994) 5-10.

Bassermann-Jordan 1922 | Ernst von Bassermann-Jordan, *Uhren: Ein Handbuch für Sammler and Liebhaber,* Richard Carl Schmidt & co., Berlin 1922.
https://archive.org/details/bub_gb_qdM0AQAAMAAJ
[also https://goo.gl/tX3mgC, last accessed in June 2017]

Beale 1894 | Thomas William Beale, *An Oriental Biographical Dictionary,* revised by Henry George Keene, London.
https://archive.org/stream/orientalbiograph00bealrich#page/n7/mode/2up
[also https://goo.gl/EUL0Zi, last accessed in April 2017].

Beevers 1958 | S. Benson Beevers, 'The John Gershom Parkington Memorial Collection of Time Measurement Instruments,' *The Connoisseur Yearbook*, 1958, pp. 115-126.

Behari & Govind 1980 | Kailash Behari & Vijai Govind. 'A Survey of Historical Astrolabes of Delhi,' *Indian Journal of History of Science,* 15 (1980) 94-104.

Ben-Zaken 2011 | Avner Ben-Zaken, 'The Revolving Planets and the Revolving Clocks: Circulating Mechanical Objects in the Mediterranian,' *History of Science,* 44 (2011) 125-148.

Berggren 1986 | J. L. Berggren, *Episodes in the Mathematics of Medieval Islam,* Springer-Verlag, New York 1986; ch. 6, pp. 157-188: Spherics in the Islamic World.

Berggren 2001 | J. L. Berggren, 'Sundials in Medieval Islamic Science and Civilization.' *The Compendium,* [Quarterly Journal of the North American Sundial Society], 8.2 (June 2001) 8-14.
http://people.math.sfu.ca/~berggren/Attachments/Dials_Publications/Islamic_sundials.pdf
[also https://goo.gl/G4PF5f, last accessed in August 2017]

Bhāskarācārya | Bhāskara, *Siddhāntaśiromaṇi* of Bhāskarācārya, with his Auto-commentary *Vāsanābhāṣya* and the commentary *Vāsanāvārttika* by Nṛsiṃha Daivajña, ed, Murali Dhara Chaturvedi, Library Rare Text Publication Series , No. 5, Sampurnanand Sanskrit University, Varanasi, 1981.

Bhattacharya 1946-47 | Bibhuti Bhushan Bhattacharya, 'Some Instruments of Ancient India and their Working Principles,' *Journal of the Ganganatha Jha Research Institute*, 4 (1946-47) 249-270.

Bhattacharya 1979 | Vibhūtibhūṣaṇa Bhaṭṭācārya (ed), *Yantrarāja-vicāra-viṃśādhyāyī by Nayanasukha Upādhyāya*, Varanasi 1979.

Bhattacharya 1987 | Arupratan Bhattacharya, Ancient India Astronomical Terms and their Interpretations in the Light of Modern Astronomy, Calcutta 1987.

Bianchini & Senatore 2016 | Carlo Bianchini & Luca J. Senatore, 'Gerbert of Aurillac (c. 940–1003)' in Michaela Cigola (ed) *Distinguished Figures in Descriptive Geometry and its Applications for Mechanism Science: From the Middle Ages to the 17th Century,* Springer 2016, pp. 33-51.

Bīrūnī 1910 | Alberuni's India: An Account of the Religion, Philosophy, Literature, Geography, Chronology, Astronomy, Customs, Laws and Astrology of India about AD 1030, tr. Edward C. Sachau, first Indian reprint: New Delhi.

Bīrūnī 1934 | Al-Bīrūnī, The Book of Instruction in the Elements of the Art of Astrology (*Kitāb al-tafsīm li-awa'il sinaī'at at-tangīm*), ed. with English translation by R. R. Wright, London 1934.

Bīrūnī 1976 | Al-Bīrūnī, *The Exhaustive Treatise on Shadows by Abu al-Rayḥhān Muḥammad b. Aḥmad al-Bīrūnī.* Translation & Commentary by E. S. Kennedy. Vol. I: Translation; Vol. II: commentary. Institute for the History of Arsabic Science, University of Aleppo, Aleppo, 1976.

Boileau 1833 | J. T. Boileau, 'Description of a Sun-dial in the Court of the Moti Masjid, in the Fort of Agra,' *Journal of the Asiatic Society of Bengal*, 2 (1833) 251. pl. IX.

Boileau 1837 | A. H. E. Boileau, *Personal Narrative of a Tour through the Western States of Rajwara, in 1835*,…, Calcutta 1837, pp. 156-157: on Jaipur Observatory and Gun Foundry.

Bose, Sen & Subbarayappa 1971 | D. M. Bose, S. N. Sen & B. V. Subbarayappa, *A Concise History of Science in India,* Indian National Science Academy, New Delhi.

Brache, Tycho | *Tycho Brache's Description of his Instruments and Scientific Work as given in Astronomiae Instauratae Mechanica* (Wandesburgi 1598), translated and edited by Hans Raeder, Elis Strömgren and Bengt Strömgren, Kobenhavn 1946.

Brahmagupta | Brahmagupta, *Brāhmasphuṭasiddhānta,* ed. Sudhakara Dvivedi with his own ṭīkā, Benares 1902.

Brenni 1996 | Paolo Brenni, Mara Miniati, Luigi Pippa & Anthony Turner, *Orologi e Strumenti della Collezione Beltrame,* Istituto Museo di Storia della Scienza, Firenze 1996.

Bruin 1966 | Frans Bruin, 'The Making of an Astrolabe,' *Al-Biruni Newsletter*, No. 3, Beirut, February 1966.

Bruin 1967 | Frans Bruin, 'The Astronomical Observatory of Ulugh Beg in Samarqand,' *Al-Biruni Newsletter*, No. 9, Beirut, November 1967.

Bruin 1968a | Frans Bruin, 'The Outflow Clepsydra,' *Al-Biruni Newsletter*, No. 12, Beirut, March 1968.

Bruin 1968b | Frans Bruin, 'The Astronomical Observatory of Naṣīr al-Dīn al Ṭūsī in Marāghah,' *Al-Biruni Newsletter*, No. 13, Beirut, June 1968.

Bruin 1977 | Frans & Margaret Bruin, 'The Limits of Accuracy of Aperture-Gnomons' in: Y. Maeyama and W. G. Saltzer (hrsg), ΠΡΙΣΜΑΤΑ: *Naturwissenschaftageschichtliche Studien: Festschrift für Willy Hartner*, Wiesbaden 1977, pp. 21-42.

Bud 1998 | Robert Bud et al, *Instruments of Science: An Historical Encyclopedia,* The Science Museum, London & The National Museum of American History, Smithsonian Institution, in association with Garland Publishing, Inc., New York & London 1998.

Burrow 1790 | Reuben Burrow, 'A Proof that the Hindoos had the Binomial Theorem,' *Asiatick Researches* 2 (1790) 486-497; on astrolabes 488-9.

C

Cakradhara | Cakradhara, *Yantra-cintāmaṇi,* his commentary *Vivṛti,* Rāma Daivajña's commentary *Yantra-dīpikā*, and Hindi translation, by Bhāgīrathī-prasāda Śarmā, Benares 1883.

Calvo 1994 | Emilia Calvo, 'On the Construction Ibn Bāṣo's Universal Astrolabe (14th C.) according to a Moroccan Astronomer of the 18th Century,' *Journal of the History of Arabic Science,* 10 (1994) 53-67.

Calvo 1996 | Emilia Calvo, 'Ibn Bāṣo's Astrolabe in the Maghrib and East' in: Josep Casulleras and Julio Samsó (ed), *From Baghdad to Barcelona: Studies in the Islamic Exact Sciences in Honour of Prof. Juan Vernet,* Barcelona 1996, pp. 755-767.

Calvo 2000 | Emilia Calvo, 'A Study of the Use of Ibn Bāṣo's Universal Astrolabe Plate,' *Archives internationales d'histoire des sciences* 50 (2000) 264-295.

Calvo 2007 | Emilia Calvo, 'Ibn Baṣo: Abū ᶜAlī al-Ḥusayn ibn Abī Jaᶜfar Aḥmad ibn Yūsuf ibn Baṣo' in: Thomas Hockey et al (ed), *The Biographical Encyclopedia of Astronomers, Springer Reference,* New York: Springer, 2007, pp. 552-553, http://islamsci.mcgill.ca/RASI/BEA/Ibn_Baso_BEA.htm, [also http://goo.gl/LLqMsA, last accessed in April 2017]

Calvo & Puig 2006 | Emilia Calvo & Roser Puig, 'The Universal Plate Revisted,' *Suhayl: Journal for the History of the Exact and Natural Sciences in Islamic Civilisation,* 6 (2006) 113-157.

Campbell 2004 | Heather Suzanne Campbell, *Art of the Astrolabe,* Master of Arts Dissertation, Department of Arabic Studies, American University of Cairo, 2004 (unpublished).

Canobbio 1976 | Ernesto Canobbio, 'An Important Fragment of a West Islamic Spherical Globe,' *Annali dell'Instituto e Museo di Storia della Scienza d Firenzi,* 1 (1976) 37-41.

Casanova 1923 | Paul Casanova, 'Le montre du sultan Nour ad Din,' *Syria,* 4 (1923) 282-299.
http://www.persee.fr/doc/syria_0039-7946_1923_num_4_4_3008
[also https://goo.gl/iVcJEa, last accessed in June 2017]

Catamo et al 2000 | Mario Catamo, Nicoletta Lanciano, Kurt Locher, Manuel Lomardero & Manuel Valdés, Fifteen further Greco-Roman Sundials from the Mediterranean Area and Sudan, *Journal of History of Astronomy,* 31 (2000) 203-221.

CCA | Sharon L. Gibbs, Janice A. Henderson & Derek de Sola Price, *A Computerized Checklist of Astrolabes*, Yale University, New Haven 1973 Astrolabes are identified with the serial numbers given here.

CESS | David Pingree, *Census of Exact Sciences in Sanskrit,* Series A, vols. 1-5, Philadelphia 1970-1994.

Chandra 1949 | Moti Chandra, *Jain Miniature Paintings from Western India,* Ahmedabad 1949

Chapin, Saymour L. | 'Le Gentil de la Galaisiere, Guillaume-Joseph-Hycinthe-Jean-Baptiste' *Dictionary of Scientific Biography,* 8: 143-145.

Chardin 1735 | Jean Chardin, *Voyages du chevalier Chardin, en Perse et autres lieux de l'orient.* Nouvelle edition. Tome troisième. Amsterdam 1735. pp. 162-203: Chapître IX: De l'astronomie et de l'astrologie, 2 pls. (on the construction and use of the astrolabe). Reprint in: *Islamic Mathematics and Astronomy,* vol. 91 (Astronomical Instruments and Observatories in the Islamic World: Text and Studies VII), Frankfurt 1998, pp. 1-45.

Charette 2003 | François Charette, *Mathematical Instrumentation in the fourteenth-century Egypt and Syria: The Illustrated Treatise of Najm al-Dīn al Miṣrī*, Brill, Leiden 2003.

Charette 2005a | François Charette, 'An early Moghul Astrolabe' in: Cleempoel 2005, pp. 227-231.

Charette 2005b | François Charette, 'An Astrolabe from Moghul Lahore by Muḥammad Muqīm ibn Mullā 'Īsā (1051/1641-42)' in: Cleempoel 2005, pp. 231-236.

Charette 2005c | François Charette, 'A splendid Safavid astrolabe by Muḥammad Mahdī al-Yazdī (1070/1659-60)' in: Cleempoel 2005, pp. 244-257.

Charette 2005d | François Charette, 'An astrolabe from Ayyubid Damascus, signed a-Sarrāj' in: Cleempoel 2005, pp. 210-216.

Charette 2006 | François Charette, 'The Locales of Islamic Astronomical Instrumentation,' *History of Science* 44 (2006) 123-138.

Charette & Schmidl 2001 | François Charette & Petra G. Schmidl. 'A Universal Plate for Timekeeping by the Stars by Ḥabash al-Ḥāsib: Text, Translation and Preliminary Commentary,' *Suhayl: J for the History of the Exact and Natural Sciences in Islamic Civilisation,* 2 (2001) 107-159.

Charette & Schmidl 2004 | François Charette & Petra G. Schmidl. 'al-Khwārizmī and Practical Astronomy in Ninth-Century Baghdad. The Earliest Extant Corpus of Texts in Arabic on the Astrolabe and other Portable Instruments,' *SCIAMUS* 5 (2004) 101-198.

Chaucer | Geoffrey Chauser, *The Treatise on the Astrolabe* in: *The Complete Works of Geoffery Chaucer*, ed. Rev. Walter W. Skeat, Vol. III. Oxford, Impression of 1996.

Cleempoel 2005 | Koenrad van Cleempoel et al (ed), *Astrolabes at Greenwich: A Catalogue of the Astrolabes in the National Maritime Museum,* Oxford University Press & National Maritime Museum, 2005.

Cleempoel 2005a | Koenrad van Cleempoel, 'The Problem of Authenticity' in: Cleempoel 2005, pp. 91-98.

Colebrooke 1837 | H. T. Colebrooke, 'On the Indian and Arabic Divisions of the Zodiac,' in: *Miscellaneous Essays,* vol. II, London 1837, pp. 321-373; esp. 345 ff: on the Armillary Sphere.

Creswell 1947 | K. A. C. Creswell, 'A Bibliography of Islamic Astrolabes,' *Bulletin of the Faculty of Arts, Fouad I University,* Cairo, 9.2 (1947) 1-15.

Crommelin 1948 | C. A. Crommelin, 'Un Astrolabe de Lahore du XVIIeme Siècle dans la Collection du Musée National de l'Histoire des Sciences Exactes et Naturelles à Leiden,' *Orientalia Niederlandia,* 1948, 240-250.

Czenakali 1967 | V. L. Czenakali, 'The Astronomical Instruments of the 17th-18th C in the Museums of the USSR,' *Vistas in Astronomy*, 9 (1967) 53-77.

D

Dalen 2000 | Benno van Dalen, 'Origin of Mean Motion Tables of Jai Singh,' *Indian Journal of History of Science,* 35.1 (2000) 41-66.

Dallal 1984 | A. Dalal, 'Al-Bīrūnī on Climates,' *Archives internationales d'histoire des sciences*, 34 (1984) 3-18.

Dar 1994 | Saifur Rahman Dar, 'Three rare Astrolabes in the Collection of Lahore Museum and Lahore's Contribution towards Astrolabe-Making,' *Lahore Museum Bulletin* 7.1-2 (January-December 1994), pp. 165-198, pl. I-X, figs. 1-3.

Das 1928 | Sukumar Ranjan Das, 'Astronomical Instruments of the Hindus,' *Indian Historical Quarterly,* 4 (1928) 259-269.

Das 2018 | Debasish Das, 'Sundials to tell the Times of Prayers in the Mosques of India', https://lighteddream.wordpress.com/2018/01/01/sundials-to-tell-the-times-of-prayers-in-the-mosques-of-india/
[also https://goo.gl/v9LfY8, last accessed in January 2018]

Dekker 1992 | Elly Decker, 'Der Himmelsglobus. Eine Welt für sich' in: Gerhard Brot (ed), *Focus Behaim Globus*, Nürnberg 1992, vol. I, pp. 89-100.

Dekker & Krogt 1993 | Elly Decker & Peter van der Krogt, *Globes from the Western World*, London 1993.

Dekker & Kunitzsch 2008 | Elly Decker & Paul Kunitzsch. 'An Early Islamic Tradition in Globe Making' *Zeitschrift für Geschichte der Arabisch-Islamischen Wissenschaften,* 18 (2008/9) 155-211.

Dhama 1928-29 | B. L. Dhama, '[Acquisitions by] Delhi Fort Museum,' *Annual Report of the Archaeological Survey of India*, 28 (1928-29) 143-144.

Dikshit 1963 | Sankara Balakrishna Dikshit, *Bhāratīya Jyotiṣa,* translated from the original Marathi into Hindi by Śivanātha Jhārakhaṇḍī, Hindī Samiti Granthamālā 2, second edition, Hindi Samiti, Sucana Vibhag, Uttar Pradesh, Lucknow 1963.

Dikshit 1968 | Sankara Balakrishna Dikshit*, English Translation of Bharatiya Jyotisha Sastra* (*History of Indian Astronomy*)*,* translated [from Marathi into English] by R. V. Vaidya, Part I: History of Astronomy during the Vedic and Vedanga Periods, Director General of Observatories, New Delhi, 1968. https://archive.org/details/BharatiyaJyotishSastra1
[also https://goo.gl/c8KuUF, last accessed in April 2017].

Dikshit 1981 | Sankara Balakrishna Dikshit*, English Translation of Bharatiya Jyotisha Sastra* (*History of Indian Astronomy*)*,* translated [from Marathi into English] by R. V. Vaidya, Part II: History of Astronomy during the Siddhantic and Modern Periods, Director General of Observatories, New Delhi, 1981.
https://archive.org/details/BharatiyaJyotishSastra2
[also https://goo.gl/qy4fRZ, last accessed in April 2017]

Dizer 1986 | Muammar Dizer, *Astronomi Hazineleri,* Kandilli Rasathanesi, Bogazici Universitesi, Istanbul 1986.

Dizer 2001 | Muammar Dizer, 'Observatories and Astronomical Instruments,' in: A. Y. Al-Hassan, et al (ed). *Science and Technology in Islam* (vol. 4 of *The Different Aspects of Islamic Culture*), part I: The Exact and Natural Sciences, UNESCO Publishing, Paris, 2001, ch. 2.2(b), pp. 235-265.

Dizer & Meyer 1979 | M. Dizer & W. Meyer, 'The Celestial Globe of Kandilli made by Ja'far ibn Dawlatshah Al-Kirmani,' in: Said 1979, part I, pp. 14-21.

Donaldson 1945 | Dwight M. Donaldson, 'The Nomenclature and Common Uses of the Astrolabe,' *Islamic Culture*, 19 (1945) 49-53.

Dorn 1842 | B. Dorn, 'Über ein drittes in Russland befindliches Astrolabium mit Mogenländischen Inschriften,' *Bulletin scientifique publié par l'Acad.Imp.des Sciences de St. Pétersbourg* 9 (1842) 61-73; reprinted in Fuat Sezgin (hrsg), *Arabische Instrumente in Orientalistischen Studien*, Frankfurt am Main 1991, Vol. 1, pp. 143-151.

Drach 1894 | C. Alhard von Drach, *Die zu Marburg im Mathematisch-Physikalischen Institut befindliche Globusuhr Wilhelms IV von Hessen, als Kunstwerk und astronomisches Instrument, beschriben und besprochen von Dr. C. Alhard von Drach, Professor under Universität Marburg, mit zwei Lichtdrucktafen,* N. C. Elwertsche Verlagsbuchhandlung, Marburg 1894.

Drecker 1928 | J. Drecker, 'Des Johannes Philoponos Schrift über das Astrolab,' *Isis*, 11 (1928) 15-44.

Dreyer 1886 | J. L. E. Dreyer, 'On the Invention of the Sextant,' *Astronomische Nachrichten,* Nr. 2739 (1886).

Drier 1979 | Franz Adrian Drier, *Winkelmessungsinstrumente vom 16. bis zum frühen 19. Jahrhundert*, Katalog von der Ausstellung im Kunstgewerbemuseum Berlin vom 9.11.1979 bis 23.2.1980. Berlin 1979.

DSB | Charles Couston Gillipse*Dictionary of Scientific Biography,* 16 vols, 1970-1980.

Dube 1928 | Padmakara Dube, 'Astrolabes in the State Library Rampur,' *The Journal of the United Provinces Historical Society*, 4.1 (October 1928) 1-11, Pl. I-IV.

Dvivedi 1923 | Padmakara Dvivedi, 'A Seventeenth Century Astrolabe' in: Gopinath Kaviraj (ed), The Princess of Wales Saraswati Bhavan Studies, volume II, Benares 1923, pp. 129-136.

E

Eiseman 1990 | Fred B. Eiseman Jr, *Bali: Sekala and Nishkala.* volume II: Essays on Society, Tradition and Craft. Periplus Editions, Berkley and Singapore 1990; pp. 240-250 on the use of water clock during cock fights.

Elgood 1968 | C. Elgood, 'Persian Science' in: A. J. Arberry (ed), *The Legacy of Persia*, Oxford 1953, reprinted 1968, pp. 293-317.

Elliot & Dawson | *The History of India, as told by its own Historians: The Muhammadan Period,* edited from the posthumous papers of the late Sir H. M. Elliot, K.C.B., East India Company's Bengal Civil Service, by Professor John Dowson, M.R.A.S., Staff College, Sandhurst, vols. I-VIII, Trübner & Co., London 1867-1877.

English 1968 | Paul Ward English, 'The Origin and Spread of Qanats in the Old World,' *Proceedings of the American Philosophical Society*, 112.3 (21 June1968) 170-181

ESS | Emilie Savage-Smith, Islamicate Celestial Globes: Their History, Construction and Use, Washington, D.C., 1985.

F

Falk 2000 | Harry Falk, 'Measuring Time in Mesopotamia and ancient India,' *Zeitschrift der Deutschen Morgenländischen Gesellschaft,* 150 (2000) 107-132.

Falk 2012 | Harry Falk, 'Ancient Indian Eras: An Overview,' *Bulletin of the Asia Institute* 21 (2012) 131-145.

Faransīs & Naqshabandī 1957 | Bashīr Faransīs & Naṣīr Naqshabandī, '*Al-Asṭurlābāt fī Dār al-āthār al-ᶜarabiyya fī Baghād,' Sumer* (Baghdad) 13 (1957) 9-33 and 5 plates; reprinted in: Sezgin 1998, XIII.

Fatimi 1979 | S. Q. Fatimi, 'The Genesis of the 'Kamal' in: Said 1979, part I, pp. 29-45.

Feldhaus 1931 | Franz M. Feldhaus, *Die Technik der Antike und des Mittelalters*, Potsdam 1931.

Fergusson 1910 | James Fergusson, *History of Indian & Eastern Architecture,* 1910, reprint: Delhi 2006.

Filippoupoliti 2013 | Anastasia Filippoupoliti, '"What a scene it was, that labyrinth of strange relics of science": Attitudes towards Collecting and Circulating Scientific Instruments in Nineteenth-Century England,' *Cultural History* 2.1 (2013)16–37.

Firneis 1987 | Maria Firnais, 'A Moorish Astrolabe from Granada' in: Swarup et al (ed), *History of Oriental Astronomy*, Cambridge 1987, pp. 227-32.

Fischel 2012 | Roy Fischel, *Society, Space, and the State in the Deccan Sulṭānates, 1565-1636,* Dissertation, University of Chicago, 2012. UMI Dissertation Publishing, UMI Number 3526296.

Fleet 1915 | J. F. Fleet, 'The Ancient Indian Water-Clock,' *Journal of the Royal Asiatic Society* (1915) 213-230.

Folsach 1945 | Kjeld von Folsach, *Islamic Art: The David Collection,* Copenhagen 1990. Introduction pp. 9-32; Metal: pp. 182-185, 1945, 207, 214-15.

Forbes 1983 | Eric G. Forbes, 'A 16th-Century Indian Miniature illustrating two Arab Navigational Instruments' in: Papers Presented [at the] International Conference on Science in Islamic Polity 2: Islamic Scientific Thought and Muslim Achievements in Science, Islamabad 1983, vol. II, pp. 330-337.

Frank 1920 | Joseph Frank, *Zur Geschichte des Astrolabes*, Habilitationsscrift - Auszug. Erlangen 1920; reprinted in: Sezgin 1998, IV, pp. 31-62.

Frank 1921 | Joseph Frank, 'Über zwei astronomische Arabische Instrumente,' *Zeitschrift für Instrumentenkunde,* 41.7 (Juli 1921) 193-200; reprinted in: Sezgin 1998, IV, pp. 62-70.

Frank & Meyerhof 1925 | Joseph Frank & Max Meyerhof, *Ein Astrolab aus dem Indischen Mogulreiche*, Heidelberg 1925; reprinted in: Sezgin 1998, IV, pp. 307-356

Fraser 1982 | J. T. Fraser, *The Genesis and Evolution of Time: A Critique of Interpretation in Physics*, Amherst 1982, ch. 1, pp. 1-18, esp. p. 7 on the astrolabe.

Fullerton & Fehérvári 1995 | Arlene Fullertone & Géza Fehérvári, *Kuwait: Arts and Architecture: A Collections of Essays*, Kuwait 1995.

G

Gansten & Wikander 2011 | Martin Gansten & Ola Wikander, 'Sahl and the Tājika Yogas: Indian Transformations of Arabic astrology,' *Annals of Science,* 68.4 (October 2011) 531-546.

Garg 1992 | Sanjay Garg, 'The Closure of the Delhi Mint, A.D. 1818' in: D.W. MacDowall, Savita Sharma & Sanjay Garg (ed), *Indian Numismatics, History, Art and Culture: Essays in Honour of Dr. Parmeshwari Lal Gupta*, volume II, Delhi 1992, pp.233-240.

Garrett & Guleri 1902 | A. ff. Garrett & Chandradhar Guleri, *The Jaipur Observatory and its Builder*, Allahabad 1902.

Gaulke 2007 | Karsten Gaulke (bearbeitet). *Der Ptolemäus von Kassel: Landgraf Wilhelm IV. von Hessen-Kassel und die Astronomie.* (Katalog der Museumslandschaft Hessen Kassel, Bd. 38). Museumslandschaft Hessen Kassel, Kassel 2007.

Gibbs 1976 | Sharon L. Gibbs, *Greek and Roman Sundials,* Yale University Press, New Haven and London, 1976.

Gibbs 1977 | Sharon Gibbs, 'The First Scientific Instrument,' *Technology Review*, 80.2 (December 1977) 40-51.

Gibbs, Henderson & Price 1973 | Sharon L. Gibbs, Janice A. Henderson& Derek de Sola Price, *A Computerized Checklist of Astrolabes*, Yale University, New Haven 1973 = CCA.

Gibbs & Saliba 1984 | Sharon Gibbs & George Saliba. *Planispheric Astrolabes from the National Museum of American History*, Smithsonian Studies in History and Technology 45, Washington DC 1984.

Gilchrist 1795 | John Gilchrist, 'Account of the Hindustanee Horometry,' *Asiatick Researches*, 5 (1795) 81-89.

Gingerich 1971 | Owen Gingerich, 'Rara Astronomica,' *Harvard Library Bulletin,* 19.2 (1971) 117-139, 12 plates.

Gingerich 1982a | Owen Gingerich, 'An Astrolabe from Lahore,' *Sky and Telescope* 63 (1982) 358-60; reprinted in Gingerich 1992, pp. 132-138.

Gingerich 1982b | Owen Gingerich, 'Fake Astrolabes,' *Sky and Telescope* 63 (1982) 465-468; reprinted in Gingerich 1992, pp. 139-145.

Gingerich 1986 | Owen Gingerich, 'Islamic Astronomy,' *Scientific American* 254.4 (April 1986) 74-83; reprinted in Gingerich 1992, pp. 43-56.

Gingerich 1987a | Owen Gingrrich, 'Zoomorphic Astrolabes and the Introduction of Arabic Star Names in Europe' in: David A. King and George Saliba (ed), *From Deferent to Equant: A Volume of Studies in the History of Science in the Ancient and Medieval Near East in Honor of E. S. Kennedy* (= *Annals of the New York Academy of Sciences*, vol. 500), New York 1987, pp. 89-104.

Gingerich 1987b | Owen Gingerich, 'Concluding Remarks' in: Swarup et al (ed), *History of Oriental Astronomy*, Cambridge 1987, pp. 273-276.

Gingerich 1992 | Owen Gingerich, *The Great Copernicus Chase and other Adventures in Astronomical History*, Cambridge, Mass. 1992.

Gingerich, King & Saliba 1972 | Owen Gingerich, David King & George Saliba, 'The 'Abd al-A'imma Astrolabe Forgeries,' *Journal of History of Astronomy,* 2 (1972) 188-198.

Glick 1969 | Thomas Glick, 'Medieval Irrigation Clocks,' *Technology and Culture,* 10 (1969) 424-28.

Gole 1989 | Susan Gole, Indian Maps and Plans: From Earliest Times to the Advent of European Surveys, New Delhi, 1989.

Gotstedter 1994 | Anton von Gotstedter (hrsg.), *Ad Radices. Festband zum fünfizigjährigen Bestehen des Instituts für Geschichte der Naturwissenschaften der Johann Wolfgang Goethe-Universität Frankfurt am Main*, Stuttgart 1994.

Govind 1979 | Vijai Govind, 'A Survey of Medieval Indian Astrolabes,' *Bhāratīya Vidyā*, 39.1 (1979) 1-30.

Graaf 2011 | Wilfred de Graaf, *Astrolabe,*
http://www.astro.ru.nl/~fverbunt/iac2011/astrolabe.pdf
[also http://goo.gl/rqjhrX, last accessed in April 2017]

Gulbadan Begam | Gulbadan Begam, *The History of Humāyūn* (*Humāyūn-Nāma*), tr. Annette S. Beveridge, London 1902.

Gunther 1923 | R. T. Gunther, *Early Science in Oxford*, vol. II: Astronomy, Oxford 1923: pp. 187-199: Oriental Astrolabes.

Gunther 1932 | R. T. Gunther, *The Astrolabes of the World*, Oxford 1932; reprint: Holland Press, London 1976; vol. 1: The Eastern Astrolabes is reprinted in Sezgin 1998, X, pp. 1-262.

Gutas 1998 | Dimitri Gutas, Greek Thought, Arabic Culture: The Graeco-Arabic Translation Movement in Baghdad and the Early 'Abbāsid Society (2nd-4th/8th-10th centuries). Routledge, London nd New York, 1998.

Guye & Michel 1971 | Samuel Guye & Henri Michel, *Uhren und Messinstrumente des 15. Bis 19. Jahrhunderts,* Mit einem Vorwort von Nicolas E. Landau, Fotos von Pierre Devinoy, aus dem Französischen übersetzt von Alfred P. Zeller, Orell Füssli Verlag, Zürich, 1971 [original: *Mesures du tomps et de l'space,* Office du Livre, Fribourg, 1970]

H

Habib 1977 | Irfan Habib, 'Cartography in Mughal India,' *Medieval India: A Miscellany,* 4 (1977) 122-134.

Habib 1986 | Irfan Habib, *An Atlas of the Mughal Empire: Political and Economic Maps with Detailed Notes, Bibliography and Index,* Oxford University Press, New Delhi 1982; reprinted with corrections 1986.

Hartner 1968 | Willy Hartner, *Oriens-Occidens: Ausgewählte Schriften zur Wissenschafts- und Kulturgeschichte*, Festschrift zum 60. Geburtstag, Hildesheim 1968, pp. 287-311.

Hartner 1968a | Willy Hartner, 'The Principles and Use of the Astrolabe' in: Hartner 1968, pp. 287-311.

Hartner 1968b | Willy Hartner, 'Asṭurlāb' in: Hartner 1968, pp. 312-318.

Hayashi 2017 | Takao Hayashi, 'The Units of Time in Ancient and Medieval India,' *History of Science in South Asia,* 5.1 (2017) 1-116.

Hayton 2012 | Darin Hayton, *An introduction to the Astrolabe*, ebook, http://dhayton.haverford.edu/wp-content/uploads/2012/02/Astrolabes.pdf [also https://goo.gl/KSKs7E, last accessed in January 2018].

Heilbron 1993 | J. L. Heilbron, 'Some Uses for Catalogues of Old Scientific Instruments' in: R. G. W. Anderson et al (ed), *Making Instruments Count: Essays on Historical Scientific Instruments presented to Gerard L'Estrange Turner*, Variorum, Aldershot 1993, pp. 1-16.

Helmecke 1985 | Gisela Helmecke, 'Das Berliner Astrolab des Muḥammad Zamān al-Mašhadī,' *Forschungen und Berichte der Staatlichen Museen zu Berlin, Hauptstadt der DDR,* Akademie Verlag, Berlin, 25 (1985) 129-142, pls. 31-32.

Higgins 1953 | Kathleen Higgins, 'The Classification of Sundials,' *Annals of Science*, 9.4 (Dec 1953) 342-358.

Hill 1974 | *The Book of Knowledge of Ingenious Mechanical Devices* (*Kitāb fī maᶜrifat al-ḥiyal al-handasiyya*) by Ibn al-Razzāz al-Jazarī, translated and annotated by Donald R. Hill, Dordrecht-Boston 1974.

Hill 1981 | Donald R. Hill, *Arabic Water-Clocks.* Sources & Studies in the History of Arabic-islamic Science. History of Technology Series-4. University of Aleppo, Institute for the History of Arabic Science, Aleppo, Syria, 1981.

Hill 1982 | Donald R. Hill, 'Ḥiyal' (device/machinery), *Encyclopedia of Islam*, New Edn., Supplement, Fasc. 5-6, Leiden, 1982, pp. 371-374.

Hill 1996 | Donald R. Hill, 'Engineering' in: Roshdi Rashed 1996, vol. 3, pp. 751-95.

Hill 1998 | Donald R. Hill, *Studies in Medieval Technology: From Philo to al-Jazarī — from Alexandria to Diyār Bakr,* edited by David A. King, Ashgate/Variorum, Aldershot 1998.

Hinüber 1978 | Oskar von Hinüber, 'Probleme der Technikgeschichte im alten Indien.' *Saeculum,* 29.3 (1978) 215-230.

Hodivala 1939 | Shapurshah Hormasji Hodivala, *Studies in Indo-Muslim History. A Critical Commentary of Elliot-Dowson's History of India as told by its own historians.* Bombay 1939.

Hoernle 1890 | August Friedrich Rudolf Hoernle, 'Exhibition of two Astrolabes,' *Proceedings of the Asiatic Society of Bengal,* 1890, April, pp. 148-149; reprinted in: Sezgin 1998, VIII, pp. 348-349.

Hogendijk 2001 | Jan P. Hogendijk, 'The Contributions by Abu Nasr ibn 'Iraq and al-Saghani to the Theory of Seasonal Hour Lines on Astrolabes and Sundials,' *Zeitschrift für Geschichte der Arabisch-Islamischen Wissenschaften,* 14 (2001) 1-30.

Holbrook, Anderson & Bryden 1992 | Mary Holbrook, R. G. W. Anderson & D. J. Bryden, Science Preserved: A Directory of Scientific Instruments in Collections in the United Kingdom and Eire, London 1992.

Honey 2006 | Leonard Honey, 'The Nocturnal and other Early Scientific Instruments,' *Horological Journal,* December 2006, pp. 457-459.

Hunter 1799 | William Hunter, 'Some Account of the Astronomical Labours of Jayasinha, Rajah of Ambhere, or Jayanagar,' *Asiatick Researches*, 5 (1797) 177-211.

I

Ideler 1809 | Ludewig Ideler, *Untersuchungen über den Ursprung und die Bedeutung der Sternnamen: Ein Beytrag zur Geschichte des gestirnten Himmels*, Berlin 1809.

Irani 1955 | R. K. Irani, 'Arabic Numerical Forms,' *Centaurus*, 4 (1955) 1-12.

I-Tsing 1896 | Yijing (modern spelling), *A Record of the Buddhist Religion as practised in India and the Malay Archipelago (A.D. 671-695),* tr. J. Takakusu, (London 1896); reprint: Delhi 1966.

J

Jacobi 1920 | Hermann Jacobi, 'Einteilung des Tages und Zeitbestimmung in alten Indien,' *Zeitschrift der Deutschen Morgenländischen Gesellschaft*, 74 (1920) 247-263.

Jagannātha 1976 | *Siddhāntasamrāṭ, Jaganntha-samrāḍ-viracitaḥ,* University of Sagar, Sagar 1976.

Jagannātha 1967-69 | *Samrād Jagannāth-viracita Samrāṭ-siddhānta* (*Siddhānta-sāra Kaustubha*), ed. Ram Swarup Sharma et al, 3 vols., Indian Institute of Astronomical and Sanskrit Research, New Delhi 1967-69.

Jahangir | *The Tūjuk-i-Jahāngīrī Or Memoirs of Jahāngīr,* tr. Alexander Rogers & Henry Beveridge, London 1909-1914.
http://persian.packhum.org/persian/main?url=pf%3Ffile%3D80201010%26ct%3D0,
[also http://goo.gl/7Qjz7X, last accessed in January 2018]

Jardine, Nall & Hyslop 2017 | Boris Jardine, Joshua Nall & James Hyslop, 'More than Mensing? Revisiting the Question of Fake Scientific Instruments', *Bulletin of the Scientific Instrument Society,* No. 132 (2017) 22-29.

Jawnpūrī 1835 | Ghulām Ḥussayn Jawnpūrī, *Jāmiᶜ Bahādur Khānī*, Calcutta 1835; book 2, chapter 5 on instruments.

K

Kapoor 2016 | R. C. Kapoor, 'Ghulām Ḥusain Jaunpūrī, an early 19th century moden Indian astronomer,' *Current Science,* 110.12 (25 June 2016) 2309-2314.

Kauṭilya, *Arthaśāstra* | *The Kauṭilīya Arthaśāstra,* Part I: Text with Glossary; Part II: Translation with Critical and Explanatory Notes, ed & tr. K. P. Kangle, 7th reprint, Delhi 2010.

Kaye 1918 | G. R. Kaye, *The Astronomical Observatories of Jai Singh*, (Archaeological Survey of India, New Imperial Series, vol. XL), Calcutta 1918; reprint: Archaeological Survey of India, New Delhi 1982.

Kaye 1920 | G. R. Kaye, *A Guide to the Old Observatories at Delhi, Jaipur, Ujjain, Benares*. Calcutta, Superintendent of Government Printing, India, 1920; reprint: Gurgaon 1985.

Kaye 1921 | G. R. Kaye, *Astronomical Instruments in the Delhi Museum*, (Memoirs of the Archaeological Survey of India, 12), Calcutta 1921; reprinted in: Sezgin 1988, IV, pp. 71-101.

Kennedy 1961 | E. S. Kennedy, 'Al-Kāshī's Treatise on Astronomical Observsational Instruments,' *Journal of the Near Eastern Studies,* 20.2 (April 1961) 98-108.

Kennedy 1978 | E. S. 'Al-Biruni,' *Dictionary of Scientific Biography,* vol. 2, pp. 147-158.

Kennedy 1987a | E. S. & M. H. Kennedy, *Geographical Coordinates of Localities from Islamic Sources,* Institute für Geschichte der Arabisch-Islamischen Wissenschaften an der Johann Wolfgang Goethe-Universität, Frankfurt am Main 1987.

Kennedy 1987b | E. H. & M. H. Kennedy, *Al-Kāshī's Geographical Table*, Transactions of the American Philosophical Society, Volume 77, Part 7, Philadelphia 1987.

Kennedy 1989 | E. S. Kennedy, 'Al-Ṣūfī on the Celestial Globe,' *Zeitschrift für Geschichte arabisch-islamischen Wissenschaften,* 5 (1989) 48-93.

Kennedy 1995-96 | E. S. Kennedy, 'Treatise V of Kāshī's Khāqānī Zīj: Determination of the Ascendent,' *Zeitschrift für Geschichte der arabisch-islamischen Wissenschaften,* 10 (1995-96) 123-145.

Kern 1976 | Hermann Kern, *Kalendarbauten: Frühe astronomische Grossgeräte aus Indien, Mexico und Peru,* Staatliche Museen für angewandte Kunst, München, 1976.

Khareghat 1950 | M. P. Khareghat, *Astrolabes*, M. P. Khareghat Memorial Volume II, edited by Dinshaw D. Kapadia, Bombay 1950.

King 1981 | David A. King, 'The Origin of the Astrolabe According to the Medieval Islamic Sources,' *Journal for the History of Arabic Science* 5 (1981) 43-62; 81-83.

King 1982 | David A. King, 'Astronomical Alignments in Medieval Islamic Religious Architecture,' *Annals of the New York Academy of Sciences,* 1982, pp. 303-312.

King 1985a | David A. King, 'The Sacred Direction in Islam: A Study of the Interaction of Religion and Science in the Middle Ages,' *Interdisciplinary Science Reviews* 10.4 (1985) 315-328.

King 1985b | David A. King, 'The Medieval Yemeni Astrolabe in the Metropolitan Museum of Art in New York City,' *Zeitschrift für Geschichte der Arabisch-Islamischen Wissenschaften*, 2 (1985) 99-122.

King 1987a | David A. King, *Islamic Astronomical Instruments*, Variorum reprints, London 1987.

King 1987b | David A. King, 'Astronomical Instrumentation in the Medieval Near East' in: King 1987a, I, pp. 1-21.

King 1987c | David A. King, 'On the Early History of the Universal Astrolabe in Islamic Astronomy, and the Origin of the Term 'Shakkazīya' in Medieval Scientific Arabic' in: King 1987a, VII, pp. 244-257.

King 1991 | David A. King, 'Medieval Astronomical Instruments: A Catalogue in Preparation,' *Bulletin of the Scientific Instrument Society*, 31 (1991) 3-7.

King 1992a | David A. King, 'Weltkarten zur Ermittlung der Richtung nach Mekka' in: Gerhard Brot (ed), *Focus Behaim Globus*, Nuernberg 1992, vol. I, pp.167-171.

King 1992b | David A. King, 'Die Astrolabiensammlung des Germanischen Nationalmuseums' in: Gerhard Brot (ed), *Focus Behaim Globus*, Nuernberg 1992, vol. I, pp. 101-114.

King 1992c | David A. David, 'Some Remarks on Islamic Astronomical Instruments,' *Scientiarum Historia*, 18.1 (1992) 5-23.

King 1993a | David A. *Islamic Mathematical Astronomy,* Variorum, Second Edition, 1993.

King 1993b | David A. King, *Astronomy in the Service of Islam,* Variorum 1993.

King 1993c | David A. King, 'On the Astronomical Tables of Islamic Middle Ages' in: King 1993a, II.

King 1993d | David A. King, 'Science in the Service of Religion: the Case of Islam' in: King 1993b, I.

King 1993e | David A. King, 'Mīkāt: Astronomical Time-Keeping' in: King 1993b, V.

King 1993f | David A. King, 'Some Medieval Astronomical Instruments and their Uses' in: Renato G. Mazzolini (ed), *Non-Verbal Communication in Science prior to 1900*, Firenze 1993, pp. 29-52.

King 1993g | David A. King, 'Rewriting History through Instruments: The Secrets of a Medieval Astrolabe from Picardy' in: Anderson 1993, pp. 42-62.

King 1994 | D[avaid] A. King, 'Rub^{c},' *The Encyclopaedia of Islam*, new edition, vol. VIII, fascs. 139-140, Leiden: E. J. Brill, 1994, pp. 574-575.

King 1995 | David A. King, 'Early Islamic Astronomical Instruments in Kuwaiti Collections' in Fullerton & Fehérvári 1995, pp. 76-96.

King 1996a | David A. King, 'The Neglected Astrolabe' in: Menso Folkerts (ed), *Mathematische Probleme im Mittelalter: Der lateinische und arabische Sprachbereich*, Wiesbaden 1996, pp. 45-55.

King 1996b | David A. King, 'The Earliest known European Astrolabe in the Light of other Early Astrolabes,' *Physis: Rivista internazionale di storia della scienza*, 32 (1996) 359-404.

King 1996c | David A. King, 'Astronomy and Islamic Society: Qibla, Gnomonics and timekeeping' in: Roshid 1996, I, pp. 128-184.

King 1997 | David A. King, 'Two Iranian World Maps for Finding the Direction and Distance to Mecca,' *Imago Mundi, the International Journal for the History of Cartography*, 49 (1997) 62-82.

King 1999a | David A. King, 'Bringing Astronomical Instruments back to Earth—The Geographical Data on Medieval Astrolabes (to ca. 1100)' in: Lodi Nauta & Arjo Vanderjagt (ed), *Between Demonstration and Imagination: Essays in the History of Science and Philosophy presented to John D. North*, Brill: London-Boston-Köln 1999, pp. 3-53; reprinted in King 2005, pp. 963-992.

King 1999b | David A. King, *World-Maps for Finding the Direction and Distance to Mecca: Innovation and Tradition in Islamic Science*. Islamic Philosophy, Theology and Science: Texts & Studies, XXXVI. London: al-Furqān Islamic Heritage Foundation, and Leiden: Brill, 1999.

King 2000a | David A. King, 'Cataloguing Medieval Astronomical Instruments (Essay Review of Francis Maddison and Emilie Savage-Smith, *Science, Tools & Magic*, vol. XII (in 2 parts) of *The Nasser D. Khalili Collection of Islamic Art of Islamic Art,* London 1997 in: *Bibliotheca Orientalis,* 57.3-4 (May-August 2000) 248-258.

King 2000b | David A. King, 'The Star-Names on Three 14th-Century Astrolabes from Spain, France and Italy' in: Menso Flokerts & Richard Lorch (ed), *Sic ad Astra: Studien zur Geschichte der Mathematik und Naturwissenschaften: Festschrift für den Arabisten Paul Kunitzsch zum 70. Geburtstag,* Wiesbaden 2000, pp. 307-333.

King 2002-03 | David A. King, 'An Astrolabe from 14th-century Christian Spain with Inscriptions in Latin, Hebrew and Arabic: A unique Testimonial to an intercultural Encounter,' *Suhayl: Journal for the History of the Exact and Natural Sciences in Islamic Civilisation,* 3 (2002-03) 9-156.

King 2004 | David A. King, *In Synchrony with the Heavens: Studies in Astronomical Time Keeping and Instrumentation in Medieval Islamic Civilization.* Brill, London-Boston 2004. Islamic Philosophy Theology and Science, Texts and Studies, edited by H. Daibar and D. Pingree. Volume One: The Call of the Muezzin (Studies I-IX).

King 2005 | David A. King, *In Synchrony with the Heavens: Studies in Astronomical Time Keeping and Instrumentation in Medieval Islamic Civilization.* Brill, London-Boston 2005. Islamic Philosophy Theology and Science, Texts and Studies, edited by H. Daibar and D. Pingree. Volume Two: Instruments of Mass Calculation (Studies X-XVIII).

King 2008 | David A. King, 'An Instrument of Mass Calculation made by Nasṭūlus in Baghdad *ca.* 900,' *Suhayl,* 8 (2008) 93-119.

King & Lorch 1992 | David A. & Richard P. Lorch. 'Qibla Charts, Qibla Maps, and Related Instruments' in: J. B. Herley & David Woodward (ed), *Cartography in the Traditional Islamic and South Asian Societies* (*The History of Cartography*, Vol. II, 1), Chicago 1992, pp. 189-205.

King & Turner 1994 | David A. King & Gerard L'E. Turner. 'The Astrolabe presented by Regiomontanus to Cardinal Bessarion in 1462,' *Nuncius: Annali di Storia della Scienza*, 9 (1994) 165-206.

Klüber 1935 | Harald von Klüber, 'Über einen Arabischen Himmelsglobus aus Indien,' *Baesler Archiv: Beitraege zur Voelkerkunde* 18 (1935) 1-21.

Kulkarni 1988 | R. P. Kulkarni, 'A Water Instrument to Measure the Time of one Nālikā,' *Annals of the Bhandarkar Oriental Research Institute* 69 (1988) 279-281

Kumari 1994 | Krishna Kumari, *Studies on Medieval Andhra History and Culture,* New Delhi 1994, pp. 67-70: 'Evidence of the Use of Gadiyaramu in Medieval Andhra'

Kunitzsch 1959 | Paul Kunitzsch, *Arabische Sternnamen in Europa,* Otto Harrassowitz, Wiesbaden 1959.

Kunitzsch 1982 | Paul Kunitzsch, *Glossar der arabische Fachausdrücke in der mittelalterlichen europäischen Astrolabliteratur,* Vandenhoeck & Ruprecht, Göttingen 1982.

Kunitzsch 1984 | Paul Kunitzsch, 'Remarks Regarding the Terminology of the Astrolabe,' *Zeitschrift für die Geschichte der Arabisch-Islamischen Wissenschaften*, 1 (1984) 55-60; reprinted in: Kunitzsch 1989, VIII.

Kunitzsch 1986 | Paul Kunitzsch, 'Star Catalogues and Star Tables in Medieval Oriental and European Astronomy, *Indian Journal of History of Science,* 21.2 (1986) 113-122.

Kunitzsch 1989 | Paul Kunitzsch, The Arabs and the Stars: Texts and Traditions on the Fixed Stars and their Influence in Medieval Europe, Variorum, Northompton 1989.

Kunitzsch 1989a | Paul Kunitzsch, 'Remarks Regarding the Terminology of the Astrolabe' in: Kunitzsch 1989, VIII.

Kunitzsch 1989b | Paul. Kunitzsch, 'Al-Khwārizmī as a Source for the *scientie astrolabii'* in: Kunitzsch 1989, IX.

Kunitzsch 1989c | Paul Kunitzsch, 'On the Authenticity of the Treatise on the Composition and the Use of the Astrolabe ascribed to Messahalla' in: Kunitzsch 1989, X,

Kunitzsch 1989d | Paul Kunitzsch, 'al-Manāzil' in: Kunitzsch 1989, XX.

Kunitzsch 1998 | Paul Kunitzsch, 'Traces of a Tenth-Century Spanish-Arabic Astrolabe,' *Zeitschrift für Geschichte der arabisch-islamischen Wissenschaften,* 12 (1998) 113-120.

Kunitzsch 2005 | Paul Kunitzsch, 'The Stars on the Astrolabe,' in: Cleempoel 2005, pp. 41-46.

Kunitzsch & Smart 1986 | Paul Kunitzsch & Tim Smart, *Short Guide to Modern Star Names and their Derivations,* Otto Harrassowitz, Wiesbaden 1986. Reprint: Sky Publishing, USA, 2006.

Kurz 1975 | Otto Kurz, *European Clocks and Watches in the Near East,* The Waburg Institute, University of London, London & E. J. Brill, Leiden, 1975.

L

Lalla | *Śiṣyadhīvṛddhida Tantra of Lalla,* with the commentary of Mallikārjuna Sūri, Critical Edition with Introduction, English Translation, Mathematical Notes and Indices by Bina Chatterjee, Part I: Critical Edition with Commentary, Part II: Translation and Mathematical Notes, Indian National Science Academy, New Delhi, 1981.

Lagadha, *Vedāṅga-jyotiṣa* | *Vedāṅga Jyotiṣa of Lagadha, in its Ṛk and Yajus Recensions,* with the Translation and Notes by T. S. Kuppanna Sastry, critically edited by K. V. Sarma, Indian National Science Academy, New Delhi 1985.

Linton 1980 | Leonard Linton, *Collection Leonard Linton et de divers amateurs,* Catalogue of Auction at Paris on 9-10 October 1980, Paris 1980.

Lorch 1976 | R. P. Lorch, 'The Astronomical Instruments of Jābir ibn Aflah and the Torquetum,' *Centaurus,* 20.1 (1976) 11-34.

Lorch 1980 | Richard Lorch, 'Al-Khāzinī's Sphere that Rotates by Itself,' *Journal for the History of Arabic Science*, 4 (1980) 287-329.

Lorch 1981 | Richard Lorch, 'A Note on the Horary Quadrant,' *Journal for the History of Arabic Science*, 5 (1981) 115-120.

Lorch 1994 | Richard Lorch, 'Mischastrolabien im arabisch-islamischen Kulturgebiet' in: Gotstedter 1994, pp. 231-236.

Lorch 2005a | Richard Lorch, *Al-Farghānī on the Astrolabe,* Arabic Text edited with Translation and Commentary, Franz Steiner verlag, Wiesbaden 2005.

Lorch 2005b | Richard Lorch, 'The Literature of the Astrolabe' in: Cleempoel 2005, pp. 23-30.

M

Mackensen 1982 | Ludolf von Mackensen et al, *Die erste Sternwarte Europas mit ihren Instrumenten und Uhren: 400 Jahre Jost Bürgi in Kassel*, zweite bearbeitete und vermehrte Auflage zum 350. Todesjahr von Jost Bürgi, München 1982.

Maddison 1957 | Francis Maddison, *A Supplement to a Catalogue of Scientific Instruments in the Collection of J. A. Billmeir, Esq.,* C.B.E., Exhibited by the Museum of the History of Science, Oxford, Oxford-London 1957.

Maddison 1962 | Francis Maddison, 'A 15th Century Islamic Spherical Astrolabe,' *Physis*, 4 (1962) 101-107.

Maddison 1963 | Francis Maddison, 'Early Astronomical and Mathematical Instruments,' *History of Science*, 2 (1963) 16-50.

Maddison 1992 | Francis R. Maddison, 'The Barber's Astrolabe,' *Interdisciplinary Science Reviews*, 17.4 (1992) 349-355.

Maddison 1997a | Francis Maddison, 'Observatoires portatifs: les instruments arabes à usage pratique,' in: Rashed, Roshdi. *Histoire des sciences arabes,* sous la direction de Roshdi Rashed avec la collaboration de Régis Morelon, 1. Astronomie, théreque et appliqué, Paris, 1997, pp. 138-172.

Maddison 1997b | Francis Maddison, 'On the Origin of the Mariner's Astrolabe,' SPHAERA, Occasional Papers, No. 2, February 1997, Museum of the History of Science, Oxford.

Maddison 2002 | Francis Maddison, 'On al-Khujandi's astrolabe of 374/984-5' in: James Allen, *Metal Work Treasures from the Islamic Countries,* James Allen with a Contribution by Francis Maddison, Doha & London 2002.

Maddison & Brieux | See Répertoire.

Maddison & Savage-Smith 1997 | Francis Maddison & Emilie Savage-Smith. *Science, Tools & Magic*, Part One: *Body and Spirit, Mapping the Universe*, by Francis Maddison and Emilie Savage-Smith. Part Two: *Mundane Worlds*, by Emilie Savage-Smith with contributions from Francis Maddison, Ralph Pinder-Wilson and Tim Stanley (The Nasser D. Khalili Collection of Islamic Art, Vol. XII), London: Nour Foundation in Association with Azimuth Editions; Oxford: Oxford University Press, 1997.

Maddison & Turner 1976 | Francis Maddison & Anthony Turner. Catalogue of an Exhibition 'Science and Technology in Islam' held at the Science Museum, London, April- August 1976, in association with the Festival of Islam, (typescript privately circulated).

Mahdi 1996 | Muhsin Mehdi, 'Postface: Approaches to the History of Arabic Science,' in: Rashed 1996, vol. 3, pp. 1026-1044.

Mahendra Sūri | *Yantrarāja* of Mahendra Sūri, together with the Commentary of Malayendu Sūri and *Yantraśiromaṇi* of Viśrāma, ed. Kṛṣṇaśaṃkara Keśavarāma Raikva, Bombay 1936. (cited by page, or by chapter and verse).

Majumdar 1956 | A. K. Majumdar, *Chaulukyas of Gujarat.* Bombay 1956

Malayendu Sūri | Commentary in: *Yantrarāja of Mahendra Sūri, together with the Commentary of Malayendu Sūri and Yantraśiromaṇi of Viśrāma,* ed. Kṛṣṇaśaṃkara Keśavarāma Raikva, Bombay 1936. (cited by page, or by chapter and verse).

Maslikov & Sarma 2016 | Sergei Maslikov & Sreeramula Rajeswara Sarma, 'A Lahore Astrolabe of 1587 at Moscow: Enigmas in its Construction,' *Indian Journal of History of Science,* 51.3 (2016) 454-477.

Mayer 1956 | L. A. Mayer, *Islamic Astrolabists and their Works*, Genève 1956.

Mayer 1959 | L. A. Mayer, 'Islamic Astrolabists: Some New Material' in: *Aus der Welt der islamischen Kunst: Festschrift für Ernst Kühnel zum 75. Geburtstag am 26.10.1957.* Berlin 1959, pp. 293-296; reprinted in Sezgin 1998, XII, pp. 291-294.

Meghani 2017 | Kajal Meghani, *Splendours of the Subcontinent: A Prince's Tour of India 1875-76,* Royal Collection Trust, London 2017.

Mercier 1984 | Raymond Mercier, 'The Astronomical Tables of Rajah Jai Singh Sawā'ī,' *Indian Journal of History of Science,* 19.2 (1984) 143-47.

Mercier 1993 | Raymond Mercier, 'Account by Joseph Dubois of Astronomical Work under Jai Singh Sawā'ī,' *Indian Journal of History of Science,* 28.2 (1993) 157-66.

Michaels 1986 | Axel Michaels, 'Der Cire-Perdue-Guss im Silpasastra', *Studien zur Indologie und Iranistik,* 11-12 (1986) 77-108.

Michaels 1988 | *The Making of a Statue - Lost-wax Casting in Nepal,* Nepal Research Centre Publications 6, Franz Steiner Verlag, Wiesbaden 1988.

Michel 1936 | Henri Michel, 'Description d'un Astrolabe person construit par Muhammad-Mehdi', *Ciel et Terre, Bulletin mensuel de la Société Belge d'Astronomie*, 52.8-10 (1936) 1-16; reprinted in: Sezgin 1998, X, pp. 297-314.

Michel 1941 | Henri Michel, 'Methodes de tracé et d'exécution des astrolabes persans,' *Ciel et Terra, Bulletin mensuel de la Société Belge d'Astronomie*, 1941, pp. 481-496.

Michel 1947 | Henri Michel, *Traite de l'astrolabe*, Paris 1947.

Michel 1976 | Henri Michel, *Treatise on the Astrolabe* (*Traite de l'astrolabe*), translated, edited and revised by James E. Morrison, Libraire Alain Brieux, Paris 1976.

Middleton 1839 | J. Middleton, 'Description of an Astronomical Instrument presented by Raja Ram Singh, of Khota [sic! Kota], to the Government of India,' *Journal of the Asiatic Society*, New Series, 32 (1839) 831-838.

Middleton 1841 | J. Middleton, 'Description of a Persian Astrolabe, submitted to the Asiatic Society by Major Pottinger,' *Journal of the Asiatic Society*, New Series 34 (1841) 759-777.

Misra 1996 | P. K. Misra, 'Evaluation of the Accuracy of Measurements in Indian Astronomy – I: Sāmanta Candraśekhara,' *Indian Journal of History of Science,* 31 (1996) 281-289.

Moini 1989 | Syed Liyaqat Hussain Moini, 'Rituals and Customary Practices at the Dargah of Ajmer' in: C. W. Troll (ed), *Muslim Shrines of India,* Oxford University Press, Delhi 1989, rep. 2004, pp. 60-75.

Mollan 1995 | Charles Mollan, *Irish National Inventory of Historic Scientific Instruments*, Samton Limited, Dublin 1995.

Mookerjee 1966 | Ajit Mookerjee, *Tantra Art, its Philosophy & Physics,* Kumar Gallery, New Delhi, New York, Paris 1966.

Mookerjee & Khanna 1977 | Ajit Mookerjee & Madhu Khanna, *The Tantric Way: Art, Science, Ritual,* Thames and Hudson, London 1977.

Morley 1856 | William H. Morley, *Description of a Persian Astrolabe constructed for Shah Husain Safawi*, 1856, reprinted in: Gunther 1932, pp. 1-50; reprinted in: Fuat Sezgin (ed), *Arabische Instrumente in Orientalischen Studien,* Frankfurt 1991, vol. 1, pp. 249-325.

Morley 1860 | William H. Morley, 'Description of an Arabic Quadrant,' *Journal of the Royal Asiatic Society*, 17 (1860) 322-330; reprinted in Sezgin 1998, I, pp. 326-336.

Morrison 1994a | James E. Morrison, 'The Electronic Astrolabe,' *Interdisciplinary Science Reviews*, 19.1 (1994) 55-69.

Morrison 1994b | James E. Morrison, 'Updating the Astrolabe' in: Gotstedter 1994, pp. 251-272.

Morrison 2007 | James E. Morrison, *The Astrolabe,* Janus, Rehonoth Beach, Delaware, 2007.

Morrison 2010 | James E. Morrison, *The Personal Astrolabe: Classic Edition,* Janus, Rehonoth Beach, Delaware, 2010.

Moskowitz 1979 | Saul Moskowitz, *Historical Technology,* Auction Catalog.

Moskowitz 1984 | Saul Moskowitz, *Historical Technology,* Auction Catalog 127, Fall 1984.

Mouliérac 1989 | Jeanne Mouliérac, 'La Collection Marcel Destombes,' *Astrolabica* 5 (1989) 77-126

Mundy 1914 | Peter Mundy, *The Travels of Peter Mundy in Europe and Asia 1608-1667,* ed. Richard Carnac Temple, vol. II: Travels in Asia, 1628-1634. London 1914.

N

Nadvi 1935 | Syed Sulaiman Nadvi,* 'Some Indian Astrolabe Makers,' *Islamic Cullture*, 9 (1935) 621-631.

Nadvi 1937a | Syed Sulayman Nadvi, 'The Early Relations between Arabia and India,' *Islamic Culture,* 11 (1937) 172-179.

Nadvi 1937b | Sayyid Sulayman Nadvi, 'Indian Astrolabe-Makers,' *Islamic Culture,* 11 (1937) 537-539.

Nadvi 1946 | Sayyid Sulaiman Nadvi, 'Muslim Observatories,' *Islamic Culture*, 20 (1946) 267-281.

Naffrah 1989 | Christiane Naffrah, 'Un cadran cylindrique ottoman du XIII^{ème} siècle,' *Astrolabica 5: Etudes 1987-1989,* éditée par A. J. Turner, Institut du Monde Arabe / Société Internationale de l'Astrolabe, Paris 1989, pp. 37-51.

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* His name is spelt variously.

Nahata | Agar Chand Nahata, 'Ustaralāva yantra sambandhī ek Mahattva-pūrṇa Jaina Grantha' [in Hindi], *Jaina-Siddhānta-Bhāskara*, 18.2 (year ?) 119-128.

Naik 2000 | Prahallad Chandra Naik, 'Date of Birth of Samanta Chandra Sekhar,' *Indian Journal of History of Science,* 35 (2000) 149-160.

Naik & Satpathy 1995 | P. C. Naik & L. Satpathy. 'Samanta Chandra Sekhar: Life and Work,' *Current Science*, 69.8 (25 October 1995) 705-710.

Naik & Satpathy 1998 | P. C. Naik & L. Satpathy. 'Samanta Chandra Sekhar: The great Naked Eye Astronomer,' Bulletin of the Astronomical Society of India, 26 (1998) 33-49. http://articles.adsabs.harvard.edu//full/1998BASI...26...33N/0000033.000.html [also http://goo.gl/1WT2Fz, last accessed in April 2017]

Narvekar 2007 | Shekhar Narvekar, 'Astronomical Instruments in Ancient India,' 12th IFToMM World Congress, Besançon (France), June 18-21, 2007, pp. 1-6. https://oldthoughts.files.wordpress.com/2009/04/astroinstru.pdf [also https://goo.gl/dBYTNr, last accessed in September 2016]

National Maritime Museum 1976 | National Maritime Museum, *The Planispheric Astrolabe* (together with 'Make-it-yourself astrolabe kit'), Greenwich 1976; several reprints.

Needham 1959 | Joseph Needham, *Science and Civilisation in China,* vol. 3: Mathematics and the Sciences of the Heavens and the Earth, Cambridge 1959.

Neugebauer 1947 | O. Neugebauer, 'Studies in Ancient Astronomy VIII: The Water Clock in Babylonian Astronomy.' *Isis* 37 (1947) 37-43.

Neugebauer 1949 | O. Neugebauer, 'Early History of the Astrolabe,' *Isis*, 40 (1949) 240-256; reprinted in idem, *Astronomy and History: Selected Essays*, New York 1983, pp. 278-294.

Neugebauer 1951 | O. Neugebauer, 'The Study of Wretched Subjects,' *Isis* 42 (1951) 111.

Newbury 2006 | B. Newbury et al, 'The Astrolabe Craftsmen of Lahore and Early Brass Metallurgy,' *Annals of Science,* 63.2 (April 2006) 201-213.

Nisbet 1901 | John Nisbet, *Burma under British Rule - and before,* Archibald Constable & Co, 2 vols., Westminster 1901.

North 1974 | J. D. North, 'The Astrolabe,' *Scientific American*, 230 (January 1974) 96-106; reprinted in: idem, *Stars, Minds and Fate: Essays in Ancient and Medieval Cosmology*, London-Ronceverte 1989, pp. 211-220.

North 1981 | J. D. North, 'Astrolabes and the Hour-Line Ritual,' *Journal for the History of Arabic Science*, 5 (1981) 113-114.

Noti 1911 | Noti, Severin Noti, Land und Volk des königlichen Astronomen Dschaisingh II Maharadscha von Dschaipur, Berlin 1911.

Nṛsiṃha | Bhāskara, *Siddhāntaśiromaṇi* of Bhāskarācārya, with his auto-commentary *Vāsanābhāṣya* and the commentary *Vāsanāvārttika* by Nṛsiṃha Daivajña, ed, Murali Dhara Chaturvedi, Library Rare Text Publication Series , No. 5, Sampurnanand Sanskrit University, Varanasi, 1981.

O

Oestmann 2014 | Günther Oestmann, *Geschichte, Konstruction und Anwendung des Astrolabiums bei Zifferblättern astronomischer Uhren,* Musée international d'horologie, Editions 'Institut l'homme et le temps', La Chaux-de-Fonds 2014.

Ôhashi 1986-87 | Yukio Ôhashi, 'History of Astronomical Instruments of Delhi Sultanate and Mughal Periods,' *Studies in History of Medicine and Science*, 10-11 (1986-87) 165-182.

Ôhashi 1987 | Yukio Ôhashi, 'A Note on Some Manuscripts on Astronomical Instruments' in: G. Swarup et al (ed), *History of Oriental Astronomy,* Cambridge 1987, pp. 191-195.

Ôhashi 1988 | Yukio Ôhashi, 'Astronomical Instruments of Bhāskara II and After' in: B. V. Subbarayappa and S. R. N. Murthy (ed), *Scientific Heritage of India*, Bangalore 1988, pp. 19-23.

Ôhashi 1993 | Yukio Ôhashi, 'Development of Astronomical Observation in Vedic and Post-Vedic India,' *Indian Journal of History of Science*, 28.3 (1993) 185-251.

Ôhashi 1994 | Yukio Ôhashi, 'Astronomical Instruments in Classical Siddhāntas,' *Indian Journal of History of Science*, 29.2 (1994) 155-314.

Ôhashi 1997 | Yukio Ôhashi, 'Early History of the Astrolabe in India,' *Indian Journal of History of Science,* 32 (1997) 199-295.

Ôhashi 1998 | Yukio Ôhashi, 'The Cylindrical Sundial in India,' *Indian Journal of History of Science,* 33 (1998), S-147-205.

Ôhashi 2008 | Yukio Ôhashi, 'Astronomical Instruments in India' in: Helaine Selin (ed), *Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures* (2nd edition), Springer, 2008, pp. 269-273.

Ôhashi 2016 | Yukio Ôhashi, 'The mathematical and observational astronomy in traditional India' in: K. Ramasubramanian, Aniket Sule & Mayank Vahia (ed), *History of Indian Astronomy: A Handbook,* Mumbai 2016, pp. 231-307.

Orthmann 2008 | Eva Orthmann, 'Sonne, Mond und Sterne: Kosmologie und Astrologie in der Inszenierung von Herrschaft unter Humāyūn' in: Lorenz Korn et al (hrsg), *Die Grenzen der Welt: Arabica et Iranica ad honorem Heinz Gaube,* Wiesbaden 2008, pp. 297-306.

P

Padmanābha | Padmanābha, *Dhruvabhramādhikāra,* with extracts from the autocommentary and translation by S. R. Sarma, Apx.D2.

Pandya et al 2017 | Aalok Pandya, Tej Bahadur & Sandip Bhattacharya, 'Sundial for Time-keeping at Jaisalmer Fort,' *Indian Journal of History of Science,* 52.2 (2017) 138-147.

Pargiter 1915 | F. G. Pargiter, 'The Telling of Time in Ancient India.' *Journal of the Royal Asiatic Society* (1915) 699-715.

Peng Lu 2015 | Peng Lu, 'Bhāskara I on the Construction of the Armillary Sphere,' *History of Science in South Asia,* 3 (2015) 1-19. https://journals.library.ualberta.ca/hssa/index.php/hssa/article/view/1/1 [also https://goo.gl/wFuc2v, last accessed in June 2017]

Pereira 2003 | José Manuel Malhão Pereira. *The Stellar Compass and the Kamal: an Interpretation of its Practical Use.* Lisboa: Academia de Marinha, 2003.

Pingree 1973 | David Pingree, 'The Mesopotamian Origin of Early Indian Mathematical Astronomy,' *Journal for History of Astronomy,* 4 (1973) 1-12

Pingree 1975 | David Pingree, 'Al-Bīrūnī's Knowledge of Sanskrit Astronomical Texts' in: Peter J. Chelkovski (ed), *The Scholar and the Saint*, New York 1975, pp. 67-81.

Pingree 1978a | David Pingree, 'Jayasiṃha' in *Dictionary of Scientific Biography,* vol. 7, 1978, pp. 80-82.

Pingree 1978b | David Pingree, 'History of Mathematical Astronomy of India,' *Dictionary of Scientific Biography*, New York 1978, vol. 15, pp. 533-633.

Pingree 1981 | David Pingree, Jyotiḥśāstra: Astral and Mathematical Literature, Wiesbaden.

Pingree 1985 | David Pingree, 'Astorlāb,' *Encyclopaedia Iranica,* ed. Ehsan Yarshater. Routlege and Kegan Paul, London etc. 1985. vol. 1, pp. 853-857.

Pingree 1987 | David Pingree, 'Indian and Islamic Astronomy at Jayasiṃha's Court' in: David A. King & George Saliba (ed), *From Deferent to Equant: A Volume of Studies in the History of Science in the Ancient and Medieval Near East in honor of E. S. Kennedy, Annals of the New York Academy of Sciences*, volume 500, New York 1987, pp. 313-328.

Pingree 1996 | David Pingree, 'Sanskrit Geographical Tables,' *Indian Journal of History of Science,* 31 (1996) 173-220.

Pingree 1997 | David Pingree, '*Tājika:* Persian Astrology in Sanskrit' in: idem, *From Astral Omens to Astrology: From Babylon to Bīkāner,* Instituto Italiano per l'Africa e l'Oriente, Roma 1997, pp. 79-90.

Pingree 1999 | David Pingree, 'An Astronomer's Progress,' *Proceedings of the American Philosophical Society,* 143.1 (March 1999) 73-85.

Pingree 2000 | David Pingree, 'Sanskrit Translations of Arabic and Persian Astronomical Texts at the Court of Jayasiṃha of Jayapura,' *Suhayl,* 1 (2000) 101-106.

Pingree 2002 | David Pingree, Philippe de la Hire's Planetary Theories in Sanskrit' in: Yvonne Dold-Samplonius et all (ed), *From China to Paris: 2000 Years of Transmission of Mathematical Ideas,* Franz Steiner Verlag, Stuttgart 2002, pp. 429-453.

Pingree 2003 | *A Descriptive Catalogue of the Sanskrit Astronomical Manuscripts Preserved at the Maharaja Mansingh II Museum in Jaipur, India*, compiled by David Pingree, from the Notes taken by Setsuro Ikeyama, Christopher Minkowski, David Pingree, Kim Plofker, Sreeramula Rajeswara Sarma, Gary Tubb, American Philosophical Society, Philadelphia, 2003.

Pingree 2009 | David Pingree, *Eastern Astrolabes* (Historic Scientific Instruments of the Adler Planetarium & Astronomy Museum, vol. II, General Editor, Bruce Chandler), Adler Planetarium, Chicago 2009.

Plofker 2000 | Kim Plofker, 'The Astrolabe and Spherical Trigonometry in Medieval India,' *Journal for the History of Astronomy*, 21 (2000) 37-54.

Plofker 2010 | Kim Plofker, 'The Mathematics of Measuring Time: Astronomical Timekeeping and the Sinking-Bowl Water-Clock in India' in: Dick Jardine & Amy Shell-Gellash (ed), *Mathematical Time Capsules: Historical Modules for the Mathematics Classroom,* Mathematics Association of America (Book 77), 2010, pp. 55-62.

Pohl 1979 | Karl-Heinz Pohl, 'Für die Gelehrsamkeit, für Kanzel und Seefahrt: Geschichte und Konstruktion der Sanduhr,' *Kunst und Antiquitäten*, 1 (1979) 23-28.

Powell 1872 | B. H. Baden Powell, *Handbook of the Manufactures and Arts of the Panjab*, Lahore 1872; pp. 259-263: mathematical and philosophical instruments exhibited in the Lahore Exhibition of 1864.

Price 1957 | Derek J. Price, 'Precision Instruments: To 1500' in: Charles Singer et al (ed), *A History of Technology*, III, Oxford 1957, pp. 582-619.

Price 1955 | Derek de Solla Price, 'An International Checklist of Astrolabes,' *Archieves Internationles d'Histoire des Sciences,* 8 (1955) 243-263; 363-381.

Princep 1836 | James Princep, 'Note on the Nautical Instruments of the Arabs,' *Journal of the Asiatic Society of Bengal,* 5 (December 1836), 784-795; repr. Fuat Sezgin (hrsg), *Islamic Geography*, vol. 15, pp. 139-151.

Proctor 2005 | David Proctor, 'The Construction and Use of the Astrolabe' in: Cleempoel 2005, pp. 15-22.

Ptolemy | *Ptolemy's Almagest,* translated and annotated by G. J. Toomer, Springer-Verlag, New York 1984.

Puig 1985 | Roser Puig, 'Concerning the Safiḥa shakkāziya,' Zeitschrift für die Geschichte der Arabisch-Islamischen Wissenschaften, 2 (1985) 123-139.

Puig 1989 | Roser Puig, 'Al-Zarqālluh's Graphical Method for Finding Lunar Distances,' *Centaurus*, 32 (1989) 294-309.

Q

Quraishi 2012 | Fatima Quraishi, '*Asar-ul-Sanadid*: a Nineteenth-Century History of Delhi,' *Journal of Art and Historiography,* 6 (June 2012) 1-18.

R

Rahman, Alvi, Khan & Murthy 1982 | A. Rahman, M. A. Alvi, S. A. Khan & K. V. Samba Murthy, *Science and Technology in Medieval India — A Bibliography of Source Materials in Sanskrit, Arabic and Persian,* Indian National Science Academy, New Delhi, 1982.

Rai 1985 | R. N. Rai, 'Astronomical Instruments,' *Indian Journal of History of Science,* 20 (1985) 308-336.

Raikva 1936 | Kṛṣṇaśaṃkara Keśavarāma Raikva (ed), Yantrarāja of Mahendra Sūri, together with the Commentary of Malayendu Sūri and Yantraśiromaṇi of Viśrāma, Bombay 1936. (cited by page)

Raju 2006 | C. K. Raju, 'Kamāl or Rāpalagai' in: Lotika Varadarajan (ed), *Indo-Portuguese Encounters: Journeys in Science, Technology and Culture,* Indian National Science Academy & Aryan Books International, New Delhi, 2006, II, pp. 483-504.

Rāmacandra Vājapeyin | Rāmacandra Vājapeyin, *Yantraprakāśa.,* together with an auto-commentary, MS G-1363 of the Asiatic Society, Kolkata, and MS 975/1886-92 of the Bhandarkar Oriental Research Institute, Pune.

Ramasubramanian, Sule & Vahia 2016 | K. Ramasubramanian, Aniket Sule & Mayank Vahia. *Indian Astronomy: A Handbook,* Indian Institute of Technology, Bombay; Tata Institute of Fundamental Research, Mumbai 2016.

Ramaswamy 2014 | Sumathi Ramaswamy, *Going Global in Mughal India,* https://sites.duke.edu/globalinmughalindia/ [also https://goo.gl/JsgbEA, last accessed in June 2017]

Rao 2014 | S. Balachandra Rao, *Indian Astronomy: Concepts and Procedures,* Nehru Centre, Mumbai 2014.

Rao et al 2016 | S. Balachandra Rao, Rupa K & Padmaja Venugopal, 'Heliacal Rising of Canopus in Indian Astronomy,' *Indian Journal of History of Science,* 51.1 (2016) 83-91.

Rehatsek 1875 | E. Rehatsek, 'The Labours of the Arab Astronomers, and their Instruments, with the Description of an Astrolabe in the Mulla Firuz Library,' *Journal of the Bombay Branch of the Royal Asiatic Society,* 11 (1875) 311-330.

Répertoire | Alain Brieux, Francis Maddison, avec la collaboration de Ludwik Kulus et Yusuf Ragheb, *Répertoire des Facteurs d'Astrolabes, et leurs oeuvres. Islam, plus Byzance, Arménie, Géorgie et Inde Hindoue* (in press). I use the 1993 version. Here the instrument makers are listed alphabetically and under each name the instruments by this maker are listed chronologically with serial numbers. Répertoire, followed by a serial number, refers to an instrument made by the instrument maker concerned.

Rohr 1973-74 | René R. J. Rohr, 'Sonnenuhr und Astrolabium im Dienste der Moschee,' *Centaurus*, 18 (1973-4) 44-56.

Rosenfeld et al 1975 | B. A. Rosenfeld et al. 'Mathematical Methods used in Construction of Astronomical Instruments in the Arab Countries, Iran and central Asia,' *Proceedings of the XIV International Congress of History of Science*, Kyoto 1975, vol. 3, pp. 339-342.

Roshid 1996 | Roshdi Roshid, in collaboration with Régis Morelon, *Encyclopedia of the History of Arabic Science,* 3 vols., London & New York 1996.

Rumley | Peter T. J. Rumley, 'Medieval Mass Dials Decoded,' http://www.buildingconservation.com/articles/mass-dials/mass-dials.htm [also https://goo.gl/Kwft9t, last accessed in August 2017]

S

Sabra 1987 | A. I. Sabra, 'The Appropriation and subsequent Naturalization of Greek Science in Medieval Islam: A Preliminary Statement,' *History of Science,* 25 (1987) 223-243.

Said 1979 | Hakim Mohammad Said (ed), History and Philosophy of Science: Proceedings of the International Congress of the History and Philosophy of Science, Islamabad, 8-13 December, 1979, Hamdard Foundation Press, Karachi 1979.

SaKHYa 2014 | SaKHYa (= Sreeramula Rajeswara Sarma, Takanori Kusuba, Takao Hayashi & Michio Yano), 'The Turyayantraprakāśa of Bhūdhara: Chapters One to Ten,' [critical edition of the text, translation and commentary], *Sciamus* 15 (2014) 3-55.

Saliba 1985 | George Saliba, 'The Function of Mechanical Devices in Medieval Islamic Society' in: Pamela O. Lang (ed), *Science and Technology in the Medieval Society*, New York 1985 (Annals of the New York Academy of Sciences, vol. 441), pp. 141-151.

Saliba 1994 | George Saliba, *A History of Arabic Astronomy: Planetary Theories during the Golden Age of Islam*, New York University Press, New York and London 1994.

Sarma 1983 | Sreeramula Rajeswara Sarma, 'Varṇamālikā System of Determining the Fineness of Gold in Ancient and Medieval India' in: *Aruṇa-Bhāratī: Professor A. N. Jani Felicitation Volume*, Baroda 1983, pp. 169-189.

Sarma 1985 | Sreeramula Rajeswara Sarma, 'An Unpublished MS on Arab Astronomical Instruments attributed to Sawai Jai Singh II: A Preliminary Report,' *Studies in History of Medicine and Science,* 9.1-2 (1985) 86-95.

Sarma 1986-87a | Sreeramula Rajeswara Sarma, 'Astronomical Instruments in Brahmagupta's Brāhma-sphutasiddhānta,' *Indian Historical Review*, New Delhi, 13 (1986-87) 63-74; reprinted in: Sarma 2008a, pp. 47-63.

Sarma 1986-87b | Sreeramula Rajeswara Sarma, *Yantraprakāra of Sawai Jai Singh*. Edited and Translated. Supplement to *Studies in History of Medicine and Science,* 10-11 (1986-87).

Sarma 1992a | Sreeramula Rajeswara Sarma, 'Astronomical Instruments in Mughal Miniatures,' *Studien zur Indologie und Iranistik*, Hamburg, 16-17 (1992) 235-276; reprinted in: Sarma 2008a, pp. 76-121.

Sarma 1992b | Sreeramula Rajeswara Sarma, 'Perpetual Motion Machines and their Design in Ancient India,' *Physis: Rivista Internationale di Storia della Scienza*, Rome, 29.3 (1992) 665-676; reprinted in: Sarma 2008a, pp. 64-75.

Sarma 1994a | Sreeramula Rajeswara: 'The Bowl That Sinks and Tells Time,' *The India Magazine*, New Delhi, 14.9 (September 1994) 31-36; reprinted in: Sarma 2008a, pp. 125-135.

Sarma 1994b | Sreeramula Rajeswara: 'Indian Astronomical and Time-Measuring Instruments: A Catalogue in Preparation,' *Indian Journal of History of Science,* 29.4 (1994) 507-528; reprinted in: Sarma 2008a, pp. 19-46.

Sarma 1994c | Sreeramula Rajeswara Sarma, 'From al-Kura to Bhagola: On the Dissemination of the Celestial Globe in India,' *Studies in History of Medicine and Science,* 13.1 (1994) 69-85; reprinted in: Sarma 2008a, 275-293.

Sarma 1994d | Sreeramula Rajeswara Sarma, 'The Lahore Family of Astrolabists and their Ouvrage,' *Studies in History of Medicine and Science,* 13.2 (1994) 205-224; reprinted in: Sarma 2008a, pp. 199-222.

Sarma 1996a | Sreeramula Rajeswara Sarma, *Astronomical Instruments in the Salar Jung Museum,* Salar Jung Museum, Hyderabad 1996.

Sarma 1996b | Sreeramula Rajeswara Sarma, 'The *Safiha Zarqaliyya* in India' in: Josep Casulleras and Julio Samso (ed), *From Baghdad to Barcelona: Studies in the Islamic Exact Sciences in Honour of Prof. Juan Vernet,* Barcelona 1996, pp. 719-735; reprinted in: Sarma 2008a, pp. 223-239.

Sarma 1996c | Sreeramula Rajeswara Sarma, 'Sanskrit as Vehicle for Modern Science: Lancelot Wilkinson's Efforts in the 1830's,' *Studies in History of Medicine and Science,* 14 (1995-96) 189-199.

Sarma 1998 | Sreeramula Rajeswara Sarma, 'Translation of Scientific Texts into Sanskrit under Sawai Jai Singh,' *Sri Venkateswara University Oriental Journal*, 41 (1998) 67-87.

Sarma 1999a | Sreeramula Rajeswara Sarma, 'Yantrarāja: The Astrolabe in Sanskrit,' *Indian Journal of History of Science,* 34 (1999) 145-158; reprinted in: Sarma 2008a, pp. 240-256.

Sarma 1999b | Sreeramula Rajeswara Sarma, 'Kaṭapayādi Notation on a Sanskrit Astrolabe,' *Indian Journal of History of Science,* 34 (1999) 273-287; reprinted in: Sarma 2008a, pp. 257-272.

Sarma 1999c | Sreeramula Rajeswara Sarma, 'A Brief Introduction to the Astronomical Instruments preserved in Khuda Bakhsh Library, Patna,' *Khuda Bakhsh Library Journal*, No. 118 (December 1999) 1-10.

Sarma 2000 | Sreeramula Rajeswara Sarma, 'Sultān, Sūri and the Astrolabe,' *Indian Journal of History of Science,* 35 (2000) 129-147; reprinted in: Sarma 2008a, pp. 179-198.

Sarma 2001a | Sreeramula Rajeswara Sarma, 'Some Indo-Persian Astronomical Instruments of the early Nineteenth Century,' *Khuda Bakhsh Library Journal,* No. 123 (April 2001) 1-16.

Sarma 2001b | 'Measuring Time with Long Syllables: BhāskaRās Commentary on Āryabhaṭīya, Kālakriyāpāda 2,' *Indian Journal of History of Science,* 36.1-2 (2001) 51-54; reprinted in: Sarma 2008a, pp. 143-146.

Sarma 2002 | 'From Yāvanī to Saṃskṛtam: Sanskrit Writings inspired by Persian Works,' *Studies in the History of Indian Thought,* Kyoto, 14 (November 2002) 71-88.

Sarma 2003 | Sreeramula Rajeswara Sarma, *Astronomical Instruments in the Rampur Raza Library,* Rampur Raza Library, Rampur 2003.

Sarma 2004 | Sreeramula Rajeswara Sarma, 'Setting up the Water Clock for Telling the Time of Marriage' in: Charles Burnett et al (ed), *Studies in the History of the Exact Sciences in Honour of David Pingree*, Brill, Leiden-Boston, 2004, pp. 302-330; reprinted in: Sarma 2008a, pp. 147-175.

Sarma 2006 | Sreeramula Rajeswara Sarma, 'Instrumentation for Astronomy and Navigation in India at the Advent of the Portuguese' in: Lotika Varadarajan (ed), *Indo-Portuguese Encounters: Journeys in Science, Technology and Culture,* Indian National Science Academy, New Delhi 2006, vol. II, pp. 505-513.

Sarma 2008a | Sreeramula Rajeswara Sarma, The Archaic and the Exotic: Studies in the History of Indian Astronomical Instruments, Manohar, New Delhi 2008.

Sarma 2008b | Sreeramula Rajeswara Sarma, 'On the Life and Works of Rāmacandra Vājapeyin' in: Radhavallabh Tripathi (ed), *Śrutimahatī: Glory of Sanskrit Tradition: Professor Ram Karan Sharma Felicitation Volume*, New Delhi 2008, vol. 2, pp. 645-661.

Sarma 2008c | Sreeramula Rajeswara Sarma, 'Cataloguing Indian Astronomical Instruments' in: Kalyan Kumar Chakravarty (ed), *Tattvabodha: Essays from the Lecture Series of the National Mission for Manuscripts,* vol. II, New Delhi 2008, pp. 141-157.

Sarma 2008d | Sreeramula Rajeswara Sarma, 'Indian Astronomical Instruments in German Collections,' XXX. Deutscher Orientalistentag, Freiburg, 24.-28. September 2007. Ausgewählte Vorträge, hrsg. im Auftrag der DMG von Rainer Brunner et at. Online-Publikation, Februar 2008.
http://srsarma.in/pdf/articles/2008_Indian_Instruments_in_German_Collections pdf
[also http://goo.gl/WX5F66]

Sarma 2009a | Sreeramula Rajeswara Sarma, *Sanskrit Astronomical Instruments in the Maharaja Sayajirao University of Baroda,* M.S. University Oriental Series No. 24, Oriental Institute, Vadodara, 2009.

Sarma 2009b | Sreeramula Rajeswara Sarma, 'On the Rationale of the Maxim *aṅkānāṃ vāmato gatiḥ*,' *Gaṇita Bhāratī,* 31(2009) 65-86.

Sarma 2009c. 'Persian-Sanskrit Lexica and the Dissemination of Islamic Astronomy and Astrology in India' in: Gherardo Gnoli & Antonio Panaino (ed), *KAYD: Studies in History of Mathematics, Astronomy and Astrology in Memory of David Pingree* (Serie Orientale Roma, CII), Rome 2009, pp. 129-150.

Sarma 2010 | Sreeramula Rajeswara Sarma, 'The Makers, Designers and Patrons of Sanskrit Astronomical Instruments: An Alphabetical Directory of Names and Related Inscriptions,' *Journal of the Oriental Institute,* 60.1-2 (Sept-Dec 2010) 75-108.

Sarma 2011a | Sreeramula Rajeswara Sarma, 'A Bilingual Astrolabe from the Court of Jahāngīr,' *Indian Historical Review,* 38.1 (June 2011) 77-117.

Sarma 2011b | Sreeramula Rajeswara Sarma, 'Yantrarāja at Edinburgh: On a Sanskrit Astrolabe made for Maṇirāma in AD 1644' in: S. R. Sarma & Gyula Wojtilla (ed), *Scientific Literature in Sanskrit,* (Proceedings of the 13th World Sanskrit Conference, Section 8), Motilal Banarsidass, Delhi 2011, pp. 77-110.

Sarma 2012a | Sreeramula Rajeswara Sarma, 'The Dhruvabhrama-Yantra of Padmanābha,' *Saṃkṛtavimarśaḥ, Journal of Rashtriya Sanskrit Samsthan, World Sanskrit Conference Special,* 6 (2012) 321-343.

Sarma 2012b | Sreeramula Rajeswara Sarma, 'The Gurmukhi Astrolabe of the Maharaja of Patiala,' *Indian Journal of History of Science,* 47.1 (2012) 63-92.

Sarma 2012c | Sreeramula Rajeswara Sarma, 'Yantrarāja for Dāmodara: the earliest extant Sanskrit Astrolabe' in: Jean-Michel Delire (ed), *Astronomy and Mathematics in Ancient India – Astronomie et Mathématiques de l'Inde ancienne,* Peeters, Leuven 2012, pp. 87-120.

Sarma 2012d | Sreeramula Rajeswara Sarma, 'The *Kaṭapayādi* System of Numerical Notation and its Spread outside Kerala,' *Revue d'histoire des mathématiques,* 18.1 (2012) 37-66.

Sarma 2014a | Sreeramula Rajeswara Sarma, 'Astronomical Instruments in India' in: Clive L. N. Ruggles (ed), *Handbook of Archaeoastronomy and Ethnoastronomy,* Springer eReference, 2014, No. 191, pp. 2007-2016.

Sarma 2014b | Sreeramula Rajeswara Sarma, 'Astronomical Instruments presented by the Maharaja of Benares to the Prince of Wales,' *Bulletin of the Scientific Instrument Society,* No. 122 (September 2014) 12-15.

Sarma 2015a | Sreeramula Rajeswara Sarma, 'Astronomy, Iconography and Calligraphy: The Constellation Figures on Ziauddin Muhammad's Celestial Globe of 1653-54 CE' in: Anila Verghese & Anna L. Dallapiccola (ed), *Art, Icon and Architecture in South Asia: Essays in Honour of Dr. Devangana Desai,* Aryan Books International, New Delhi 2015, pp. 263-275.

Sarma 2015b | Sreeramula Rajeswara Sarma, 'Lālah Bulhomal Lāhorī and the Production of Traditional Astronomical Instruments at Lahore in the Nineteenth Century,' *Indian Journal of History of Science,* 50.2 (2015) 259-305.

Sarma 2016 | Sreeramula Rajeswara Sarma, 'Indian astronomical instruments: A descriptive catalogue of extant specimens' in: Ramasubramanian, Aniket Sule & Mayank Vahia (ed), *History of Indian Astronomy: A Handbook,* Mumbai 2016, pp. 477-499

Sarma 2017 | Sreeramula Rajeswara Sarma, 'A Monumental Astrolabe made for Shāh Jahān and later reworked with Sanskrit Legends, *Medieval Encounters,* 23 (2017) 198-262. © Koninklijke Brill NV, Leiden, 2017 | DOI 10.1163/15700674-12342247.

Sarma (forthcoming) | Sreeramula Rajeswara Sarma, 'Astronomical Instruments in Bhāskarācārya's Siddhāntaśiromaṇi,' to appear in *Bhāskara-Prabhā: Proceedings of the International Conference on the 900th Birth Anniversary of Bhāskarācārya, …*

Sarma & Alam 1992 | S. R. Sarma & Ishrat Alam: 'Announcing Time: The Unique Method at Hayatnagar, 1676,' *Proceedings of the Indian History Congress, 52nd Session, New Delhi, 1991-92*, Delhi 1992, pp. 426-431; reprinted in: Sarma 2008a, pp. 136-142.

Sarma, Ansari & Kulkarni 1993 | S. R. Sarma, S. M. R. Ansari & A. G. Kulkarni, 'Two Mughal Celestial Globes,' *Indian Journal of History of Science,* 28.1 (1993) 80-8; reprinted in: Sarma 2008a, pp. 294-307.

Sarma & Bagheri 2011 | Sreeramula Rajeswara Sarma & Mohammad Bagheri, 'Shabnumā-wa-Rūznumā: A Rare Astronomical Instrument extant in two Specimens,' *Tarikh-e Elm,* 9 (2011) 21-48.

SarmaKV 1990 | K. V. Sarma, *Observational Astronomy in India*, Calicut 1990.

SarmaKV 2003 | K. V. Sarma, 'Word and Alphabetic Numerical Systems in India' in: A. K. Bag & S. R. Sarma (ed), *The Concept of Śūnya,* New Delhi 2003, pp. 37-71.

SarmaKV 2008 | K. V. Sarma, 'Armillary Spheres in India,' in: Helen Selin (ed) In *Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures*, edited by Helaine Selin, Springer 2008, p. 243.

SarmaMS 1948 | M. Somasekhara Sarma, *History of the Reddi Kingdoms (circa 1325 A.D. to circa 1448 A.D.),* Andhra University Series No. 38, Waltair 1948.

Saunders 1984 | Harald N. Sanders, *All the Astrolabes*, Oxford 1984.

Savage-Smith 1985 | Emilie Savage-Smith, *Islamicate Celestial Globes: Their History, Construction and Use*, Washington, D.C., 1985.

Savage-Smith 1990 | Emilie Savage-Smith, 'The Classification of Islamic Celestial Globes in the Light of Recent Evidence,' *Der Globusfreund: Wissenschaftliche Zeitschrift für Globen- und Instrumentenkunde*, 38/39 (1990) 23-35.

Savage-Smith 1992a | Emilie Savage-Smith, 'Celestial Mapping' in: J. B. Herley & David Woodward (ed), *Cartography in the Traditional Islamic and South Asian Societies* (*The History of Cartography*, Vol. II, 1), Chicago 1992, pp.12-70.

Savage-Smith 1992b | Emilie Savage-Smith, 'The Islamic Tradition of Celestial Mapping,' *Asian Art, Arthur M. Sackler Gallery, Smithsonian Institution,* 5.4 (Fall 1992) 5-28.

Savage-Smith 2017 | Emilie Savage-Smith, 'Of Making Celestial Globes There Seems No End,' Gerard Turner Memorial Lecture of the Scientific Instrument Society, delivered at the Society of Antiquaries of London, on 25 November 2016, *Bulletin of the Scientific Instrument Society,* No. 132 (2017) 2-10.

Sayili 1956 | Aydin Sayili, ''Alā al Dīn al Mansūr's Poems on the Istanbul Observatory,' *Bulletin* (Ankara), 20 (1956) 429-484); reprinted in Sezgin, 1998, XI, pp. 343-402.

Sayili 1960 | Aydin Sayili, *The Observatory in Islam and its Place in the General History of the Observaory*, Ankara 1960; second edition, edited by Fuat Sezgin, Frankfurt 1998 (Islamic Mathematics and Astronomy, volume 97).

Schimmel 1979 | Annemarie Schimmel, 'Gedanken zu zwei Porträts des Moghulhershers Sāh 'Ālam II Āftāb' in: Ulrich Haarmann & Peter Bachmann (ed), *Die Islamische Welt zwischen Mittelalter und Neuzeit: Hans Robert Roemer Festschrift*, Beirut 1979.

Schlagintweit-Sakünlünski 1871 | Hermann von Schlagintweit-Sakünlünski, 'Eine Wasseruhr und eine metallene Klangscheibe alter indischer Construction,' *Sitzungsberichte der mathemaisch-physikalische Classe der k. b. Akademie der Wissenschaften zu München,* 1 (1871) 128-139.

Schmalzl 1929 | Peter Schmalzl, *Zur Geschichte des Quadranten bei den Arabern,* (Diss. Erlangen), München, 1929; reprinted in: Sezgin 1998, VI, pp. 189-331.

Schmeller 1922 | Hans Schmeller, Beiträge zur Geschichte der Technik in der Antike und bei den Arabern, Erlangen 1922.

Schmidt 1935 | Fritz Schmidt, Geschichte der geodatischen Instrumente und Verfahren im Altertum und Mittelalter, Neustadt an der Haardt 1935.

Schmidl 1994 | Petra Schmidl, 'Ein Astrolab aus dem 17. Jahrhundert: prachtvoll und verfälscht' in: Gotstedter 1994, pp. 282-305.

Schmidl 2012 | Petra G. Schmidle, 'Magic and Medicine in in a Thirteenth-century Treatise on the Science of the Stars' in: Ingrid Hehmeyer & Hanne Schönig, *Herbal Medicine in Yemen: Traditional Knowledge and Practice, and Their Value for Today's World,* Brill, Leiden-Boston 2012, pp. 43-68.

Schück 1892 | A. Schück, 'Ein altes indisches und arabisches Instrument zum Bestimmen der Polhöhe gewisser Orte, *Das Ausland* (Stuttgart), 65 (1892) 814; repr. Fuat Sezgin (hrsg), *Islamic Geography*, vol. 18, pp. 183.

Schwartzberg 1992 | Joseph E. Schwartzberg, 'Cosmological Mapping ...' in: J. B. Herley & David Woodward (ed), *Cartography in the Traditional Islamic and South Asian Societies* (*The History of Cartography*, Vol. II, 1), Chicago 1992.

Sédillot 1834 | Jean-Jaques Sédillot et Louis-Amélie Sédillot: *Traité des instruments astronomique des Arabes* (= Textübersetzung des *Gāmī' al-mabādi' wa-l-gāyāt* von al-Marrākusī, 7./13. Jahrhundert). Paris 1834. Reprint: Frankfurt 1984.

Sédillot 1853 | L. P. E. A., Prolégominès des tables astronomiques d' Oloug-Beg: Traduction et commentaire, Paris 1853.

Seemann 1929 | Hugo J. Seemann, Die Instrumente der Sternwarte zu Marāgha nach den Mitteilungen von al 'Urdī, Erlangen 1929.

Sen 1990 | S. N. Sen, 'The Astrolabe - A Case for Transmission of Technique of an Astronomical Instrument in Medieval India' in: W. H. Abdi et al (ed), *Interaction between Indian and Central Asian Science and Technology in Medieval Times*, New Delhi 1990, vol. 1, pp. 111-131.

Sen, Bag & Sarma 1966 | S. N. Sen, A. K. Bag & S. Rajeswara Sarma, *A Bibliography of Sanskrit Works on Astronomy and Mathematics,* Part I: Manuscripts, Texts, Translations & Studies, National Institute of Sciences of India, New Delhi.

Sewell & Dikhsit 1896 | Robert Sewell and Śankara Bālkṛshṇa Dīkshit, *The Indian Calendar,* with tables for the conversion of Hindu and Muhammadan into A.D. dates, and vice versa, with tables of eclipses visible in India by Robert Schram, London 1896,
https://archive.org/details/IndianCalendarSewelDikshit
[also https://goo.gl/iR8KSo, last accessed in April 2017].

Sezgin 1998 | Fuat Sezgin, in collaboration with Mazen Amawi, Carl Ehring-Eggert, Eckhard Neubauer (collected and reprinted), *Astronomical Instruments and Observatories in the Islamic World: Texts and Studies*. 12 volumes [including the 6 published in 1991] (Islamic Mathematics and Astronomy, volumes 85-96). Institute for the History of Arabic-Islamic Science at the Johann Wolfgang Goethe University, Frankfurt am Main, 1998.

Sezgin 2000 | Fuat Sezgin, 'Der Kalif al-Ma'mūn und sein Beitrag zur Weltkarte: Arabischer Ursprung europäischer Karten,' *Forschung Frankfurt: Wissenschaftsmagazin der Johann Wolfgang Goethe-Universität, Frankfurt am Main*, 18.4 (2000) 22-31.

Sezgin 2003 | Fuat Sezgin, *Wissenschaft und Technik im Islam,* 5 vols, Institut für Geschichte der Arabisch-Islamischen Wissenschaften an der Johann Wolfgang Goethe-Universität Franfurt am Main. Frankfurt 2003.
http://www.ibttm.org >>> http://www.ibttm.org/publikationen.html
[also http://goo.gl/iYLsFg, last accessed in April 2017].

Sezgin 2011 | Fuat Sezgin, Science and Technology in Islam: Catalogue of the Collection of Instruments of the Institute for the History of Arabic and Islamic Sciences, translated from the Original German by Renate Sarma and Sreeramula Rajeswara Sarma, 5 vols., Institut für Geschichte der Arabisch-IslamischenWissenschaften, Frankfurt 2011.
http://www.ibttm.org/ENG/index.html >>>
http://www.ibttm.org/ENG/publications.html
[also http://goo.gl/MBDQ72, last accessed in April 2017].

Sharma 1982 | Shakti Dhara Sharma, Śrī Gaṇeśa-Daivajña-kṛta Pratoda-Yantram : Pratoda Yantra (Chabuka Instrument by Sh. Ganesha Daivajna (A Gnomonic Whip-Shaped device to know time), edited and commented by Shakti Dhara Sharma, Kurali 1982.

Sharma 1984 | Virendra Nath Sharma, 'The Great Astrolabe of Jaipur and its Sister Unit,' *Archaeoastronomy,* No. 7, supplement to *Journal of History Astronomy,* 15 (1884) 126-128.

Sharma 1987 | Virendra Nath Sharma, 'Efforts of Sawai Jai Singh – A Review' in: G. Swarup et al (ed), *History of Astronomy,* Cambridge 1987, pp. 233-240.

Sharma 1994 | Virendra Nath Sharma, 'Miśra Yantra of the Delhi Observatory,' *Indian Journal of History of Science*, 29.3 (1994) 477-87.

Sharma 2000 | Virendra Nath Sharma, 'Astronomical Instruments at Kota,' *Indian Journal of History of Science,* 35.3 (2000) 233-244.

Sharma 2013 | Virendra Nath Sharma, 'Kapāla B Yantra at Sawai Jai Singh's Jaipur Observatory,' *Indian Journal of History of Science,* 48.4 (2013) 583-588.

Sharma 2016 | Virendra Nath Sharma, *Sawai Jai Singh and his Astronomy*, Delhi 1995; second revised edition, Delhi 2016.

Sharma & Mehra 1991 | Virendra Nath Sharma & Anjani K. Mehra, 'Precision Instruments of Sawai Jai Singh,' *Indian Journal of History of Science,* 26.3 (1991) 249-276.

Shukla 1967 | Kripa Shankar Shukla, 'Āryabhata I's astronomy with Midnight Day-Reckoning,' *Gaṇita* 18.1 (June 1967) 83-105.

Siddiqui 1988 | Iqtidar H. Siddiqui, 'Basātīn al-'Uns: A source of information on the Sultanate of Delhi under the early Tughluq Sultans,' *Quarterly Journal of the Pakistan Historical Society*, 36.4 (1988) 293-302.

Siddiqui 1994 | Iqtidar Husain Siddiqui, 'Science and Scientific Instruments in the Sultanate of Delhi,' Presidential address of section III: Medieval India, Indian History Congress, 54th Session, Mysore, December 1993; reprinted in *Proceedings of the Indian History Congress, 54th Session, Mysore (1993)*, Delhi 1994, pp. 137-148.

Sinha & Hayashi 1983 | Sri Rama Sharma & Takao Hayshi, 'The Yantra of Koneri,' *University of Allahabad Studies,* vol. 15 (NS), no. 1, pp. 1-8, February 1983.

Skinner 2002 | Skinner [Auction House], Bolton, Messachusetts, *Science &Technology featuring Mechanical Music,* Sale 2133, April 13, 2002.

Smith 1925 | David Eugene Smith, *History of Mathematics*, Boston 1925.

Smith 2002 | B. S. Smith, 'An astrolabe from Passa Pau, Cape Verde Islands,' *The International Journal of Nautical Archaeology,* 31.1 (2002) 99-107.

Sokolovskaya 1975 | Z. K. Sokolovskaya, 'Classification of Pre-telescopic Astronomical Instruments using an Example of al-Biruni's Instruments,' *Proceedings of the XIV International Congress of History of Science*, Kyoto 1975, vol. 3, pp. 83-86.

Sottas 1930 | Jules Sottas, 'Description d'un astrolabe Arabe construit à Lahore,' *Académie de marine. Communications et Mémoires (Paris)*, 9 (1930) 153-185; reprinted in: Sezgin 1998, VI, pp. 343-375.

Śrīdhara, *Pāṭīgaṇita* | *The Patiganita of Sridharacarya,* ed & tr, Kripa Shankar Shukla, Lucknow University, Lucknow 1959.

Srinivasan 1979 | Saradha Srinivasan, *Mensuration in Ancient India,* Ajanta Publications, Delhi 1979.

Stautz 1994 | Burkhard Stautz, 'Die frueheste bekannte Formgebung der Atrolabien' in: Gotstedter 1994, pp. 315-328.

Stautz 1997 | Burkhard Stautz, *Untersuchungen von mathematisch-astronomischen Darstellungen auf mittelalterlichen Astrolabien islamischer und europäischer Herkunft*, Bassum 1997.

Stautz 1999 | Burkhard Stautz, *Die Astrolabiensammlung des Deutschen Museums und des Bayerischen Nationalmuseums*, Oldenbourg, München 1999.

Steingass 1892 | F. Steingass, *Comprehensive Persian-English Dictionary,* London 1892 (many reprints).

Stephen 1876 | Carr Stephen, *The Archaeology and the Monumental Remains of Delhi,* Ludhiana and Calcutta, 1876.

Sticker 1968 | Bernhard Sticker, 'Historical Scientific Instruments as Cultural Landmarks,' *Vistas in Astronomy* 9 (1968) xv-xvi; 103-108.

Stimson 1988 | Alan Stimson, *The Mariner's Astrolabe. A Survey of known, surviving Sea Astrolabes*, Utrecht 1988.

Stone 1958 | A. P. Stone, 'Astronomical Instruments at Calcutta, Delhi and Jaipur,' *Archives internationales d'histoire des sciences,* 11 (1958) 159-162.

Strauch 2002 | Ingo Strauch, *Lekhapaddhati-Lekhapañcāśikā* : *Briefe und Urkunden im mittelalterlichen Gujarat,* Text, Übersetzung, Kommentar, Glossar, Dietrich Reimer Verlag, Berlin 2002.

Subbarayappa & Sarma 1985 | B. V. Subbarayappa & K. V. Sarma, K. V., *Indian Astronomy: A Source-Book*, Bombay 1985.

Ṣūfī 1874 | H. C. F. C. Schjellerup, *Description des Étoiles Fixes, composée au milieu du dixième siècle de notre ère par l'Astronome Persan Abd-al-Rahman al-Sûfi*, St. Petersburg 1874.

Ṣūfī 1954 | Abu'l-Ḥusain 'Abdu'r-Raḥmān as-Ṣūfī, *Suwaru'l-Kawākib or (Uranometry) (Description of the 48 Constellations) Arabic Text with 'Urjūza of Ibn'Ṣūfī*, edited from the oldest extant Mss and based on the Ulugh Beg Royal Codex (Bibliotheque Nationale, Paris, arabe 5036) with Introduction, plates, diagrams etc. Published by the Dāirtu'l-Ma'ārif-il-'Osmania (Osmania Oriental Publications Bureau), Hyderabad-Deccan 1373 AH / 1954 AD.

Syndram 1989 | Dirk Syndram, *Wissenschaftliche Instrumente und Sonnenuhren*, Kunstgewerbesammlung der Stadt Bielefeld, Stiftung Huelsmann (Kataloge der Kunstgewerbesammlung/Stiftung Huelsmann, Band 1), München 1989.

T

Tekeli 1980 | S. Tekeli, 'The Observational Instruments of Istanbul Observatory,' in: M. Dizer (ed), *International Symposium on the Observatories in Islam, 19-23 September 1977,* Istanbul 1980, pp. 33-44.

Thorndyke 1929 | Lynn Thorndyke, 'On the Cylinder called the Horologue of the Travelers,' *Isis*, 13 (1929) 51-52.

Thurston 1907 | Edgar Thurston, 'Steel-Yards, Clepsydras, Knuckle-dusters, Cock-Spurs, Tallies, Dry Cupping.' *Ethnographical Notes in Southern India.* (1907) Reprint: Delhi 1975, Part II, pp. 560-566.

Tibbets 1981 | G. R. Tibbets, *Arab Navigation in the Indian Ocean before the Coming of the Portuguese, being a Translation of Kitāb al-Frawā'id fī uśūl al-baḥr wa'l-qawā'id of Aḥmad b. Mājid al-Najdī, together with an Introduction on the History of Arab Navigation, Notes on the Navigational Techniques and on the Topography of the Indian Ocean, and a Glossary of Navigational Terms*, The Royal Asiatic Society of Great Britain and Ireland, London 1981.

Titley & Wood 1999 | Norah Titley & Frances Wood, *Oriental Gardens,* The British Library, London 1991.

Toll 180-90 | Christopher Toll, 'A Persian Astrolabe from A.H. 1187/A.D.1773-74,' *Orientalia Suecana*, 38-39 (1989-90) 163-170.

Torod 1989 | R. K. E. Torode, 'A mathematical System for Identifying the Stars of an Astrolabe and Finding its Age,' *Astrolabica,* 5 (1989) 53-76.

Torod 1992 | R. K. E. Torode, 'A Study of Astrolabes,' *Journal of the British Astronomical Association,* 102.1 (1992) 5-30.

Türstig 1980 | Hans-Georg Türstig, *Das System der indischen Astrologie,* Wiesbaden.

Turner 1973 | A. J. Turner, *The Clockwork of the Heavens*, London 1973.

Turner 1982 | A. J. Turner, 'The Accomplishment of Many Years': Three Notes towards a History of the Sand-glass,' *Annals of Science*, 39 (1982) 161-172.

Turner 1984 | A. J. Turner, *Water-Clocks, Sand-Glasses, Fire-Clocks,* The Time Museum, Catalogue of Collection, vol. I, part 3: Rockford 1984.

Turner 1985 | A. J. Turner, *Astrolabes, Astrolabe-related Instruments,* The Time Museum, Catalogue of Collection, vol. I, part 1: Rockford 1985.

Turner 1990 | A. J. Turner (ed), *Time* [catalogue of an Exhibition organised by the Foundation 'Tijd voor Tijd'], The Hague 1990.

Turner 1993a | A. J. Turner, 'Interpreting the History of Scientific Instruments' in: Anderson 1993, pp. 17-26.

Turner 1993b | A. J. Turner, 'Mathematical Instruments and the Education of Gentlemen' in: idem, *Of Time and Measurement: Studies in the History of Horology and Fine Technology*, Variorum, Aldershot 1993, XIX.

Turner 1993c | A. J. Turner, 'Sundials: History and Classification' in: idem, *Of Time and Measurement: Studies in the History of Horology and Fine Technology*, Variorum, Aldershot 1993, II.

Turner 1993d | A. J. Turner, 'The Origins of Modern Time' in: idem, *Of Time and Measurement: Studies in the History of Horology and Fine Technology*, Variorum, Aldershot 1993, I.

Turner 1993-94 | A. J. Turner, 'A Seventeenth Century Calendar Scale for Coins and Mathematical Instruments, with a Checklist of Coin-Calendars in the Museum of the History of Science, Oxford, ' *AJN* (*American Journal of Numismatics?*) Second Series 5-6 (1993-94) 209-219.

Turner 2002 | A. J. Turner, 'Donald Hill and Arabic Water Clocks,' *Antiquarian Horology,* December 2002, 206-213.

Turner 1998 | Anthony Turner, 'Sun-dial': in Bud 1998, pp. 588-589.

Turner 2015 | Anthony Turner, 'Concerning a Pointer on the Astrolabe,' *Journal for the History of Atronomy,* 46.4 (2015) 413-418.

Turner 1979 | Gerard L'E. Turner, 'Johann Daniel von Berthold: A Clerical Craftsman and his Universal Ring-Dial' in Turner 1990, V.

Turner 1986 | Gerard L'E. Turner, 'Report on a Tour of Indian Museums of Science including some University Departments and Colleges, sponsored by the British Council, 16 February to 10 March 1986,' privately circulated.

Turner 1990 | Gerard L'E. Turner, *Scientific Instruments and Experimental Philosophy 1550-1850,* Variorum, Aldershot 1990.

U

Unniyal 1994-95 | C. P. Unniyal, 'A Technical Note on the Astronomical Instruments of Salar Jung Museum,' *Salar Jung Museum Bi-Annual Research Journal,* 31-32 (1994-95) 187-189.

Upadhyaya 1994 | Baladeva Upādhyāya, *Kāśī kī Pāṇḍitya-Paraṃparā,* second edition, Varanasi 1994.

V

Vafea 2006 | Flora Vafea, 'Les traités d'al-Sūfī sur l'astrolab,' doctoral dissertation, Université Diderot-Paris 7, 2006.

Varadarajan 2004 | Lotika Varadarajan (ed), The Rahmani of M. P. Kunhikunhi Malmi of Kavarati: A Sailing Manual of Lakshadweep. Manohar. New Delhi 2004.

Varāhamihira | Varāhamihira, *Pañcasiddhāntikā of Varāhamihira,* with Translation and Notes by K. S. Kuppanna Sastry, citically edited and with Introduction and Appendices by K. V. Sarama, P. P. S. T. Foundation, Adyar, Madras 1993.

Verdet 1994 | Jean-Pierre Verdet, 'A propos de deux petits quadrants indiens' in: W. D. Hackmann & A. J. Turner (ed), *Learning, Language and Invention: Essays presented to Francis Maddison*, Aldershot & Paris 1994, pp. 309-321.

Verma 1978 | Som Prakash Verma, *Art and Material Culture in the Paintings at Akbar's Court,* Vikas Publishing House Pvt. Ltd., New Delhi 1978.

Vernet | J. Vernet, 'Al-Zarqālī' in: *Dictionary of Scientific Biography*, xiv, 592-595.

Vitruvius | Vitruvius, *The Ten Books on Architecture,* tr. Morris Hickey Morgan, prepared under the direction of Herbert Langford Warren, Harvard University Press, Cambridge & Oxford University Press, London, 1914.
https://ia802604.us.archive.org/24/items/vitruviustenbook00vitruoft/vitruviustenbook00vitruoft.pdf
[also https://goo.gl/JWjdxE, last accessed in August 2017].

W

Wahi 1990 | Tripta Wahi, 'Henry Miers Elliott – A Reappraisal,' *Journal of the Royal Asiatic Society of Great Britain and Ireland,* 1 (1990) 64-90.

Ward 1958 | F. A. B. Ward, *Handbook of the Collection illustrating Time Measurement,* Part I: Historical Review, Part II: Descriptive Catalogue, 4th edn, London 1958.

Ward 1970 | F. A. B. Ward, *Time Measurement: Historical Review*, London 1970.

Ward 1981 | F. A. B. Ward, A Catalogue of European Scientific Instruments in the Department of Medieval and Later Antiquities of the British Museum, London 1981.

Watson 2016 | Bruce Watson, 'The Astrolabe, Astronomy's First Hot Spot,' *Sky and Telescope* (February 2016) 24-27.

Webster 1998 | Roderick & Marjorie Webster, *Western Astrolabes,* with an Introduction by Sara Schechner Genuth. (Historic Scientific Instruments of the Adler Planetarium & Astronomy Museum, Volume I). Chicago: Adler Planetarium & Astronomy Museum, 1998.

Webster & MacAlister 1984 | Robert S. Webster & Paul R. MacAlister, *The Astrolabe: Some Notes on its History, Construction and Use* (together with an astrolabe assembling kit), Lake Bluff, Illiois, 1984.

Wellesz 1965 | Emmy Wellesz, *An Islamic Book of Constellations,* Bodleian Library, Oxford 1965.

White 1960 | Lynn White, 'Tibet, India, and Malaya as Sources of Western Medieval Technology,' *American Historical Review*, 65 (1960) 515-526; reprinted in: idem, *Medieval Religion and Technology: Collected Essays*, Berkley 1978, pp. 43-57.

White 1964 | Lynn White, *Medieval Technology and Social Change*, London 1964.

Wiet 1936 | Gaston Wiet, 'Une Familie de fabricantes d'astrolabes,' *Bulletin de l'Institut francais d'archaéologie orientale*, Cairo, 36 (1936) 97-99.

Wilkinson 1834 | Lancelot Wilkinson, 'On the Use of the Siddhantas in the Work of Native Education,' *Journal of the Asiatic Society of Bengal,* 3 (1834) 504-519.

Wilkinson & Sastri 1861 | Translation of the Súrya Siddhánta by Pundit Bápú Deva Śastri and of the Siddhánta Śiromani by the late Lancelot Wilkinson, Esq., C.S., revised by Pundit Bápú Deva Śastri, from the Sanskrit, (Bibliotheca Indica XXXII), The Asiatic Society of Bengal, Calcutta 1861.

Winter 1964 | H. J. J. Winter, 'A Shepherd's Time-Stick, Nāgarī inscribed,' *Physis: Rivista Internazionale di Storia dello Scienze*, 4 (1964) 377-384.

Woepcke 1853 | W. Woepke, Über ein in der königlichen Bibliothek zu Berlin befindliches arabisches Astrolabium, aus den Abhandlungen der königl. Akademie der Wissenschaften zu Berlin 1853. Berlin, 1958. reprint: Franz Woepcke, *Études sur les Mathématiques arabo-islamiques,* Nachdruck der Schriften aus den Jahren 1842-1874, hrsg. Futat Sezgin, Institut für Geschichte der Arabisch-Islamischen Wissenschaften an der Johann Wolfgang Goethe-Universität, Frankfurt am Main, 1986, Band II, pp. 131-165.

Wulff 1966 | Hans E. Wulff, *Traditional Crafts of Persia: their Development, Technology and Influence on Eastern and Western Civilizations*, The MIT Press, Cambridge/Mass and London, 1966.

Wulff 1968 | H. E. Wulff, 'The Qanats of Iran,' *Scientific American,* 218.4 (April 1968) 94-105.

Würschmidt 1918 | Joseph Würschmidt, 'Ein türkisch-arabisches Quadrant-Astrolab,' *Archiv für Geschichte der Naturwissenschaften und der Technik* (Leipzig), 8 (1918 167-181; reprinted in: Sezgin 1998, IV, pp. 1-15.

Wynter & Turner 1975 | Harriet Wynter & Anthony Turner, *Scientific Instruments*, London 1975.

Y

Yano 1994 | Michio Yano, 'Calendar and Related Subjects in the Nīlamatapurāṇa' in: Yasuke Ikari (ed), *A Study of the Nīlamata: Aspects of Hinduism in Ancient Kashmir,* Institute for Research in Humanities, University of Kyoto, Kyoto 1994, pp. 223-236.

Yantraprakāra | *Yantraprakāra of Sawai Jai Singh,* ed & tr, Sreeramula Rajeswara Sarma, Supplement to *Studies in History of Medicine and Science,* 10-11 (1986-87).

Z

Zinner 1930 | Ernst Zinner, 'Horologium viatorum,' *Isis*, 14 (1930) 385-387.

Zinner 1939 | Ernst Zinner, *Die ältesten Räderuhren und modernen Sonnenuhren: Forschungen über den Ursprung der Wissenscaft,* XXVII. Bericht d. Naturforschende Gesellschaft, Bamberg 1939
http://www.zobodat.at/pdf/Bericht-Naturforsch-Ges-Bamberg_28_0001-0129.pdf
[also https://goo.gl/T7j3Xx, last accessed in November 2017].

Zinner 1947 | Ernst Zinner, 'Über die früheste Form des Astrolabs,' *Naturforschende Gesellschaft Bamberg XXX Bericht*, 1947, pp. 7-21; reprinted in: Sezgin 1998, XI, pp. 53-65.

Zinner 1967 | Ernst Zinner, 'Some Reflections on Research in the History of Astronomy,' *Vistas in Astronomy*, 9 (1967) 171-175.

Zinner 1979 | Ernst Zinner, *Deutsche und Niederländische Astronomische Instrumente des 11.-18. Jahrhunderts*, München 1956, reprint: München 1979.

APX.B INDEX OF MUSEUMS WITH INDIAN ASTRONOMICAL INSTRUMENTS

India

Ahmedabad, L. D. Institute
D023

Aligarh, Aligarh Muslim University, Tibbiya College
F013

Chennai, Government Museum
R010

Hyderabad, Salar Jung Museum
A001, A026, A067, A107, A116, F019, F034, G005, Y001

Hyderabad, Saidiya Library
A048, A057, Y009, Y016, Y019

Hyderabad, State Museum of Archaeology
A127, C014, Q008

Jaipur, Jai Singh's Observatory
A051, A072, A090, A091, A131, C021, C022, D001, D009, D077, D078, D079, D080, D081, D082, D083, D084, D085, D086, D087, D088, D089, H001, I001, K009, L001, N001, N005, N016, O001, O002, T001, T002, T003, T004, T005, Y018

Jaipur, Government Maharaja's Sanskrit College
C032

Jaipur, Maharaja Sawai Man Singh II Museum, City Palace
G024, N006, T006

Jaipur, Museum of Indology
D027, K001, L014, N007, N008, O003

Jaipur, Shri Sanjay Sharma Museum & Research Institute
D035, L019, L020, N009, N010, P002, P003, X002

Kolkata, Asiatic Society of Bengal
A111, K015, P023

Kolkata, Indian Museum
A027, Y004, Y010

Kota, Rao Madho Singh Museum
I002, N011, N012, R011

Lucknow, Darul Uloom Nadwatul Ulama
A062, G019

Mumbai, Chhatrapati Shivaji Maharaj Vastu Sangrahalay
(formerly Prince of Wales Museum)
B009, J004

Mumbai, K. R. Cama Oriental Institute
Y007, Y011, Y015

Mysuru, Maharaja's Sanskrit College
I006

New Delhi, Red Fort, Mumtaj Mahal Museum (Archaeological Museum)
A021, A025, A100, C017, F023, G002, G026, Y005, Y006

New Delhi, National Museum
B017, B027, B028, B029, C016, D028, D053, F004, G012, G020, L015, Q011, U002, X008, X016

Patna, Khuda Bakhsh Oriental Public Library
A011, A082, A130, B012, F005, L024, Q012, X004, X011, Y003

Pune, Bhandarkar Oriental Research Institute
C004

Pune, Raja Dinkar Kelkar Museum
C002, F035, L010

Rampur, Rampur Raza Library
A084, C028, F027, J002, L025, X015, Y002, Y012, Y013, Y014

Srinagar, Sir Pratap Singh Museum
A088, C029, D069, D070, G013

Vadodara, M. S. University of Baroda, Oriental Institute
C007, D054

Vadodara, M. S. University of Baroda, Sanskrit Mahavidyalaya
I007, K007, K008, L021, N014, W002

Varanasi, Banaras Hindu University, Bharat Kala Bhavan
D048, L012, N013, Y008

Varanasi, Ramnagar, Maharaja Banaras Vidyamandir Trust Museum
X023

Varanasi, Sampurnanand Sanskrit University, Saraswati Bhavan Library
B002, C015, D055, X022, Y017

Canada

Don Mills, Ontario Science Centre
A037

Czech Republic

Prague, Náprstek Museum of Asian, African and American Cultures
P022

Egypt

Cairo, Museum of Islamic Art
F016, F017

France

Paris, Institut du Monde Arabe
A042, A108, G004

Paris, Observatoire de Paris
L003

Germany

Berlin, Museum für Asiatische Kunst
F018

Bielefeld, Kunstgewerbesammlung der Stadt Bielefeld, Summlung Huelsmann
D026

Frankfurt, Museum für Angewandte Kunst
B006

Hannover, Kestner Museum
A009

Stuttgart, Linden Museum
I004, U006

Iraq

Baghdad, Museum of Arab Antiquities = National Museum of Iraq
A012, A017

Mosul, Al Basha Mosque
A086

Netherlands

Leiden, Museum Boerhaave
A058

Pakistan

Islamabad, Islamabad Museum
A024

Karachi, National Museum of Pakistan
B013, G009, J003, X010

Lahore, Lahore Museum
A036, B024, F031, X017

Qatar

Doha, Museum of Islamic Art
A049, A052, A056, A110, A125, C013, C033, C034, D041, E003, F007, , F025

Russia

Moscow, State Museum of Oriental Art
B001

St. Petersburg, The State Hermitage Museum
F009

Switzerland

Geneva, Musée d'histoire des sciences
E002

Turkey

Istanbul, Kandilli Observatory and Earthquake Research Centre
A020

Istanbul, Türk va Islam Eserlieri Müzesi
A124

UK

Cambridge, Cambridge University, Whipple Museum of History of Science
F033

Cardiff, National Museum of Wales
A066, F015

Clitheroe, Lancashire, Stonyhurst College
F001

Edinburgh, Royal Scottish Museum
A117, C006, F020, I003, P010, P011

London, British Museum
A032

London, Clockmaker's Company, Guild Hall
A113

London, Guildhall Library
R008

London, Horniman Museum
P013, P014, R009

London, Nasser D. Khalili Collection of Islamic Art
A014, A015, A016, A078, A092, A093/E005, A105, A112, G003/H002, G010, G011, J001, X009, W003

London, National Maritime Museum, Greenwich
A004, A029, F030

London, Science Museum
A018, A021, A132, B021, D008, D011, D029, D090, G008, G017, L005, L009, P015, P016, P017

London, Victoria and Albert Museum
A085, A103, A122, B010, C012, D034, F003, F012, F014, G007, L007, L018, U001, V001, X012, X018

Oxford, Museum of the History of Science
A002, A003, A013, A028, A030, A040, A055, A068, A074, A095, A099, B007, B018, B019, D013, D022, F021, G016, K005, L004, P001, P018, W001

Oxford, Pitt Rivers Museum of Ethnology
C010, P019, P020, R001, R002, R003, R004, R005, R006, R007

USA

Cambridge/Mass, Harvard University, Houghton Library
A106

Chicago, Adler Planetarium and Astronomy Museum
A005, A006, A059, A061, A077, A081, A096, A102, A104, A134, D052, D060, F026, F029, F036, K016, N017, W004

New Haven, Yale University
A039

New York, Brooklyn Museum
A064

New York, Columbia University, Butler Library
D010, D071, F008, H004, L006, U003, U004, U005, X003

Salem, Peabody Museum
B014

Washington DC, National Museum of American History
A031, A076, A128, C024, F028, X006

Uzbekistan

Samarqand, The Samarqand Museum of History and Art of the Uzbek People
A022

APX.C INDEX OF THE INSTRUMENT MAKERS, DESIGNERS AND THEIR PATRONS*

ᶜAbd al-A'immā (*fl.* 1688-1719)
Astrolabes Y009, Y010, Y011.

ᶜAbd al-ᶜAlī (*fl.* 1707)
Astrolabe Y011.

ᶜAbd al-Qādir al-Muḥibb al-Asṭurlābī (*fl.* 1621-22)
Indo-Persian astrolabes B003, B004, B005, B006.

ᶜAbd Allāh Aḥqar (*fl.* 1915)
Sundial Q003.

Abū al-Ḥasan. Nawāb Khwājā Abū al-Ḥasan (*fl.* 1627)
Patron of Indo-Persian astrolabe Y011.

Acaleśvara (*fl.* 1889-1902)
Owner of Sanskrit astrolabes D035, D036.

Aḥmad (*fl.* 1813)
Indo-Persian astrolabe B020.

ᶜAlī ibn Ibrahīm (*fl.* 1324)
Kufic astrolabe E002.

ᶜAlī Kashmīrī ibn Luqmān (*fl.* 1589)
Indo-Persian celestial globe G001.

Allāhdād. Ustād Shaykh Allāhdād Asṭurlābī Humāyūnī Lāhūrī (*fl.* 1567)
Indo-Persian astrolabes A001, A002, A003, A004.

Amīn ibn Muḥammad Ṭāhir. Muḥammad Amīn ibn Muḥammad Ṭāhir (late 17th century)
Astrolabe Y010.

Anwar ᶜAlī Siddiqī, Ḥāfiz Anwar ᶜAlī Siddiqī (*fl.* 1829)
Sundial & ᶜAṣr indicator Q002.

Aurangzeb, Mughal emperor (r. 1658-1707)
Patron of Indo-Persian openwork celestial globe F026.

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* For a detailed index of Sanskrit names, cf. Sarma 2010.

Bāqī. Sayyid ʿAbd al-Bāqī ibn Sayyid Ḥusain (*fl.* 1789-900)
Indo-Persian astrolabes B018, B019.

Bulhomal. Lālah Bulhomal Lāhorī (*fl.* 1839-1851):
Indo-Persian astrolabes B021, B022, B023, B024, B025, B026;
Sanskrit astrolabes with multiple plates C028, C029, C030;
Sanskrit astrolabes with single plates D069, D070;
Indo-Persian Celestial globes G008, G009, G010, G011, G012, G013, G014, G015, G016;
Sanskrit Celestial globes H003, H004;
Dhruvabhrama-yantras, L006, L007;
Sanskrit Horary Quadrant K005;
New instruments designed by him U001, U002, U003, U004, U005.

Cakrapāṇi (*fl.* 1625)
Sanskrit astrolabe C003.

Caṇḍīdāsa (*fl.* 1605)
Commissioned Sanskrit astrolabe C001.

Caṇḍīdatta's son (mid-19th century)
Owner of *Yantracintāmaṇi* K016.

Dāmodara (*fl.* 1605)
Owner of Sanskrit astrolabe C001.

Dharm Chand. Joshi Dharm Chand (*fl.* 1854-73)
Perpetual Calendars & Horary Quadrants in Persian X015, X016, X017;
Perpetual Calendars & Horary Quadrants in English X018, X019;
Parts of an unknown instrument X020;
Plate of Horizons & Sine Quadrant U006, U007.

Ḍiyā' al-Dīn Muḥammad ibn Qā'im Muḥammad (*fl.* 1637-1680)
Indo-Persian astrolabes A059, A060, A061, A062, A063, A064, A065, A066, A067, A068, A069, A070, A071, A072, A073, A074, A075, A076, A077, A078, A079, A080, A081, A082, A083, A084, A085, A086, A087, A088, A089, A090, A091, A092, A093, A094, A095, A096, A097, A098, A099, A100, A101, A102, A103, A104;
Indo-Persian celestial globes F008, F009, F010, F011, F012, F013, F014, F015, F016, F017, F018, F019, F020, F021, F022, F023, F024, F025, F026, F027, F028, F029, F030, F031, F032;
Indo-Persian sine quadrant J001.

Elliott, Sir Henry Miers Elliot (1808-1853)
Patron of Indo-Persian astrolabe B021.

Gajadhar Sarūp Khemānī (*fl.* 1859)
Palabhā-yantra N004.

Gaṅgāsahāya (*fl.* 1870-1895)
Designer of Sanskrit astrolabes D090, D091.
Designer of *Phalaka-yantra* M004.

Ghulām Qādir Kapūrthalī (*fl.* 18610)
Indo-Persian astrolabes B027, B028, B029.

Gokulantha Śarmā (*fl.* 1882)
Palabhā-yantra N005.

Ḥāmid ibn Muḥammad Muqīm (*fl.* 1655-1691)
Indo-Persian astrolabes A105, A106, A107, A108, A109, A110, A112, A113, A114, A115, A116, A117, A118, A119, A120;
Indo-Persian celestial globes F033, F034, F035.

Haranātha. Josī Haranātha (*fl* 1638)
Owner of Sanskrit astrolabe C004.

Haridatta (*fl.* 1903)
Designer of Sanskrit astrolabe D037.

Hṛṣīkeśa (mid-19th century)
Yantracintāmaṇi K016.

Ibn Muḥammad Ḥaqīqā (*fl.* 1647-48)
Indo-Persian astrolabe B007.

Iftikhār Khān. Nawāb Iftikhār Khān (*fl.* 1680)
Patron of Indo-Persian astrolabe A091.

Indrajī. Josī Indrajī (*fl.* 1673)
Owner of Sanskrit astrolabe C010.

Iʿtiqād Khān. Nawāb Iʿtiqād Khān (*fl.* 1623)
Owner of Indo-Persian celestial globe F001.

ʿĪsā. Mullā / Ḥāfiz ʿĪsā ibn Allāhdād (*fl.* 1601-1604)
Indo-Persian astrolabes A005, A006, A007, A008.

Jaʿfar ibn ʿUmar al-Kirmānī (*fl.* 1388)
Kufic astrolabe Y004.

Jamāl al-Dīn ibn Muḥammad Muqīm (*fl.* 1666-1691)
Indo-Persian astrolabes A121, A122, A123, A124, A125, A126.

Jamāl al-Dīn Muḥammad ʿAlī Ḥussaynī (*fl.* 1856)
Indo-Persian sine quadrant J002.

Jayakṛṣṇadāsa (*fl.* 1887-1903)
Designer of Sanskrit astrolabes D035, D036, D037, D038.

Jemaṃgala (*fl.* 1884)
Carved Wooden Column Dial P013.

Jīvatāpa (*fl.* 1651)
Owner of Sanskrit astrolabe C007.

Jyotiṣācārya (19th century)
Owner of Sanskrit astrolabes D067, D068.

Kalyāṇa (*fl.* 1642)
Sanskrit astrolabe C005.

Kastūrīcandra (19th century)
Designer of Sanskrit astrolabes D062, D063, D064, D065.

Keśarīsiṃha, ruler of Kuchaman (r. 1857-1877)
Patron of Sanskrit astrolabe D037;
Astronomical compendia V002, V003.

Khāliq. Shaykh ᶜAbd al-Khāliq (*fl.* 1659-60)
Patron of Indo-Persian celestial globe G002.

Kheūjī Ācārya (19th century)
Owner of Sanskrit astrolabe D061.

Kīrticandra, king of an unidentified kingdom (*fl.* 1784)
Patron of *Dhruvabhrama-yantra* L002.

Kiśorasiṃha, ruler of Kota (r. 1817-1827)
Patron of *Dhruvabhrama-yantra* L005.

Lakṣmīnārāyaṇa (*fl.* 1883-1903)
Sanskrit astrolabe with multiple plates C032;
Sanskrit astrolabes with single plates D035, D036, D037, D038.

Lehna Singh Majithia (ca. 1806-1854)
Palabhā-yantra N003;
Iron column dial P023.

Madho Singh. Sawai Madho Sngh (r. 1750-1767)
Yantrādhipati T001;
Ghoṭā-yantra T002;
Śoṭā-yantras T003, T004, T005;
Star-chart T006.

Mahdī al-Khadīm al-Yazdī. Muḥammad Mahdī al-Khadīm al-Yazdī (*fl.* 1660)
Astrolabe Y008.

Maḥmūd bin ᶜAlī bin Yūshāᶜ (*fl.* 1271)
Kufic astrolabe E001.

Maḥmūd ibn Shaukat al-Baghdādī (*fl.* 1306)
Kufic astrolabe Y003.

Muḥammad ibn Jaᶜfar ibn ᶜUmar ibn Dawlatshah al-Kirmānī (*fl.* 1393-1431)
Kufic celestial globe Y013.

Mangaran (*fl.* 1858)
Universal equinoctial sundials X011, X012, X013, X014.

Maṇirāma (*fl.* 1644)
Owner of Sanskrit astrolabe C006.

Mannālāla (mid-19th century)
Commissioned Sanskrit astrolabe D008.

Māyārāma. Sūtradhāra Māyārāma (*fl.* 1810)
Sanskrit astrolabes C027, C028.

Mīr Qāsim (*fl.* 1694)
Sundial Q001.

Mīrzā Faḍl ᶜAlī ᶜAmīl (19th century)
Shabnumā-wa-Rūznumā L025.

Morāraji. Sonī Morarajī (*fl.* 1815)
Dhruvabhrama-yantras L003, L004

Motīrāma (*fl.* 1784)
Dhruvabhrama-yantra L002.

Mulchand (*fl.* 1872)
Sanskrit astronomical clock X024.

Muqīm. Muḥammad Muqīm ibn ᶜĪsā (*fl.* 1621-1659)
Indo-Persian astrolabes A017, A018, A019, A020, A021, A022, A023, A024, A025, A026, A027, A028, A029, A030, A031, A032, A033, A034, A035, A036, A037, A038, A039, A040, A041, A042, A043, A044, A045, A046, A047, A048, A049, A050, A051, A052, A053, A054, A055, A056, A057, A058;
Indo-Persian celestial globes F006, F007.

Murārajī Kuarajī. Ṭhākura Murārajī Kuarajī (*fl.* 1638)
Sanskrit astrolabe C004.

Nadhīr al-Dīn Ḥussayn (*fl.* 1803)
Shabnumā-wa-Rūznumā L024.

Nandarāma Miśra (*fl.* 1767)
Reworked Indo-Persian celestial globe H002.

Nayanānanda (*fl.* 1701)
Reworked Indo-Persian astrolabe E005.

Nareṃdrasiṃgha Mahīṃdra Bahādrajī, Maharaja of Patiala (r. 1845-1862)
Patron of Gurmukhi astrolabe C031.

Pandit (*fl.* 1616)
Bilingual astrolabe B002.

Pīr Bakhsh Lāhūrī (*fl.* 1841)
Indo-Persian astrolabe B024.

Premajī Pāṇḍyā (*fl.* 1815)
Owner of *Dhruvabhrama-yantras* L003, L004.

Puruṣottama (*fl.* 1642)
Owner of Sanskrit astrolabe C005.

Qā'im Muḥammad ibn ᶜĪsā (*fl.* 1624-1635):
Indo-Persian astrolabes A009, A010, A011, A012, A013, A014, A015, A016, A017;
Indo-Persian celestial globes F001, F002, F003, F004, F005.

Rāghavajit (*fl.* 1669)
Owner of Sanskrit astrolabe C008.

Rahīm Bakhsh (*fl.* 1850)
Gurmukhi astrolabe C031.

Ram Charan (*fl.* 1875)
Universal equinoctial sundial X014.

Rāmacandra, Josī Rāmacandra (*fl.* 1884)
Astronomical compendia V002, V003.

Rāmanātha Jyotirvid (*fl.* 1827)
Dhurvabhrama-yantra L005.

Rāmapratāpa (*fl.* 1895)
Sanskrit astrolabe D091;
Phalaka-yantra M004.

Rāmayatna Ojha (early 20th century ?)
Sometime owner of Sanskrit astrolabe C015.

Raṇakuṃjalāla (*fl.* Ca. 1867)
Owner of Sanskrit astrolabe D050.

Rishīkes (*fl.* 1850)
Designer of Gurmukhi astrolabe C031.

Ṣāliḥ. Muḥammad Ṣāliḥ Tatawī (*fl.* 1659-1666):
Indo-Persian astrolabes B008, B009, B010, B011, B012, B013, B014;
Indo-Persian celestial globes G002, G003.

Sakhārām Jośī (*fl.* 1790-1796)
Sanskrit astrolabes D056, D057;
Dhruvabhrama-yantra L022;
Phalaka-yantra M001.

Seshachariar. Karur Seshachariar (20th century)
Sanskrit armillary sphere I006.

Sharīf, Muḥammad Sharīf ibn Muḥammad (17th century)
Indo-Persian astrolabe A134.

Shah Faridul Haque Emadi (20th century)
Sundial Q004.

Shah Jahan, Mughal emperor (r. 1628-1658)
Patron of Indo-Persian astrolabe A093.

Sirāj. Al-Sirāj Dimashqī (*fl.* 1226-1229)
Kufic astrolabes Y001, Y002.

Śivadatta (mid-19th century)
Sanskrit astrolabe D008.

Śivalāla (*fl.* 1870)
Sanskrit astrolabe D090.

Sūryamalla. Sūtradhra Sūryamalla (*fl.* 19th century)
Sanskrit astrolabes D062, D063, D064, D065.

Tipu Sultan (1750-1799)
Patron of sundials Q005, Q006.

Vaijanātha's son (*fl.* 1834)
Yantra-cintāmaṇi K015.

Vīrabhadra (*fl.* 1805-1809)
Sanskrit astrolabes C024, C025C025.

Wafa' bin Munajjim (*fl.* 1608)
Kufic astrolabe E003.

Wilson, Professor Horace Hayman Wilson (1786-1860)
Owner of reworked astrolabe E001.

Yādo Josī of Ukala-grāma (mid-19th century)
Owner of *Dhruvabhrama-yantra* L010.

Zamān. Muḥammad Zamān (*fl.* 1659)
Astrolabe Y007.

APX.D1 THE YANTRARĀJA OF MAHENDRA SŪRI WITH MALAYENDU SŪRI'S COMMENTARY: SOME EXTRACTS

INTRODUCTION

MAHENDRA SŪRI'S YANTRARĀJA

Mahendra Sūrī's *Yantrarāja* is the first Sanskrit manual on the construction and use of the astrolabe.[*] He commences the work with a homage to Sarvajña (Jina) and to his own teacher Madana Sūri. He concludes each of the five chapters with an almost identical verse employed as a refrain, where he pays homage once again to Madana Sūri of Bhṛgupura, who was the crest-jewel of the circle of astronomers and the teacher of Mahendra Sūri. Bhṛgupura, now known as Bharoch (21; 43° N – 72; 59° E), is in Gujarat. In his commentary on his work, Malayendu Sūri, emulates this practice; he too commences the commentary with homage to Sarvajña (Jina) and to his own teacher Mahendra Sūri; he too concludes the commentary of each chapter with an almost identical verse which proclaims that Mahendra Sūri was the foremost astronomer (*sarva-gaṇaka-praṣṭa*) at the court of Sultan Fīrūz Shāh Tughluq (r. 1351-1388) of Delhi.

Mandra Sūri and his pupil Malayendu Sūri were Jaina monks, hailing originally from Bhauch in Gujarat; they spent some time at the court of Fīrūz Shāh at Delhi, where the text *Yantrarāja* and the commentary were composed. Malayendu informs that the text was completed in Śaka 1272.[†] In fact, the star longitudes mentioned in this text pertain precisely to the 15th day in the bright half of the month Caitra in Śaka 1272 (11 April 1370).[‡] Malayendu Sūri appears to have completed his commentary around 1378.

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[*] Cf. Dikshit 1981, pp. 230-231; Pingree 1978b, pp. 626-628; Pingree 1981, pp. 52-53; Ôhashi 1997; Sarma 1999a; Sarma 2000.

[†] Malayendu Sūri, p. 29: *ayam granthaḥ śāke 1292 varṣe niṣpannaḥ* (this text was competed in the year 1292 Śaka = AD 1370-71). In the same year was completed the Persian chronicle *Sīrat-ī Fīrūzshāhī* which contains valuable information Fīrūz's Shāh's interest on the astrolabe and its promotion and manufacture at his court. On a comparison between Mahendra's *Yantrarāja* and the *Sīrat,* see Sarma 2000.

[‡] Malayendu Sūri, p. 35.

The *Yantrarāja* is divided into five chapters. [*] The first chapter *Gaṇitādhyāya* provides various trigonometrical parameters needed for the construction of the astrolabe. Malayendu's commentary supplements these by several detailed tables drawn for each degree of arc from 1° to 90°. There are tables of sines and cosines for the Radius 3000, a table of declinations with the obliquity of 23;35°, shadow tables for the gnomon of 12 digits and the gnomon of 7 feet. There is a list of 76 localities and their latitudes; there are tables that show the eccentricities and radii of altitudes circles at 6° intervals for six localities in India with latitudes ranging from 18° to 31°. More important is the star catalogue providing the Arabic and Sanskrit names of 32 astrolabe stars with their longitudes and latitudes, for 1370 when the *Yantrarāja* was composed and for 1437 when the longitudes increase by 1° due to precession.

The second chapter *Yantraghaṭanādhyāya* mentions the components of the astrolabe.[†] The third chapter *Yantraracanādhyāya* mentions briefly the different types of the astrolabes and then discusses the construction of three major types, viz. northern astrolabes (*saumya-yantra*), southern astrolabes (*yāmya-yantra*) and a combination of these two (*miśra-yantra*).[‡] The fourth chapter *Yantraśodhanādhyāya* explains how to test whether the astrolabe is properly constructed or not. The final and the fifth chapter, entitled *Yantravicāraṇādhyāya* discusses the use of the astrolabe as an observational and computational instrument and dwells on the various problems in astronomy and spherical trigonometry that can be solved by means of the astrolabe.

MALAYENDU SŪRI'S COMMENTARY

In his commentary, Malayendu explains each mathematical procedure in detail with worked examples. Interestingly, some of these examples are based on actual observations made at Delhi on specific dates. In his commentary on *Yantrarāja* 3.26, he

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[*] Cf. Ôhashi 1997, pp. 211-216.

[†] Actually there is no need of this chapter; it could have been safely combined with the third chapter.

[‡] Among the mixed varieties, importance is given one which is designated as *Phaṇīndra-yantra* (lit. instrument of the 'lord of the serpents') (verses 20-23). The significance of this name eludes us. The Persian chronicle *Sīrat-i Firūz-Shāhī* describes in great detail a very large north-south astrolabes produced for Fīrūz Shāh under the name *Asṭurlāb-i Firūz-Shāhī*. But it is difficult to say whether the Sanskrit name *Phaṇīndra-yantra* contains any allusion to this *Asṭurlāb-i Firūz-Shāhī*; cf. Sarma 2000.

shows how to derive the duration of the longest daylight from the terrestrial latitude with the concrete example of Delhi's latitude of 28;39° and derives from this latitude the maximum duration 34 *ghaṭīs,* 34 *palas* and 34 *vipalas.*[*] The dates mentioned by him are as follows:

11 April 1370, Thursday (*saṃvat 1427 varṣe caitrasudi 15*) is the gauge year of the star catalogue (commentary on I.57-58, p. 35).

7 April 1377, Tueday: the true longitudes of the sun and moon were ascertained at midnight by means of the astrolabe (*saṃ. 1433 varṣe caitra sudi 30 bhaume yantreṇa sphuṭau ravicandrau ardharātra-samaye sādhitau,* on 5.46-51, p. 76).

17 September 1377, Thursday: tropical longitudes of the sun and Venus are determined with the help of the astrolabe (*saṃ. 1434 varṣe āśvina sudi 15 gurau ardharātrasamaye sāyanau ravi-śukrau sādhitau,* on 5.58-60, p. 79).

1 October 1377, Thursday: true longitudes of the sun and Venus were determined with the help of the astrolabe (*saṃvat 1434 varṣe āśvina vadi 30 gurau ardharātrasamaye sphuṭau raviśukrau yantreṇa sādhitau,* on 5.61-53, p. 80).

13 May 1378, Thursday: the eastern altitude of the sun was 42° (*saṃvat 1435 prathama-jyeṣṭha-śukla-pañcadaśī 15 gurau raveḥ prācyonnatāṃśāḥ 42,* on 5.26-27, p. 70).

EDITIONS OF THE *YANTRARĀJA*

The *Yantrarāja* with Malayendu Sūri's commentary was edited by Sudhākara Dvivedī, Varanai 1882, and by Kṛṣṇaśaṃkara Keśavarāma Raikva, Mumbai 1936. Neither edition is very satisfactory. While the former does not contain all the 21 tables compiled by Malayendu Sūri, the latter reproduces the last table twice.[†] There are also many typographic errors in the edition of 1936.

In his *Gaṇaka-taraṅgiṇī,* Sudhakara Dvivedi makes the following remarks on the *Yantrarāja*: 'It appears that this text was not an independent work of Mahendra Sūri, but a Sanskrit rendering of some Persian text. … By looking at this work, it does not appear either Mahendra or his pupil had any mastery in mathematical astronomy … Here the

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[*] Malayendu Sūri, p. 62: dillyām akṣāṃśāḥ … dillyāṃ parama-dinam 34|34|34.

[†] Malayendu Sūri, pp. 49-51 and pp. 52-54.

determination of the *dṛkkarman* was not correctly presented.'[*] But in his own edition of the *Yantrarāja*, Dvivedi does not make any comment on the passage where Mahendra discusses the *dṛkkarman.*[†] Almost a century later, Kim Plofker supports Dvivedi's contention with a detailed analysis of verses 41-54 of the first chapter of the *Yantrarāja* and Malayendu's commentary on these and shows that Mahendra and his pupil Malayendu did not fully comprehend the principles of spherical trigonometry and substituted them with various approximation devices.[‡]

Even so, Mahendra's *Yantrarāja* (together with Malayendu's commentary) occupies an important position among the Sanskrit texts on astronomical instruments; it is the first Sanskrit text exclusively devoted to a single astronomical instrument and all other texts composed subsequently on the astrolabe broadly follow it. There exist today nearly a hundred manuscript copies of the text and commentary.[§] Several actual specimens of Sanskrit astrolabes are also based on this text. Moreover, it is an important document related to the interaction between the Islamic and the Sanskrit scientific traditions.

Therefore, some extracts from Mahendra's text and Malayendu's commentary are presented in the following pages together with an English translation. The Sanskrit text is based on Raikva's edition of 1936; typographical errors are silently corrected. In a few cases, I follow the superior readings of a manuscript dated 23 May 1853.[**]

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[*] *Ganaka-tarangini, or Lives of Hindu Astronomers,* by Mahamahopadhyaya Sudhakara Dvivedi, edited by his son Padmakara Dvidevi, Benares 1933, pp. 48-49:
ayaṃ granthaḥ kasyacit-pāraśīgranthasya saṃskṛte 'nuvādo na svātantryeṇa mahendrasūrikṛto iti pratīyate | … granthasya vilokanenāsya tadīyaśiṣyasya malayendusūreś ca gaṇite prauḍhir na vibhāti | … atra dṛkkarmmānayanaṃ na samīcīnam

[†] 1.48-53 in Dvivedi's edition; 1.49-54 in Raikva's edition.

[‡] Plofker 2000.

[§] CESS, s.v. Mahendra Sri, vol. 4, 393-395; vol. 5, 296-297; s.v. Malayendu Sūri, vol. 4, pp. 363-364; vol. 5, pp. 282-283.

[**] Jyotiṣa Ms no. 37, formerly with the Sanskrit Department of the Aligarh Muslim University, now transferred to the Maulana Azad Library of the same university.

श्रीमहेन्द्रसूरि-प्रणीत-यन्त्रराजः श्रीमलयेन्दुसूरि-कृत-व्याख्या-समेतः

1. GAṆITĀDHYĀYA (CHAPTER ON COMPUTATION)

1.1-4 PREAMBLE

śrīsarvajñapadāmbujaṃ hṛdi parāmṛśya prabhāvapradaṃ
śrīmantaṃ Madanākhyasūrisuguruṃ kalyāṇakalpadrumam |
lokānāṃ hitakāmyayā prakurute sad-Yantrarājāgamaṃ
nānābhedayutaṃ camatkṛtikaraṃ sūrir Mahendrābhidhaḥ ||1||
apāre saṃsāre katikati babhūvur na caturāḥ
paraṃ tair durbodhaṃ gaṇitam araci prauḍhamatibhiḥ |
tataḥ svalpaṃ sāraṃ viśadam idam atyantasugamaṃ
vitanve 'haṃ śāstraṃ suhṛdayahṛdānandakṛtaye ||2||
kḷptās tathā bahuvidhā yavanaiḥ svavāṇyā
yantrāgamā nijanijapratibhāviśeṣāt |
tān vāridhīn iva viloḍya mayā sudhāvat
tatsārabhūtam akhilaṃ praṇipadyate 'tra ||3||
yathā bhaṭaḥ prauḍharaṇotkaṭo 'pi śastrair vimuktaḥ paribhūtim eti |
tadvan mahājyotiṣanistuṣo 'pi yantreṇa hīno gaṇakas tathaiva ||4||

1. Having meditated in his heart upon the lotus-feet of *Sarvajña* [Jina], which bestow [intellectual] power, and upon the illustrious teacher **Madana Sūri**, the wishing tree of good fortune, **Mahendra Sūri** composes, for the welfare of mankind, the excellent treatise called ***Yantrarāja*** which contains many [interesting] details and which is stimulating.

2. There had been born clever persons in this boundless world. Of mature intellect, they wrote highly obscure manuals on astronomy. Therefore, I present this learned work (*śāstra*), which is brief, [contains just] the essence, is lucid and very easy to understand, for the delectation of the good-hearted.

3. Many kinds of manuals on [astronomical] instruments were composed by Muslims in their own language, each book distinguished by the genius of its author. Having churned them like oceans, I present their essence here like nectar.

4. Just as a soldier, though bold and fierce in warfare, is disgraced when he is without weapons, even so an astronomer (*gaṇaka*), though great an expert in astral science, [is disgraced] without instruments.

1.5-6 COMPUTATION OF SINES (*KRAMAJYĀ*) AND VERSED SINES (*UTKRAMAJYĀ*)

Table 1: sines and differences (*jīvāṃtara*) for each degree of arc from 1° to 90°.

Table 2: Versed sines (*utkramajīvā*) and differences for each degree of arc from 1° to 90°.

Table 3: Declinations and differences for each degree from 1° to 90°

1.7-12: COMPUTATION OF DECLINATION (*KRĀNTI*)

Table 4: *dyujyāphala* and difference for each degree from 1° to 189°.

1.13-15: CALCULATION OF THE ECCENTRICITIES (*KENDRA*) AND RADII (*VYĀSĀRDHA*) OF ALTITUDE CIRCLES (*UNNATA-VALAYA*) IN THE NORTHERN ASTROLABE

palair vihīnā gaganāṣṭacandrā 180 śeṣās tathākṣāḥ pṛthag eva dhāryāḥ |
śeṣākṣayor vāsarakhaṇḍakebhyo dyujyā-phalaṃ vai parisādhanīyam ||13||
tadakṣasaṃjñena phalena hīnaṃ yuktaṃ ca śeṣākṣaphalaṃ vidhāya |
ardhaṃ vidheyaṃ ca tataḥ krameṇa kendraṃ bhaved vysayutaṃ kujākhye ||14||
śeṣe tathākṣe ca yathepśitāṃśāḥ śodhyās tataḥ pūrvavad uktarītyā |
kāryāṇi kendrāṇi savistarāṇi kujākhya-vṛttāt purataḥ sphuṭāni ||15||

13. Subtract the degrees of the given latitude (*pala*) from 180. Keep the remainder and the given latitude degrees separately. From the table of the *dyujyā-khaṇḍas*, determine the *dyujyā-phala* for the remainder (A) and for the latitude degrees (B).

14. Subtract the *dyujyā-phala* of the latitude degrees from, and add to, the *dyujyā-phala* of the remainder (A - B; A + B). Halve these two quantities. These respectively are the eccentricity [(A – B) ÷ 2] and the half diameter [(A + B) ÷ 2] of the circle of horizon (*kuja*).*

* Here *kendra* (eccentricity) means the distance of the centre of the altitude circle from the north pole which is the centre of the astrolabe, measured along the meridian line.

15. Then from the remainder (*śeṣa*) and from the latitude (*akṣa*) subtract the desired degrees [depending on the desired frequency of altitude circles]. Then in the same way as before compute the eccentricities beyond the horizon together with the [half] diameter (*vistāra*).

Commentary:

palaśabdenākṣāṃśā ucyante | palaiḥ sva-sva-deśākṣāṃśair gaganāṣṭarūpā aśītyadhikaśatāṃśā 180 hīnāḥ kartavyāḥ | śeṣāṃśā akṣāṃśāś ca pṛthag dhāryāḥ | tato 'kṣaśeṣāṃśayor dyujyā-khaṇḍebhyaḥ pūrvavad dyujyāphalam ānīyākṣāṃśād āgataphalenākṣaśeṣaphalaṃ dviḥstham ekatra hīnam aparatra yutaṃ ca kṛtvā dvayam apy arthitaṃ sat krameṇa kendra-vyāsau bhujavṛttasya bhavataḥ | tad atrākṣaśeṣe vākṣe ekādiṣaṭparyanteṣu dṛṣṭonnatāṃśeṣu pātiteṣu akṣaśeṣād akṣāc ca pūrvoktarītyaiva tāvatām unnatāṃśānāṃ kendra-vyāsānayanaṃ kāryam |

*atrodāharaṇam | yathā śrīmad**yoginīpure** saumyākṣāṃśāḥ 28|39 ete aśītyadhikaśata 180 madhyāt pātite śeṣāṃśāḥ 151|21 ebhyo dyujyāphalam ānīyate | yathā rāśiṣaṭkasya svāhorātra-pramāṇa-phala-jyā-koṣṭhakeṣu ekapañcāśad-adhika-śatādhaḥ prāptaṃ dyujyā-phalaṃ 75|59 tadatho 'ntaraṃ 2|50 anenāntareṇāṃśādhaḥsthitāḥ kalāḥ 21 guṇyante jātāḥ 42|1050| adhastanāṅkasya ṣaṣṭi 60 bhāge labdhāḥ 17 ete uparitanāṅke 42 yojyante jātāḥ 59 ete dyujyāphalāṅka 75|59 madhye yojyante jātam akṣaśeṣaphalaṃ bhāgādyaṃ 76|58 | anayaiva rītyā akṣāṃśebhyaḥ 28|39 dyujyāphalaṃ prasādhyam | tad idam akṣāṃśaphalaṃ bhāgādyaṃ 5|1 tadanu pūrvānītaṃ śeṣāṃśaphalaṃ sthānadvaye saṃsthāpyākṣāṃśaphalam ekatrapātayitvānyatra yojayitvā cāvaśiṣṭāṃśe 'rdhīkṛte krameṇa bhujavṛttasya kendraṃ 35|58|30 vyāsaś ca 40|52|30 syātām ||*

atha bhujavṛttād agretanānām unnatāṃśānāṃ kendra-vyāsānayanam | pūrvoktād akṣaśeṣāt 151|21 ṣaḍunnatāṃśāḥ pātyante jātāḥ śeṣāṃśāḥ 145|21 tathākṣāṃbhyo 'pi 28;39 ṣaṭ pātyante jātā akṣāṃśāḥ 22|32 tataḥ pūrvoktarītyā ṣaḍunnatāṃśānāṃ kendraṃ 29|32 vyāsaḥ 33|28| evaṃ kriyamāṇe caturviṃśaty-unnatāṃśānām pātanāc cheṣāṃśāḥ 127|21 akṣāṃśāḥ 4|39 | ebhyaḥ pūrva-sādhitarītyā sādhitaṃ kendraṃ 19|35 vyāsaḥ 20|24||

The word *pala* here denotes the degrees of latitude. Hence, subtract the *palas*, i.e. the degrees of the given latitude, from 180 degrees. Keep the remaining degrees and the latitude degrees separately. Then in the same manner as taught before, determine the *dyujyā-phalas* for the remainder (A) and for the latitude degrees (B). Next subtract the *dyujyā* corresponding to the latitude degrees (B) from the *dyujyā* corresponding to the remainder (A) at one place (A – B) and at another place add these two (A + B). Halve both the quantities. These will be the eccentricity and radius respectively of the circle of horizon (*bhuja-vṛtta*). Next from the remainder (*akṣaśeṣa*) and from the latitude (*akṣa*) subtract the desired altitude degrees (*iṣṭa-unnatāṃśa*) from 1 up to 6 and from the resulting remainder and latitude, determine anew the eccentricity and radius for that many altitude degrees above the horizon.

Example: The latitude of the glorious **Yoginīpura** (= Delhi) is 28/39°. These degrees are subtracted from 180. The remaining degrees are 151/21. For these two values, the *dyujyā* is computed. In the table of the *svāhoratrapramāṇaphalas* (i.e., the *dyujyā* table) under 151 degrees, the value given is day radius 75|59 and below that the difference is 2|50. With this difference, the 21 minutes written below are multiplied. The product is 42|1050. The lower number is divided by 60, the quotient 17 is added to the upper number 42 and we get 59|30. These are added to the value of the day radius found in the table, viz. 75|59. We get 76|58 as the *phala* corresponding to the *akṣaśeṣa* (A). The result in degrees and sub-multiples (*bhāgādya*) is 76 degrees and 58 minutes. In the same manner the day radius should be computed for the latitude 28;39. This value is 5;1. After this, place the value for the remainder at two places and from one subtract the value for the latitude and at another add and halve it at both places. Thus we get the eccentricity 35;58,30 and the radius 40;59,30 of the circle of horizon.

Now the computation of the eccentricities and radii of altitude circles above the horizon. From the remainder of latitude (*akṣa-śeṣa*) mentioned before 151/21 subtract 6 degrees of altitude, remaining are 145/21. Likewise from the latitude also [reduce 6 degrees] 28/39 – 6 = 22/39. Then in the same manner as before, the eccentricity of the circle of altitude 6 ° is obtained as 29/32; diameter 33/28. Thus proceeding further, when 24 altitude degrees are subtracted, the remainder (*śeṣāṅka*) is 127/21 and latitude 4;39. The eccentricity computed from these, in the same manner as before, is 19;35 and the diameter 20;24.

1.16-17: PROCEDURE TO FOLLOW WHEN THE LATITUDE IS LOWER THAN THE ALTITUDE.

1.18-21: CALCULATION OF THE ECCENTRICITIES AND RADII (*VYĀSĀRDHA*) OF ALTITUDE CIRCLES (*UNNATA-VALAYA*) IN THE SOUTHERN ASTROLABE.

Climates

Commentary:

> *atha nirakṣāl laṅkā-pradeśāt meruparvata-paryantaṃ pūrvāparadigvyāpinaḥ sapta 7 vibhαgāḥ tadantarvartināṃ nagarāṇām akṣāṃśajñānārtham ādyaiḥ kalpitāḥ santi | teṣāṃ yavana-bhāṣayā ikalameti saṃjñā kṛtā | śani-guru-bhauma-ravi-śukra-somāḥ kramāt svāminaś ca | evaṃ nirakṣalaṅkāpradeśāt pratibhāgam akṣāṃśās trayodaśa navaliptābhir nyūnāḥ 12|51 madhyarekhātaḥ pūrvāparabhāgasthā bhavanti | evaṃ yantrāṃśās trayodaśa 13, ṣaḍviṃśatiḥ 26, ekonacatvāriṃśat 39, dvipañcāśad 52, pañcaṣaṣṭiḥ 65, aṣṭasaptataiḥ 78, navati 90 paryantāḥ | anenaiva krameṇa sapta bhāgāḥ syuḥ | paraṃ dvipañcāśad-akṣāṃśān yāvan manuṣyāṇāṃ nivāsaḥ | tadagrataḥ ṣaṭṣaṣṭyaṃśaparyantaṃ śītabāhulyād andhakārāc ca manuṣyāṇām alpa eva saṃcāraḥ | tatparataḥ kiṃnara-gandharva-vidyādhara-siddhānāṃ pracārā devabhūmayaḥ ||`
>
> *atha caturvibhāgāntarvartināṃ nagarāṇāṃ sukhāvabodhārtham akṣāṃśāḥ pradarśyante | tad yathā | laṅkāyām akṣāṃśāḥ 0|0, ādane 11, tilaṅge 18, …**śrībhṛgukaccha**-nandabhadrava-vaṭapatra-stambhatīrtha-dhavalake 22, … dillyāṃ **śrīyoginīpure** 28|39 … **śrīperojanṛpavāsita-siṃsāra-perojābāde** 29|45, … samarakanda 40, khurāśāna 42|20, kāsagara 44, bulagāra 49, etvatparyantaṃ nivāsabhūmiḥ |*[*]

Now, the ancients have conceived of seven divisions stretching from the east to the west from the 0° latitude at Laṅkā up to the north pole (*meru-parvata*) for the knowledge of the latitudes of the towns situated within them. These divisions are

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[*] Three places are honoured with the honorific *śrī*: Bhṛgukaccha (Bharuch) which is the seat of Madana Sūri, the preceptor of Mahendra Sūri; Yoginīpura sacred to Jainas and the place of residence of Mahendra Sūri and Malayendu Sūri, and Hissar-Firozabad where Fīrūz Shāh Tughluq built a fortified palace in 1354.

designated as *iqlīm* in Arabic language.* Saturn, Jupiter, Mars, Sun, Venus, Mercury and Moon are the lords of these divisions successively. Thus starting from the equator, each division spreads up to 13 degrees minus by 9 minutes (*liptā*) = 12;49°. These divisions spread to the east and west from the meridian.

Accordingly, the divisions on the instrument are [in integral degrees] 13, 26, 39, 52, 65, 78, 91. In the same sequence let the seven divisions be. But human habitation is up to 52° . Beyond that up to 66°, few humans live because of excessive cold and darkness. Beyond that are realms of the celestials (*deva-bhūmayaḥ*) where *Kinnaras, Gandharvas, Siddhas* and *Vidyādharas* move about.

Now for the convenience [of readers] we write the latitude degrees of [certain] towns situated within the first four divisions.†

Table Apx.D1-1 Geographical Gazetteer

	Place Name	φ	Modern Name	Modern φ	Modern L
1	Laṅkā	0;0	Equator	0;0	0;0
2	Ādana	11	Aden, Yemen	12;48	45;02
3	Tilaṅga	18	Hyderabad	17;21,58	78;28
4	Anagūndī	18;10	Hampi Vijayanagar Karnataka	15;20,06	76;27
5	Gaṅgāsāgara	18;20	Sagar Island, WB	21;48	88;06
6	Hāvasa	18;30	al-Ḥabasha (= Abyssinia)‡		

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* Malayendu clearly did not understand the concept of the climates of classical antiquity which divides the 'inhabited portion' of the northern hemisphere (and not the entire northern hemisphere from latitude 0° to latitude 90°) into seven strips which reach roughly up to 50;30°; several Lahore astrolabes carry tables of climates on the back (e.g., Figure A041.3, Figure A051.4) and in many the geographical gazetteers are arranged according to climates (e.g. A024, A030).

† Here the 'first four divisions' are not the first four climates of antiquity, but the divisions as Malayendu understood them. Thefore the places listed by him belong to all the seven climates. These are arranged in the following table, along with their modern names and modern coordinates. To the Indian place names are added the names of the federal states; for some of these, the following abbreviations are used: in abbreviations. Maha = Maharashtra; MP = Madhya Pradesh; Raj = Rajasthan; UT = Union Territory; WB = West Bengal.

‡ The reference here is to Jarmī, the ancient capital of Abyssinia, called al-Ḥabasha in Arabic. This place is mentioned in the gazetteers of about a dozen Indo-Persian astrolabes (A002, A013, A014

	Place Name	φ	Modern Name	Modern φ	Modern L
7	Devagiri	20;34	Daulatabad, Maha	19;56	75;13
8	Tryambaka	21	Tryambak, Maha	19;55	73;30
9	Saṃjāna	21	Sanjan, Gujarat	20;12	72;48
10	Damana	21	Daman, UT	20;25	72;51
11	Navasārikā	21	Navsari, Gujarat	20;57	72;54
12	Makkā	21;20	Mecca	21;25	39;49
13	Śrī-Bhṛgukaccha	22	Bharuch, Gujarat	21;42	72;58
14	Nandabhadrava	22	?		
15	Vaṭapatra	22	Vadodara?, Gujarat	22;18	73;12
16	Sthambhatīrtha	22	Khambhat, Gujarat	22;18	72;37
17	Dhavalaka	22	Dholka, Gujarat	22;43	72;28
18	Aṃśāvalī*	23?	Ashowal, Gujarat	23;02	72;35
19	Somanāthapattana	22;15	Somnath, Gujarat	20;53	70;24
20	Māṅgalyapura	22;15	?		
21	Raivatakācala	22;31	Girnar, Gujarat	21;29	70;30
22	Dvārakā	22;31	Dwaraka, Gujarat	22;14	68;58
23	Navapattana	22;31	?		
24	Ujjayinī	23;30	Ujjain, MP	23;11	75;46
25	Dhārā	23;30	Dhar, MP	22;36	75;18
26	Aṇahilapurapattana	24	Patan, Gujarat	23;50	72;07

etc.) as ‘Jarmī, Dār al-Mulk Ḥabasha’ and the coordinates in all cases are latitude 9;30 and longitude 65;30. The latitude 18;30 given in the present list is off the mark.

* Misreading for Āśāpallī, an old capital of Gujarat, today a suburb of Ahmedabad

	Place Name	φ	Modern Name	Modern φ	Modern L
27	Nalapura	25	Narwar, MP	25;19	77;58
28	Ajameru	26	Ajmer, Raj	26;27	74;38
29	Nāgapura	26	Nagaur, Raj	27;12	73;44
30	Vārāṇasī	26;15	Varanasi, UP	25;17	82;57
31	Lakṣaṇāvatī	26;20	Lucknow, UP	27;51	80;55
32	Kaḍānagara	26;19	Kara, UP	25;42	81;21
33	Kānyakubja	26;35	Kannauj, UP	27;04	79;55
34	Māṇikapura	26;49	Garhi Manikpur, UP	25;04	81;07
35	Tīrabhukti	27	Tirhut=Muzaffarpur Bihar	26;04	85;27
36	Jājanagara*	27	Jajpur, Orissa	20;51	86;20
37	Uddīsāsthāna	27;5	probably the same as above		
38	Ayodhyā	27;22	Faizabad, UP	26;48	82;12
39	Gopālagiri	27;29	Gwalior, MP?	26;13,17	78;10,41
40	Bundī	27;32	Bundi, Raj	25;26	75;38
41	Gopīmaṇḍala	27;45	Gopamau, MP?	27;32	80;17
42	Kola-Jalālī	28;4	Aligarh, UP	27;53	78;05
			Jalali, UP	27;52	78;16
43	Kaṃpil	28;10	Kampil, UP	27:37	79;17
44	Śivasthāna	28;15	Sistan-e Olya, Iran?	28;31	53;16
45	Uccanagara	28;20	Uch, Punjab, Pakistan	29;14	70;04

* Ancient capital of Orissa.

	Place Name	φ	Modern Name	Modern φ	Modern L
46	Vaḍānagara	28;28	Vadnagar, Gujarat	23;47	72;38
47	Ḍhillī Yoginīpura	28;39	Delhi	28;36	77;13
48	Rohītaka	28;45	Rohtak, Haryana	28;53	76;34
49	Meraṭha	29;20	Meerut, UP	28;59	77;42
50	Mūlatāna	29;40	Multan, Pakistan	30;12	71;28
51	Hāṃsī	29;45	Hansi, Haryana	29;06	75;58
52	Hiṃsāra-Phirozabada	29;48	Hissar, Haryana	29;09	75;49
53	Sarasvatīpattana	29;50	?		
54	Sthāneśvara	30;10	Thanesar, Haryana	29;59	76;49
55	Kurukṣetra	30;10	Kurukshetra, Haryana	30;06	76;45
56	Kapisthala	30;30	Kaithal, Haryana	29;48	76;23
57	Jālandhara	30;30	Jalandhar, Panjab	31;20	75;35
58	Sunnāma	30;30	Sunam, Panjab	30;08	75;48
59	Simāṇika	30;30	?		
60	Nepālapura	31	Kathmandu, Nepal	27;42	85;20
61	Lāhora	31;50	Lahore, Pakistan	31;33	74;21
62	Vodhaura	31;50	?		
63	Badaṣa(kha)sāna	36;22	Badakhshan, a region in Afghanistan and Tajikistan		
64	Dāmagām	36;30	Damghan, Iran	36;10	54;21
65	Posaṃja	36;40	?		
66	Balaṣa (Balakha)	36;40	Balkh, Afghanistan	36;45	66;54

	Place Name	φ	Modern Name	Modern φ	Modern L
67	Nayasāpura	37;10	Nishabur, Iran	36;13	58;48
68	Kāśmīra	37;20	Srinagar, JK	34;5	74;47
69	Tirimidi	37;35	Termez, Uzbekistan?	37;13	67;17
70	Vāvarada	37;40	?		
71	Cīgāni	37;50	?		
72	Kaluāra	39	?		
73	Samarakanda	40	Samarkand, Uzbekistan	39;39	66;57
74	Khuāragrāma (Khurāśāna)	42;20	Khurasan, a region in Iran		
75	Kāsagara	44	Kashgar, China	39;28	75;59
76	Bulagāra	49	Bulghar, the land of the Svavs north of the Caspian Sea around the Volga River.		

Tables 5-16: Eccentricities (*kendra*) and Radii (*vyāsārtha*) of altitude circles pertaining to six different latitudes

Commentary:

> *atha gaṇakānāṃ hitāya kiyatām apy akṣāṃśānāṃ saumya-yāmyāḥ kendravyāsāḥ sāntarāḥ parama-viṣuvaccāyā-tatkarṇa-sahitāḥ pradarśyante | yathā navīna-yāmya-saumya-miśra-yantra-karaṇatvam āyāti |*

Now for the convenience of astronomers we display for certain latitudes northern and southern eccentricities, radii, with differences, together with the maximum daylight

hours (*parama-dina*), equinoctial shadow (*viṣuvac-chāyā*) and equinoctial hypotenuse so that the novel south and north combined astrolabe can be produced.*

Table Apx.D1-2 Maximum Day Length, Equinoctial Shadow & Equinoctial Hypotenuse

Place name	φ	Maximum Day length (in *ghaṭīs*)	Equinoctial Shadow (in digits)	Equinoctial Hypotenuse (in digits)
Tilaṃga	18	32;44	3;6	12;38
Tryambaka	21	33;24	3;6	12;5
Aṇahilla-pattana	24	33;48	5;20	-
Tīrabhukti	27	34;10,54	5;5	13;2
Dillī	28;39	34;34	6;33	13;41
Nepāla-pura	31	35;6	7;12	14;01

1.22-39 Astrolabe Stars and their longitudes†

Commentary:

atha yantre bhamaṇḍalārthaṃ grantha-niṣpatti-varṣotpanna-sāyana-dvātriṃśan-nakṣtra-dhruvakāḥ saumya-yāmya-vikṣepa-sahitāḥ procyante ‖

…

śakamate *nakṣatratragole nakṣatrānāṃ dvāviṃśaty-adhikaṃ sahasram uktam asti | tanmadhyāt granthakāreṇa yāvan nakṣatragolaṃ savistaraṃ samyag avabudhya yantropayogīni dvātriṃśat nakṣatrāṇi gṛhītāni | tatra*

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* These eccentricities and radii are necessary for drawing the altitude circles or almucantars on the latitude plates of the astrolabes. Malayendu gives six tables of eccentricities and radii for six different latitudes, but these will not be reproduced here; just the parameters of these six places will be displayed in the following table.

† In verses 1.22-39, Mahendra enumerates the names of 32 fixed stars to be marked on the rete, together with their longitudes, expressing the numerical quantities in the *Bhūta-saṃkhyā* notation (cf. Pingree 1978b, p. 628.). Malayendu supplements this data with two tables, the first with longitudes as given by Mahendra for 1370 and in the second with longitudes corrected for the year 1347.

meṣe 5, vṛṣe 2, mithune 5, karke 4, siṃhe 1, kanyāyāṃ 2, tulāyāṃ 2, vṛścike 1, dhanuṣi 4, mṛge 2, kumbha 2, mīne 2 eṣāṃ granthādi dhruvakāḥ sāyanāḥ savikṣepāḥ spaṣṭārthā eva | yathā meṣe prathamakṣatrasya rāśyādi-dhruvakaḥ 0|6|43|52 uttaro vikṣepaḥ 27|0 (uttara-śaraḥ)

atha nakṣatrāṇāṃ meṣādirāśyaṃśāḥ krameṇa nakṣatra-dhruvakāḥ | meṣādirāśibhyo yāmya-saumya-vibhāgena nakṣatrāṇām antaraṃ vikṣepaḥ | tathā sarveṣu nakṣatra-dhruvakeṣu dvipañcāśad vikalā vikṣepāḥ | nakṣatranāmādi-nyāso nakṣatrakoṣṭhakebhyo'avadhāryaḥ | etāni nakṣatrāṇi dṛkkarmaśddhāni kṛtvā gurūpadeśd yantre sthāpyāni | dṛkkarmakaraṇaṃ purastād vakṣye, nakṣatragole punaḥ dṛkkarmarahitāni sthāpyānīti śeṣaḥ | saśarāṇi sthāpyānīti viśeṣaḥ |

Now for the sake of the rete of the astrolabe, the tropical longitudes (*sāyana-dhruvaka*) of thirty-two fixed stars pertaining to the year in which the present manual is completed (i.e., Śaka 1292), together with the latitudes (*vikṣepa*), north or south, are enumerated. …

In Islamic [astronomical] theory (*śaka-mata*), 1022 fixed stars were mentioned in the celestial globe (*nakṣatra-gola*). The [present] author, having understood the celestial globe (*nakṣatra-gola*) with all its details (*sa-vistara*), chose from the [1022] thirty-two fixed stars which are suitable for the astrolabe. Of these 5 are from Aries, 2 from Taurus, 5 from Gemini, 4 from Cancer, 1 from Leo, 2 from Virgo, 2 from Libra, 1 from Scorpio, 4 from Sagittarius, 2 from Capricorn, 2 from Aquarius and 2 from Pisces.

Of these stars, the tropical (*sāyana*) longitudes and latitudes at the time of composition of the present manual are known. For example: the star in Aries has the longitude 0 signs, 6 degrees, 43 minutes, and 52 seconds and the northern latitude is 27 degrees 0 minutes.

The longitudes (*dhruvaka*) of the stars are their positions along the ecliptic in the signs like Aries etc. Latitude (*vikṣepa*) indicates their distance in the north and south from the (ecliptic consisting of) signs like Aries etc. …

The names of the *nakṣatras* and other particulars are set down in the tables. These stars (scil. these coordinates) after correcting for *dṛkkarman*, should be marked in the astrolabe according to the instruction of the teacher. The process of the *dṛkkarman* will

be explained later. On the other hand, the coordinates should be marked on the celestial globe (*nakṣatra-gola*) without the correction for *dṛkkarman*.

1.40 ANNUAL RATE OF PRECISION

granthdidhruvakebhyo 'bhīṣṭavarṣe nakṣatradhruvakānayanam āha |
dvinandasūrya 1292 rahitāḥ śakābdā nabho'śviśailair 720 guṇitāḥ khakhāṣṭaiḥ 800 |
āptaṃ kalādyena yutaṃ bham iṣṭe varṣe bhavet sāyananāmakaṃ tat || 40||

Now he teaches the calculation of the star longitudes in a desired year from the star longitudes at the time of the composition of the present manual.

40. Diminish the Śaka years by 1292, multiply by 720 and divide by 800. Add the quotient in minutes etc. to the longitude as given here (*bhaṃ*); that will be the tropical longitude in the desired year.

Commentary:

iṣṭavarṣasya śakābdān dvinandasūryar 1292 ūnayitvā śeṣaṃ nabho'śviśailair 720 guṇayitvā khakhāṣṭaiḥ 800 bhājyās tebhyo yal labdhaṃ kalādikaṃ phalaṃ tadyuktāḥ sāyana-granthādi-nakṣatra-dhruvakā iṣṭavarṣasya dhruvakā bhavanti |

*atrodāharaṇam | ayaṃ granthaḥ śāke 1292 varṣe niṣpanna eṣu pātiteṣu śāke kiñcin na tiṣṭhati | tataḥ kalpanayā śāke 1304 varṣe nakṣatra-dhruvakodāharaṇaṃ pradarśyate | sthāpanā — śāke 1304 varṣe ebhyo dvinandasūryaiḥ 1292 pātite śeṣaṃ 12 nabho'śviśailaiḥ 720 saṃguṇite jātaṃ 8640 khakhāṣṭabhāge 880 labdhaṃ kalādyaṃ 10|48 | **yavanamate** meṣādirāśyaṃśaṃ varṣaiḥ 66 māsaiḥ 8 nakṣatram atrikrāmati | prativarṣaṃ catuḥpañcāśat 54 vikalāḥ | labdhāḥ kalā 10|48 etāḥ pūrvokte sāyane meṣādyanakṣatradhruvake 0|6|43|52 kṣipyante jāto 'bhīṣṭavarṣasya nakṣatradhruvako 'yaṃ 0|6|54|40 evaṃ śeṣā api granthādi-nakṣatradhruvakebhyaḥ svayam ūhyāḥ ||*

The Śaka years in the desired year are diminished by 1292; the remainder is multiplied by 720 and divided by 800. The quotient in minutes etc. is added to the tropical longitudes of the stars at the time of the composition of the [present] manual; the sum is the longitude of the desired year.

Example: This manual was completed in Śaka 1292. If this [number] is diminished by (1292) there will be no remainder. Therefore, we take the examples of star longitudes for the hypothetical case of Śaka 1304. Write down Śaka 1304. From these years 1292 is subtracted, the remainder 12 is multiplied by 720; it becomes 8640. When divided by 800, the quotient is 10 degrees and 48 minutes.

According to the Islamic [astronomical] theory (*yavana-mata*), a star traverses one degree of ecliptic in 66 years 8 months. Thus it traverses 54 minutes in each year. The obtained minutes are then added to the above mentioned tropical longitude of the first star in Aries, namely 0|6/43/52 (0 signs, 6 degrees, 43 minutes, 52 seconds). It becomes 0/6/54/40 (0 signs, 6 degrees, 54 minutes, 40 seconds), which is the tropical longitude of the same star in the desired year. Thus from the star longitudes at the time of the completion of the present manual, the longitudes for other years can be computed.

Mahendra's Astrolabe Stars

[In verses 1.22-39, Mahendra enumerates the names 32 fixed stars to be marked on the rete and mentions their longitudes.* Malayendu supplements this with two tables, the first with longitudes as given by Mahendra for Śaka 1292 and in the second with longitudes corrected for Śaka 1347. Mahendra states that according to the Islamic view, the rate of precession is 1 degree of arc in 66 years and 8 months. Therefore Malayendu chooses the second year which is removed from the year of composition of Mahendra's manual by roughly 66 years and 8 months and increases the star longitudes by 1°.]

[Malyendu's tables contain both the Arabic and the Sanskrit star names. The former are called *Pārasīka-nāma* (Persian name) because Mahendra and Malayendu derived these from Persian sources. But strangely, the Sanskrit names are referred to as *Hindu-nāma,* although they themselves are Jainas and not Hindus. Because of the difficulty in transcribing Arabic or Persian words in Devanagari, the 'Persian names' given in these tables are difficult to understand. Besides the names in these languages, Malayendu's star list contains the following additional data.]

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* Mahendra derived the longitudes by adding 18;53° for precession to the longitudes of Ptolemy; cf. Pingree 1978b, p. 628 and table XI.3.

[Table 17: Star table for Śaka 1292 (AD 1370-71), providing for 32 fixed stars, star names in Persian (*pārasī-nāma*), star names in Sanskrit (*hindu-nāma*), longitudes at the completion of the manual (*granthādi-dhruvaka*), latitude (*vikṣepa*), direction of the latitudes (*dik*), longitudes corrected for *dṛkkarman* (*dṛkkarma-śuddha-rāśyādikam*), day-radius north (*saumyaṃ svāhorātram*), day-radius south (*yāmyaṃ svāhorātram*), maximum altitude (*paramonnatāṃśāḥ*).]

[Table 18: Star table for Śaka 1437 (AD 1359-1360), providing for the same 32 fixed stars, names in Persian (*pārasī-nāma*), names in Sanskrit (*hindu-nāma*), longitudes at the completion of the manual (*granthādi-dhruvaka*), latitude (*vikṣepa*), direction of the latitudes (*dik*), declinations (*krāntayaḥ*), their direction (*dik*), longitudes corrected for *dṛkkarman* (*dṛkkarma-śuddhāḥ*), day radius north (*saumyaṃ svāhorātram*), day radius north (*yāmyaṃ svāhorātram*), maximum altitude (*paramonnatāṃśāḥ*). On the top of the table is written *dillyāṃ dṛkkarma 7|5|20* (*dṛkkarman* at Delhi 7;5,20°.]

[The names of the thirty-two star names are arranged in the following table together with the meaning of the Arabic star names and their identification.]

Table Apx.D1-3 Astrolabe Stars

No	Sanskrit Name	*pārasīka-nāma* (Persian) Name	Meaning of the Arabic Name	Identification
1 *	*Aśvanābha*	*Surrat al-Faras*	navel of the horse	δ Pegasi = α Andromeda
2 *	*Nadyantaka*	*Akhir al-Nahr*	end of the river	θ Eridani
3 *	*Matsyodara*	*baṭn al-Ḥūt*	belly of the fish	β Andromedae
4	*Aśvinī*	*Sharatayn*		γ Arietis
5 *	*Kartitakara*	*Kaff al-Khaḍīb*	the dyed hand	β Cassiopeiae
6 *	*Pretaśirāḥ Manuṣyaśirā*	*Ra's al-Ghūl*	head of the ghoul	β Persei
7 *	*Manusyapārśva*	*Mirfāq al-Thurayyā*	elbow of al-*Thurayyā*	α Persei
8	*Rohiṇī*	*ᶜAyn al-Thawr Dabarān*	eye of the bull follower	α Tauri

No	Sanskrit Name	*pārasīka-nāma* (Persian) Name	Meaning of the Arabic Name	Identification
9 *	*Mithuna-dakṣiṇa-pāda*	*Rizl al-Jawzā' al-Yusrā*	the right foot of *al-Jawzā'*	κ Orionis
10 *	*Mithuna-vāma-skandha*	*Yad al-Jawza' al-Yusrā*	The left hand of *al-Jawzā'*	γ Orionis
11	*Ṣaḍāsya Ṣaṇmukha Kārtikeya*	*ᶜAyyūq*	(meaning obscure)	α Aurigae
12 *	*Mithuna-hasta* (*mithuna-skandha*)	*Mankib al-Jawzā'* or *Yad al-Jawzā'*	shoulder of *al-jawzā'* or arm of *al-jawzā'*	α Orionis
13	*Agastya*	*Suhayl*		α Carinae
14	*Ārdrā Lubdhaka*	*Shiᶜra Yamānī*	the southern *Shiᶜra*	α Canis Majoris
15 *	*Prathama-Bāla-śīrṣa Punarvasu*	*Ra's al-Taw'am al-Muqaddam*	head of the foremost twin	α Geminorum
16 *	*Lubdhaka-bandhu*	*Shiᶜra Shāmī*	the northern *Shiᶜra*	α Canis minoris
17	*Maghā*	*Qalb al-Asad*	heart of the lion	α Leonis
18	*Uttara-Phālgunī*	*Ṣarfah*	change of weather	β Leonis
19 *	*Kākaskandhapaksa*	*Janāḥ al-Ghurāb al-Ayman*	the right wing of the raven	γ Corvi
20	*Citrā*	*Simāk Aᶜzal*	the unarmed *Simāk*	α Virginis
21	*Svāti*	*Simāk al-Rāmiḥ*	the armed *Simāk*	α Bootis
22	*Viśākhā Mātṛmaṇḍala*	*Nayyir al-Fakkah*	the brilliant star of *al-Fakkah*	α Coronae Borealis
23	*Jyeṣṭhā*	*Qalb al-ᶜAqrab*	heart of the scorpion	α Scorpii

No	Sanskrit Name	*pārasīka-nāma* (Persian) Name	Meaning of the Arabic Name	Identification
24	*Dhanuḥkoṭi*	*Ra's al-Ḥawwā*	the head of the serpent charmer	α Ophiuchi
25	*Mūla*			λ Scorpii
26	*Dhanuḥśarāgra*			μ^{1-2} Sagittari
27	*Abhijit*	*al-Nasr al-Wāqī'*	the falling eagle	α Lyrae
28	*Śravaṇa*	*al-Nasr al-Ṭā'ir*	the flying eagle	α Aquilae
29 *	*Matsyamukha*	*Fam al-Ḥūt al-Janūbī*	the mouth of the southern fish	α Piscis Austrini
30 *	*Kakudapuccha*	*Dhanab al-Dajājah*	the tail of the fowl	α Cygni
31	*Pūrva-bhādrapadā*	*Mankib al-faras*	shoulder of the horse	β Pegasi
32 *	*Samudrapaksī*	*Dhanab al-Qayṭus Shamālī*	The northern tail of Cetus	ι Cet

[Here 14 names are literal translation of the Arabic names; these are marked with an asterisk in the table. Eleven are junction stars of the Sanskrit lunar mansions. *Aśvinī* (4), *Rohiṇī* (8), *Maghā* (17), *Uttara-phālgunī* (18), *Citrā* (20), *Svāti* (21), *Jyeṣṭhā* (23), *Mūla* (25), *Abhijit* (27), *Śravaṇa* (28), *Pūrva-bhādrapadā* (31).]

[A few other stars are mentioned in earlier Sanskrit texts. Thus *Agastya* (13) is mentioned in *Sūrya-siddhānta* 8.10. Sirius (α Canis Majoris) is mentioned in the *Sūrya-siddhānta* 8.10 as *Mṛga-vyādha* (hunter of animals); in its place, Mahendra employs a synonym *Lubdhaka* (13). Since Procyon (α Canis Minoris) can be regarded as a companion of Sirius, Mahendra names this star *Lubdhaka-bandhu* (kinsman of *Lubdhaka*).]

[In *Sūrya-siddhānta* 8.11, *Brahma-hṛdaya* is the name given for Capella (α Aurigae); ignoring this name, Mahendra calls this star *Ṣaḍāsya* (six-faced) which is another name of Kārtikeya in Hindu pantheon; in Malayendu's tables two other

synonyms are given: *Ṣaṇmukha* and *Kārtikeya.* In Sanskrit astrolabes the name *Ṣaṇmukha* appears frequently (B002, C003, C008 etc.); in some other astrolabes, in particular in those astrolabes with single plates calibrated for the latitude of Jaipur at 27°, the name *Brahma-hṛdaya* appears often for the same star (D006, D007, D009 and so on).[*]]

[As mentioned in the introduction to C on Sanskrit astrolabes, Mahendra, or rather Malayandu in in his tables, gives double name *Ārdrā-Lubdhaka* to Sirius (α Canis Majoris); however, *Ārdrā* and *Lubdhaka* are generally treated as two distinctly separate stars in Sanskrit astronomy, the former denoting α Orionis (Betelgeuse) and the latter for α Canis Majoris (Sirius). A large majority of Sanskrit astrolabes follow this nomenclature. But a small number follow Mahendra's nomenclature as well.]

[Finally the name *Samudra-pakṣī.* As mentioned in the introduction to section F on celestial globes, Mahendra must have chosen this name after seeing the pictorial representation of Cetus on Islamic celestial globes. However, Mahendra seems to have understood it as ι Ceti, the northern tip of the tail of Cetus, but on all Sanskrit astrolabes I have seen this star is shown below the equinox to represent the southern tip of the tail of Cetus, i.e., β Ceti. In an astrolabe made for Rāghavajit in 1669 (C008) ι Ceti is designated as *sa[mudra]pakṣī u[ttara],* i.e. 'the northern Cetus', while β Ceti was called *samudra[pakṣī].*]

Table 19: Rising times at the Equator (*laṅkodaya-pramāṇa*) of each degree of the ecliptic from 1° to 90°.

Table 20: Shadow lengths of the gnomon of 12 digits (*dvādaśāṅgula-śaṅku-cchāyā*) and the gnomon of 7 feet (*saptāṅgula-śaṅku-cchāyā*) for each degree of solar altitude from 1° to 90°.[†]

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[*] I have not been able to locate Sanskrit sources for the names *Dhanuḥkoṭi* for α Ophiuchi, *Dhanuḥ-śarāgra* for μ [1-2] Sagittari and *Viśākhā-mātṛ-maṇḍala* for α Coronae Borealis, nor the reasons why Mahendra chose these names.

[†] In Raikva's edition, this table is given on pp. 49-51 and repeated once again on pp. 52-54 with minor changes in the wording of the argument.

1.72: AUTHOR'S COLOPHON

abhūd bhṛgupure vare gaṇakacakracūḍāmaṇiḥ
kṛtī nṛpatisaṃstuto madanasūrināmā guruḥ |
tadīyapadaśālinā viracite suyantrāgame
mahendraguruṇā sphuṭaṃ gaṇitakarma pūrtīkṛtam ||71||

In the eminent city of Bhṛgupura, there lived the learned preceptor by name Madana Sūri, the crest-jewel of the circle of astronomers, who was praised by the kings. In this excellent treatise on the instrument (i.e. the astrolabe), composed by the preceptor Mahendra, a devotee of his (Madanasūri's) feet, [the first chapter dealing with] the mathematical operations is completed.

COMMENTATOR'S COLOPHON

śrīperojaśakendra-sarva-gaṇaka-praṣṭo[*] *mahendra-prabhur*
jātaḥ sūrivaras tadīyacaraṇāmbhojaikabhṛṅgadyutā |
sūriśrī-malayendunā viracite 'smin yantrarājāgama-
vyākhyāne gaṇitābhidhaḥ prathamako 'dhyāyaḥ samāptiṃ gataḥ ||

Master Mahendra Sūri, the eminent scholar, is the foremost one among all the astronomers at the court of the glorious Fīrūz, the sovereign of the Muslims. In this commentary on the treatise *Yantrarāja* composed by the illustrious Malayendu Sūri, who is like the bee at the lotus-feet of the said master, the first chapter entitled *Gaṇitādhyāya* is concluded.

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[*] Both the printed editions read *gaṇakaiḥ pṛṣṭaḥ* which makes no sense. I follow the reading in Jyotiṣa Ms. no. 37, copied on 23 May 1853, of the Aligarh Muslim University.

2. YANTRAGHAṬANĀDHYĀYA (CHAPTER ON THE CONSTITUTION OF THE ASTROLABE)

2.1-6: CONSTITUTION OF THE ASTROLABE

ādau yantraṃ mṛṇmayaṃ dhātujaṃ vā vistīrṇaṃ ca svecchayā kārayitvā |
dairghyavyāsau pālivrittasya tasminn āryaiḥ kāryau yantracakrānumānāt ||1||
yāmye bhāge 'sya trikoṇaṃ kirīṭam īdṛg yantraṃ koṣṭhakāgāram uktam |
madhye tasya sveccayākṣāṃśakānāṃ patrāṇy anyāny unnatāṃśāśritāni ||2||
ekaṃ patraṃ connatāṃśasya patrād dvighnaṃ piṇḍe sādhanīyaṃ tato 'nyat |
laṅkotpannā rāśayo meṣamukhyāḥ saṃsthāpyante yatra dhiṣṇyaiḥ sametāḥ ||3||
patrāṇy evaṃ koṣṭhakāgāramadhye muktvā sādhyās teṣu pūrvādikāṣṭhāḥ |
pṛṣṭhe yantrasyāyate dve bhujāgre sūkṣme kṛtvā chidram antarbhujaṃ ca ||4||
agre paścāt tasya cānte 'bdhikoṇe kḷptvā chidre yantranetre niveśye |
chidre kḷptvā merukīlaṃ dalāliṃ tena kṣiptvā ghoṭikā saṃniveśyā ||5||
kṛtvā chidraṃ sūkṣmam asya trikoṇe tatra kṣiptvā kaṇṭakaṃ vṛścikābham |
tasya prānte mudrikāṃ lambikākhyaṃ sūtraṃ deyaṃ yantraniṣpattir evam ||6||

1. First get an instrument (i.e. disc) (*yantra*) prepared out of clay or of metal, in the desired size (*vistīrṇa*). Then the noble persons should fix on that [disc an upraised] rim (*pālivṛtta*) with height and breadth appropriate to the size of the astrolabe.

2. On the southern (i.e. the upper) part of the disc, [there should be] a triangular crown (*kirīṭa*). Such a component is called the mater (*koṣṭhakāgāra,* lit. store-house, repository). Inside this [are placed] as many latitude plates (*akṣāṃśakānāṃ patrāṇi*) as one wishes, which are endowed with [circles of equal] altitudes (*unnatāṃśa*).

3. Prepare another plate with double the thickness of the plates bearing the [circles of] altitudes. On this plate will be marked the zodiac signs starting from Aries, according to their rising times at the equator (*laṅkā*) (i.e. right ascensions) together with [some prominent] fixed stars (*dhiṣṇya*).

4. Insert these plates inside the mater (*koṣṭhakāgāra*) and mark on [each face of] them the cardinal directions like east etc. At the back of the instrument, [attach] a long arm (i.e. alidade) with pointed tips and a hole in the middle.

5. At the front and back [of the arm] (i.e. on either end of the arm) set up (*niveśye*) two rectangular sighting vanes (*yantra-netra*), having made holes in them. Into the hole [at the middle of the alidade], insert the pin which represents the north celestial pole (*meru-kīla*) so that it passes through the series of latitude plates (*dala*). Into [the other end of] this pin, insert a horse-headed wedge (*ghoṭikā*).

6. Make a small hole at [the apex of] the triangular [crown], insert into it the shackle (*kaṇṭika*), which is shaped like the scorpion's sting, into it a ring (*mudrikā*) and then pass through it a string called the suspender (*lambika*). Thus is the astrolabe constituted.

3. YANTRARACANĀDHYĀYA (CHAPTER ON THE CONSTRUCTION OF THE ASTROLABE)

3.1: VARIETIES OF THE ASTROLABE

yantraṃ proktaṃ ṣaḍvidhaṃ hy ānavatyā
eka-dvi-trīṣv-aṅga-paṅkty-aṃśa-kḷptyā |
dvedhāpy etat saumyayāmyaprabhedāt
tanmiśratve miśrasaṃjñaṃ paraṃ ca ||1||

1. The astrolabe is said to be of six kinds [according as the altitude circles] are drawn up to ninety [degrees], [with one circle] for each one (*eka*), two (*dvi*), three (*tri*), five (*iṣu*), six (*aṅga*), [or] ten (*paṅkti*) degrees (*aṃśa*). It is also of two varieties, northern (*saumya*) and southern (*yāmya*). Where these two are combined, there is one more variety called the composite (*miśra*).

3.2-3: BACK OF THE ASTROLABE

vṛttadvayaṃ karkaṭakena pṛṣṭhe yantrasya nirmāya catur diśo 'ṅkyāḥ |
prāgyāmyagāḥ koṣṭhagatās tataś ca sthāpyāḥ kha-nanda-pramitonnatāṃśāḥ ||2||
vṛtte dvitīye likhitonnatāṃśā rekhā vilekhyā pratibhāgajātāḥ |
pakṣatraye 'apakramajā vibhāgāḥ śaṅkuprabhā prāg gaditā tathā jyā ||3||

2. On the back of the astrolabe, draw two annuli (*vṛtta,* lit. circles) with a pair of compasses (*karkaṭa*) and mark the four cardinal directions. Then between the east and west points, mark out ninety (*kha-nanda*) degrees of altitude in separate cells (*koṣṭha*).
3. In the second annulus, mark the lines for each degree corresponding to the degrees of altitude written [in the first annulus]. Then in three quadrants (*pakṣa*) draw respectively the units/arcs of declination (*apakramaja vibhāga*), gnomon shadows (*śaṅkuprabhā*) and the afore-mentioned sines (*jyā*).*

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* There is some confusion here in the specifications for the four quadrants. Both the text and the commentary appear to be mentioning only three quadrants. The commentary states that the arcs/units of declination should be drawn in the south-western quadrant (*dakṣiṇapaścimāntarāla*), shadow squares in the north-western quadrant (*pascimasaumyāntarāla*) and the sine graph (*jīvāṅkāḥ*) in the north-eastern quadrant (*uttarapūrvāntarāla*). This makes sense only if is clearly stated that the shadows squares are drawn in the *two* lower quadrants. Moreover, the sine graph is usually drawn in the south-eastern quadrant, some times also in the south-western quadrant, but never in the north-eastern quadrant, as the commentary recommends.

3.4: FRONT OF THE MATER (*KOṢṬHAKĀGĀRA*)

atha yantre koṣṭhakāgārasya pūrvapakṣasādhanam āha |
vṛttatraye pāligate kṛte prāg vṛtte kirīṭāntarato ghaṭīś ca |
aṃśān abhīṣṭān kha-rasāgni-saṃkhyān rekhās tadīyās tadadho vilekhyāḥ ||4||

Now he teaches the calibration of the front (*pūrvapakṣa*) of the mater (*koṣṭhāgāra*) of the astrolabe (*yantra*).

4. Having drawn three [concentric] circles on the rim (*pāli*), in the first circle, mark the *ghaṭīs*, starting from the middle of the crown (*kirīṭa*). [In the middle circle] mark 360 degrees at desired intervals. Below that, draw the lines of their subdivisions.

3.5-8: LATITUDE PLATES (*AKṢA-PATRA*)

atha saumyayantre iṣṭākṣāṃśapatreṣūnnatavalayānāṃ sādhanam āha |
yantre ca saumye viracayya kaṃbāṃ patrānumānena vilikhya tatra |
bhāgān kharāmān racayed tadāṃśaiḥ karkādivṛttatritayaṃ daleṣu ||5||
digaṅkiteṣv eṣu ca madhyakendrād avācyarekhopari kendramānaiḥ |
cihne kṛte tacchirasaḥ pṛthutvamānena vṛttāni likhet sphuṭāni ||6||
bhūjākhyam ādyaṃ bhavatīha vṛttaṃ tataḥ paraṃ connatamaṇḍalāni |
teṣāṃ likhed ānavater vibhāgān śuddhān inādyunnatatāvagatyai ||7||
madhyāhnarekhām abhito 'sya karkavṛttasthite prāgapare vibhāge |
kramāl likhed bhāṃ paramaṃ dinaṃ taddeśābhidhānena tathākṣabhāgān ||8||

Now he teaches how to draw the altitude circles (*unnata-valaya*) in the desired latitude plates (*akṣāṃśa-patra*) in the northern astrolabe (*saumya-yantra*).

5. In the [case of the] northern astrolabe, prepare a ruler (*kambā*) according to the size of the plate (i.e. as long as the radius of the plate) and graduate it into 30 (*kha-rāma*) units (*bhāga*). With these units (*aṃśa*) draw the three circles of Cancer etc. upon the plates (*dala*).

6. On these plates, on which the cardinal directions have been marked [by means of the north-south and east-west lines], make marks on the south line, starting from the centre, at distances measured by the values of eccentricity (*kendra*). Then from each of the marks as the centre draw clear circles with the measure of the radius (*pṛthutva*) [as given in the tables].

7. The first of such circles here is called the horizon (*bhūja*). Above that will be circles of altitude (*unnata-maṇḍala*). These [altitude circles] may be drawn clearly (*śuddha*) up

to ninety degrees for ascertaining the altitude (*unnatatā*) of the sun and other [celestial bodies].

8. On both sides, i.e., in the eastern and the western sides of the meridian or midday line (*madhyāhna-rekhā*) situated inside the tropic of Cancer, one should write successively the equinoctial shadow (*bhā*), maximum daylight (*paramadina*), the name of the locality (*deśābhidhāna*) and the degrees of latitude (*akṣa-bhāga*).

3.9: Unequal Hour Lines

atha saumyayantre horāsthāpanam āha |
kujād adho dvādaśadhā vibhajya mṛgādikarkāhvayamaṇḍaleṣu |
vidhāya vṛttāny abhitaḥ pratīcyā aṅkair niveśyā dvidaśāpi horāḥ ||9||

Now he teaches the creation of the hour (*horā*) [lines] in the northern astrolabe.

9. Divide [the arcs of] the [three] circles of Capricorn, Aries and Cancer, which are situated below the horizon (*kuja*), into 12 parts each. Draw on both sides [of the meridian line, arcs of] circles (*vṛtta*) [through the respective points of division on these three circles] and number them from the west as the 12 hours (*horā*).

3.10-16: Rete (*bhacakra-patra*)

atha saumyayantre bhacakrapatre karkādivṛttatrayasādhanam | bhacakra-kendrapramāṇena bhamaṇḍalasādhanaṃ tatra nirakṣameṣādilagnānām iṣṭa-bhāgānāṃ sthāpanam āha |
bhacakrapatre 'pi puraiva kḷpte vṛttatraye 'bhyantarato 'ṣṭabhāgān |
hitvā kalāś cābdhiguṇān avācye vyāsārdhamānena vidhāya vṛttam ||10||
nirakṣameṣādivilagnamānān pūrvoditān prāci niveśya caindryāḥ |
vṛtte dvitīye tadadho niveśyās tadaṅkasaṃkhyā gaṇakair nijeṣṭāḥ ||11||
meṣe bhāgā kalāś cāpi dhiṣṇyāni gaganeṣavaḥ |
vṛṣe nandadṛśo 'bdhyakṣā yugme dantāḥ ṣaḍindavaḥ ||12||
vyutkramād eta eva syuḥ karkasiṃhakanīṣv api |
kanyādiṣaṭkamānaṃ syāt tulādau vaiparītyataḥ ||13||
vyāsākhyavṛtte 'jamukhāni santi lagnāni laṅkodayajāni yatra |
rekhā hy uḍūnāṃ pratibhāgajātās tatraiva kendrābhimukhā vilekhyāḥ ||14||
kendrāt pratīpaṃ viracayya cihnaṃ dyujyāpramāṇena ca karkaṭena |
tatraiva dhiṣṇyasya yathoditasya niveśyam asyāgram atīva sūkṣmam || 15||

dhanurmṛgāntar niśitaṃ vidheyaṃ cihnaṃ prasiddhaṃ makarāsyanāmnā |
yadbhrāmyamāṇaṃ gaṇakena viṣvaṅ muhur muhuś cumbati nāḍivṛttam ||16||

Now he teaches how to draw the three circles of Cancer and others on the rete (*bhacakrapatra*), how to draw the ecliptic circle (*bha-maṇḍala*) by means of the given value of the eccentricity of the ecliptic circle (*bhacakra-kendra*) and how to mark there the divisions of the zodiac signs according to their ascendants at the zero degree latitude (*nirakṣa-lagna*).

10. On the rete (*bhacakra-patra*) also, after having drawn the three circles [of Capricorn, Aries and Cancer] as before, leave out from the centre of the plate 8;34 units [which is the eccentricity of the ecliptic] in the south (*avācya*) (i.e. on the southern radius) [and with this point as the centre] draw a circle with the measure of the radius [of 21;26 units as shown in 1.66].

11. [On this circle], after having marked, from the east point onwards (*aindryāḥ*), the lengths of the right ascensions of the zodiac signs which have been mentioned before, in the second circle below the [previous one] the astronomer may mark their subdivisions according to his liking.

12. For Aries (*meṣa*) the degrees (*bhāga*) and minutes (*kalā*) [of right ascension] are 27;50; for Taurus (*vṛṣa*) 29;54 and for Gemini (*yugma*) 32;16.

13. The same in reverse order pertain to Cancer (*karka*), Leo (*siṃha*) and Virgo (*kanī*). The values of the six signs beginning with Virgo (*kanyā*) will apply in the reverse order to the six starting with Libra (*tulā*).

14. In the ecliptic circle (*vyāsākhya-vṛtta*) where there are the right ascensions (*laṅkodayajāni lagnāni*) of Aries and others, there draw the lines of stars, with the subdivisions, towards the centre.

15. With the measure of the day sine (*dyujyā*) make a mark away from the centre with the pair of compasses on that line. There at that point, create a very fine tip (*sūkṣmam agram*) for [the pointer of] the afore-mentioned star.

16. Between Sagittarius (*dhanus*) and Capricorn (*mṛga*) affix the well-known mark called the ‘Capricorn index’ (*makarāsya,* lit. face of Capricorn, in the sense of the first

point of Capricorn[*]) which touches the hour circle (*nāḍivṛtta*) constantly, when the rete is rotated all around by the astronomer.

Thus the preparation of the rete in the northern astrolabe is complete.

3.17-19: LATITUDE PLATES AND RETE IN THE SOUTHERN ASTROLABE

3.20-24: NORTH-SOUTH COMBINED ASTROLABE

3.25-26: COMPUTING THE MAXIMUM DAY-LENGTH (*PARAMA-DINA*) FROM THE LATITUDE

dviṣṭākṣāṃśā jinair bhaktā labdham akṣād viśodhitam |
śeṣam ardhaṃ hataṃ digbhiḥ ṣaṣṭyāptaṃ dviguṇīkṛtam ||25||
tannāḍikā vināḍyādi ūrdhvāṅkaṃ triṃśatā yutam |
nṛyugmānte ravau proktaḥ palebhyaḥ paramaṃ dinam || 26||

25. Write down the degrees of latitude separately at two places. Divide at one place by 24 and subtract the quotient from the latitude. Divide the remainder by 2, multiply by 10, divide by 60 and multiply by 2.

26. The 'higher' number, augmented by 30, denotes the *ghaṭīs* and *palas*. When the sun is at the end of Gemini, this is the maximum day length, [usually expressed] in terms of *palas.*

Commentary:

vyākyodāharaṇam eva | dillyām akṣāṃśāḥ 28|39 dvisthāḥ 28|39 caturviṃśatyā bhaktā labdhaṃ 1|11|38 akṣāṃśāt pātyate | śeṣaṃ 27|27|22 ardhitaṃ 13|43|41 daśguṇaṃ 131|17 ṣaṣṭyāptaṃ 2|17|17 dviguṇaṃ 4|34|34 upari triṃśadbhir 30 yutaṃ jātaṃ dillyāṃ paramadinam 34|34|34 evam anayā rītyā triṃśad-akṣāṃśaparyatam āyāti | agre 'antaraṃ karoti | evaṃ sarvatra ||

The example itself provides the explanation. In Delhi the degrees of latitude are 28;39°. This is written at two places. 28;39 is divided by 24. Quotient is 1;11,38. This is subtracted from the latitude. Remainder (28;39 – 1:11,38) 27;27,22 is halved 13;43,41. Ten times 137;17, divided by 60, 2;17,17. Doubled 4;34,34. The 'higher' number (higher unit) is augmented by 30; it becomes 34;34,34 (34 *ghaṭīs,* 34 *palas,* 34

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[*] Arabic *murī ra's al-Jadī.*

vipalas = 13 hours, 49 minutes, 49 seconds, 36 thirds); this is the maximum day length (*parama-dina*) at Delhi. In the same manner the result is obtained up to 30 degrees latitude. Beyond this one takes the difference.

3.27: COMPUTATION OF THE EQUINOCTIAL SHADOW (VIṢUVACCHĀYĀ) FROM THE MAXIMUM DAY LENGTH

hīnaṃ kharāmaiḥ paramaṃ dinaṃ ca ṣeṣaṃ nagaghnaṃ guṇitaṃ ca ṣaṣṭyā |
bhaktaṃ trigobāhubhir 293 aṅgulādicchāyā sphuṭā syād viṣuvadvayasya ||27||

The duration of the maximum day length is diminished by 30. The remainder is multiplied by 7 and again multiplied by 60, and then divided by 293. The quotient is the shadow in *aṅgulas* at the time of both the equinoxes.

Commentary:

atrodāharaṇam eva vyākyā | athātra paramadinaṃ 34|34|34 viṣuvaddinamānena 30 hīnaṃ 4|34|34 saptaguṇaṃ 32|1|58 kalāpiṇaṃ 1921|58 kalpita 293 bhāgahārāptaṃ viṣuvacchāyā 6|33 kalāpiṇḍaśeṣaṃ 166 anayā yuktyā chāyānayanam kāryam ||

Here the example itself provides the explanation. Now here the maximum day length is 34;34,34 (*ghaṭīs*). This is diminished by the length of the equinoctial day, namely 30. Remainder 4;34,34. Seven times of this 32;1,58. This is converted into arc minutes (*kalā*) 1921;58. Divided by 293; quotient 6;33 [*aṅgulas*] is the equinoctial shadow. The remainder of the sum of minutes (*kala-piṇḍa-śeṣam*) is 166.

4. YANTRA-ŚODHANĀDHYĀYA (CHAPTER ON TESTING THE ASTROLABE FOR ACCURACY)

4.1-2: TESTING THE ASTROLABE FOR EQUAL WEIGHT ON BOTH SIDES OF THE MERIDIAN

niṣpannayantram ullambya randhre kīlaṃ praveśayet |
tadagre lambayet sūtraṃ sūkṣmaṃ bhāreṇa saṃyutam ||1||
madhyarekhāṃ spṛśet tac cet jñeyaṃ śuddhaṃ tathā hi tat |
anyathādhikam asyāṅgaṃ ghṛṣṭvā śodhayet tataḥ ||2||

1. When the astrolabe has been made, suspend it vertically and insert a pin (*kīla*) in the hole [in the crown]. From its tip suspend a thin thread with a weight [attached to the other end].

2. If the thread coincides with the meridian line (*madhyarekhā*), then the instrument must be understood to be accurate (*śuddha*). Otherwise, grind its heavier limb and then test [once again].

4.3: TESTING THE HORIZON (KUJA) AND OTHER CIRCLES [OF ALTITUDE]

meṣadyujīvāprāgrekhāyogasparśāt kuje sphuṭe |
kendravyāsāntaraiḥ śuddhaiḥ śodhayed unnatāṃśakān ||3||

3. The two horizon circles (*kuje*) (i.e. the two eastern and the western halves of the horizon circle) are accurate (*sphuṭe*) if they touch the intersections (*yoga*) of the diurnal circle of Aries (*meṣa-dyu-jīvā* = celestial equator) and the east-[west] line (*prāgrekhā*). The other circles of altitude (*unnatāṃśaka*) are to be tested by the differences in eccentricity (*kendra*) and in the radii (*vyāsa,* lit. diameter).

Commentary:

meṣadyujīvā-prāgrekhayor yoge sannipāta ubhayatas tayoḥ sparśād uddhṛtakujākhyavṛtte sphuṭe bhavataḥ | tathā pūrvoktaiḥ kendra-vyāsāntarair unnatāṃśān arthād unnatāṃśavṛttāni śodhayet | śuddhāni kuryād ity arthaḥ |

udāharaṇam | tad yathā | madhyāt ṣaḍunnatāṃśānāṃ kendrapramāṇena 29|32 cihnaṃ kṛtvā tadupari vyāsamānena 33|28 vṛtte kṛte ṣaḍunnatāṃśānāṃ valayaṃ niṣpannam | tato yantra-madhyāt madhyāhnarekhopari unnatavalayaṃ yāvat kendravyāsāntaraṃ 3|7 kambābhāgaiḥ pramīyamānaṃ yadi syāt tadā tadvalayaṃ śuddham | evaṃ śeṣāṇy unnatavalayāni śodhyāni ||

By touching (*sparśa*) the intersections (*yoga*) of the diurnal circle of Aries and the east-[west] line (*prāgrekhā*), that is at the intersections (*sannipāta*) on both sides, the two up-raised circles (i.e. the two eastern and western halves) called horizon become accurate.

In the same manner, by the differences in eccentricity (*kendra*) and in the radii (*vyāsa,* lit. diameter), which have been mentioned before, one should test the degrees of altitude (*unnatāṃśaka*), that is, the circles of altitude (*unnatāṃśavṛttāne*). That is to say, they should be made accurate (*śuddhāni kuryāt*).

Example: From the centre (*madhya*) [of the astrolabe], at a distance of 29;32, which is the value of eccentricity (*kendra-pramāṇa*) for six degrees of altitude, make a mark. On that (i.e. with that point as the centre) draw a circle with a radius (*vyāsa-māna,* should this not be *vyāsārdha* ?) of 33;28.* This is the circle for the altitude 6°. Then the distance between the circle and the centre of the astrolabe as measured on the meridian line with the units of the ruler (*kambā*) equals 3/56† which is the difference between the given *kendra* and *vyāsa* (*kendravyāsāntara*), then that circle is correct. In this manner, test the remaining altitude circles also.

4.4: TESTING THE TWELVE LAGNAS AND THEIR SUBDIVISIONS

udayāstodīcyayāmyarekhāgre sadṛśāṃśatā |
prāksaptaturyadiksaṃkhyalagnānāṃ syād viśuddhatā ||4||

If there is symmetry in degrees (*sadṛśāṃśatā*) in the risings and settings, at the tip of the north line and the tip of the south line, between the pivots (*lagnas*) having the numbers one (*prathama,* i.e. ascendant) and seven (*sapta,* i.e. descendant); four (*turya,* i.e., lower mid-heaven) and ten (*dik,* i.e., upper mid-heaven), then there is accuracy.

Commentary:

udaye pūrvakṣitije aste'pare kṣitije udīcyarekhāgre yāmyarekhāgre ca pratha-saptama-caturtha-daśamānāṃ meṣa-tulā-karka-makarāṇāṃ sadṛśāṃśatā tulyāṃśatā yadi syāt tadā teṣāṃ caturṇāṃ lagnānāṃ śuddhatā

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* The values 29;32 for eccentricity and 33;28 for the radius pertain to the latitude of Delhi, as given in the table on p. 23 of the printed text.

† The printed text reads (p. 63) wrongly 3|7; it should be (33;28 – 29;32 =) 3;56.

jñeyā | tadvaiparītye'śuddhatā ca | evaṃ śeṣāṇyapi lagnāni aṃśaiḥ śodhanīyāni |

In the rising on the eastern horizon, in the setting on the western horizon; at the tip of the north line and at the tip of the south line; in the first and seventh; fourth and tenth [pivots] i.e. between Aries and Libra, between Cancer and Capricorn, if there is symmetry in degrees (*sadṛśāṃśatā*), i.e. equality in degrees (*tulyāṃśatā*), then it should be understood that there is accuracy in the four pivots. Otherwise, there is inaccuracy. In the same manner the remaining risings and settings also should be tested.

4.5: TESTING THE STAR-POINTERS (NAKṢATRA-CAÑCU)

| atha dṛkkarmaśuddhasthāpitanakṣatrāṃśān paramonnatāṃśair nakṣatracañcuśodhanam āha |
madhyarekhāsthite svasvarāśyaṃśe saṃpṛśed yadi |
bhāsyaṃ svān paramān aṃśān tadā taccañcuśuddhatā ‖5‖

Testing the accuracy of the star-pointers (*nakṣatra-cañcu*) by means of the star's longitude (*nakṣatrāṃśa*) corrected for *dṛkkarman* and its maximum altitude (*paramonnatāṃśa*).

5. When the star's longitude (*sva-sva-rāśyaṃśa*) is placed on the meridian (*madhyarekhā*), if the star-pointer (*bhāsya*) touches the degrees of its maximum altitude (*svān paramān aṃśān*), then the accuracy of that pointer (*cañcu*) [is established].

Commentary:

yad yad nakṣatraṃ yasya yasya rāśer yasmin yasminn aṃśe 'sti tasmin tasmin bhāge madhyarekhopari sthite sati tasya tasya nakṣatrāsyaṃ cañcusthānaṃ svān paramonnatāṃśān yadi spṛśati tadā tasya nakṣatrasyāsyaśuddhiḥ syāt | tadabhāve cañcor hāni-vṛddhir vā kāryeti śeṣaḥ | yathā śuddhaṃ rohiṇī-nakṣatraṃ mithunasya tṛtīyāṃśe pavarthate | tasminn aṃśe madhyarekhopari sthāpite yadi rohiṇyāsyaṃ svīyān paramonnatāṃśān 76|53 spṛśati tadā rohiṇyā āsyaśuddhir bhavati | evaṃ śeṣāṇy api nakṣatrāsyāni śodhanīyāni |*

If [the longitude of] a particular star is situated at a particular degree of a particular zodiac sign, when that particular degree is placed on the meridian line [by rotating the

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* Printed text (p. reads 70; but the correct value as given in the star table on p. 36 is 76;53.

rete], if that star's pointer touches its maximum altitude, then that star's pointer is accurate. If not, the pointer should be shortened or extended.

For example, the corrected longitude of *Rohiṇī* lies at the third degree of Gemini. When that degree is placed on the meridian [by rotating the rete], if *Rohiṇī*'s pointer (*rohiṇyāsya*) touches the degrees of its maximum altitude 76;53, then the pointer of *Rohiṇī* is accurate. In the same manner, other stars are to be tested.

4.6: TESTING THE ALIDADE (BHUJĀ)

bhujāgrayugmaṃ śuddhaṃ syād rekhāsthaṃ parapūrvayoḥ |
tanmadhyarekhoparigaṃ śuddhaṃ pādadvayaṃ tadā ||6||

6. The two tips of the alidade are accurate if they lie on the east-west line. The two sighting plates (*pāda-dvaya*) are accurate if they lie on the middle line of the astrolabe.

5. YANTRA-VICĀRAṆĀDHYĀYA (CHAPTER ON THE USE OF THE ASTROLABE)

MEASURING TIME IN *GHAṬĪS* AND HOURS*

5.1-2 MEASURING THE ALTITUDES OF THE PLANETS AND STARS

kare 'pasavye viniveśya yantraṃ jyotirvidā bhāskarasanmukhena |
tathā bujāgraṃ paricālanīyaṃ yathā viśec chidrayuge'rkatejaḥ ||1||
pūrve 'hani prākkubho bhujāgraspṛṣṭā raver unnatabhāgakāḥ syuḥ |
ta eva madhyaṃdinato 'parāṃśā rātrau grahoḍuṣv api caivam eva ||2||

1. The astronomer (*jyotirvid*), facing the sun, holding the astrolabe in his right hand, should so rotate the tip of the alidade (*bhujāgra*) that the sun's ray (*arka-tejas,* sun's light) enters the two holes.

2. In the forenoon the degrees of the eastern direction (*prāk-kakubha*) touched by the tip of the alidade denote the altitude degrees of the sun. The same after the noon become the altitude degrees in the west. The same is the case with planets and stars (*uḍu*) at night.

Commentary:

pūrve 'hani pūrvāhṇe prākkakubhaḥ pūrvasyā diśo bhujāgraṃ spṛṣṭā ekādyā navatiparyantā raver unnatabhāgāḥ syuḥ | evaṃ madhyaṃdinato madhyāhnād ūrdhvaṃ aparonnatāṃśāḥ syuḥ | tatra rātrau gaṇakena dakṣiṇanetraṃ nimīlya vāmanetroparisthena yantreṇa iṣṭasya grahasya dhiṣṇyasya vā vedhe bhujāgraspṛṣṭā aṃśāḥ pūrvāparadiggatatvena pūrvonnatāṃśā aparonnatāṃśāḥ jñeyāḥ ||

In the forenoon the degrees of the east, i.e. from one up to ninety, touched by the tip of the alidade, will be the altitude degrees of the sun. Likewise, from noon onwards, the same become degrees of altitude in the west (*aparonnatāṃśa*). At night, the astronomer (*gaṇaka*) closes the right eye and looks with the left eye at the desired planet

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* Sanskrit astrolabes generally contain only lines for the unequal hours counted from the western horizon, which is suitable only for the Islamic method of telling time. The astrolabes do not have lines for equal hours counted from the eastern horizon, which would be appropriate for the Indian method of telling time. Such lines can easily be drawn. In fact, some large Lahore astrolabes have such lines. Then how did Hindus/Jains measure time in *ghaṭīs* with the help of the astrolabe? The method is simple. Mahendra Sūri explains the method in 5.3-4; in 5.5 he also explains how to measure time according to Islamic fashion which he calls *āmnāya*!

or the star (*dhiṣṇya*) through the alidade, then the degrees touched by the tip of the alidade become the altitude degrees in the east or the altitude degrees in the west according as the body is in the east or west.

5.3-4 ASCERTAINING THE TIME OF THE DAY AND THE ASCENDANT

Atha ravisaṃbaddha-pūrvāparonnatāṃśebhyo dinagata-śeṣā-ghaṭikānayanaṃ lagnāna-yanaṃ cāha |

ravyaṃśakaṃ prāgapare ca bhūje dhṛtvonnatāṃśoparige kṛte' smin |

dvisthānasaṃlagnamṛgāsyamadhye kālāṃśakaiḥ paṅkti 10 palapramāṇaiḥ ‖3‖

ṣaḍbhir vibhaktair divasasya yātaṃ śeṣaṃ ca ghaṭyādi parisphuṭaṃ syāt |

tathonnataṃśaspṛśi bhāskarāṃśe prāgbhūjagaḥ sāyanalagnabhāgaḥ ‖4‖

Now he teaches the method of ascertaining the elapsed *ghaṭī* and those to come in the day (*dina-gata-śeṣa-ghaṭikā*) and the computation of the ascendant (*lagna*) from the degrees of the sun's altitude in the east or in the west.

3-4. [Rotate the rete in such a way that] the sun's [longitude in] degrees (*ravy-aṃśaka*) [as seen in ecliptic, on the given day] falls on the eastern horizon (*bhūja*) [if it is the forenoon] or on the western horizon [if it is the afternoon, and then rotate it again so that the longitude] falls on the altitude degrees. The time degrees (*kālāṃśa*) between the two positions of the Capricorn index (*mṛgāsya*), each of which equals 10 *palas*, are divided by 6. The quotient in *ghaṭīs* etc. is the time elapsed or the time to come in the day [in the forenoon and in the afternoon respectively]. Likewise, when the sun's degree is touching the altitude degree, [the point on the ecliptic of the rete] which touches the eastern horizon (*prāg-bhūja-ga*) is the degree of the tropical ascendant (*ṣayana-lagna-bhāga*).

Commentary:

iṣṭadine sāyana-meṣādi-rāśi-sthita-sūryāṃśaṃ prāci bhūje aparāhṇam astabhūje ca kṛtvāsminn eva sūryāṃśe kramād viddhe ca pūrvāparonnatāṃśopari kṛte sati kramād dvisthāna-saṃlagna-mṛāgsya-madhyasthitaiḥ kalāṃśakair daśapalapramāṇaiḥ ṣaḍbhir 6 bhakrair dinasyātītaṃ [śeṣaṃ vā] ghaṭydi parisphuṭaṃ bhavati | tathā pūrvokta eva bhāskarāṃśe viddha-pūrvāparonnatāṃśaspṛśi pūrvakṣitijagataḥ sāyana-meṣādi-lagnāṃśaḥ spaṣṭaḥ syāt ‖

On the desired day, the degree of the sun's tropical [longitude] as situated in one of the signs of the zodiac beginning with Aries (*ṣayana-meṣādi-rāśi-sthita-sūryāṃśa*) should be placed [by so rotating the rete] on the eastern horizon in the forenoon or the western horizon in the afternoon. Then place the same sun's longitude degree on the eastern or the western altitude degree that has been measured (*viddha*). When this is done, the units of time lying between the two positions of the Capricorn index (*mṛgāsya*), each of which is equal to 10 *palas*, are divided by 6. Then the elapsed *ghaṭīs* and its submultiples or those to come in the day will be obtained.

Similarly, when the afore-mentioned [longitude] degree of the sun is placed on the observed altitude circle in the east or west, then the degree of the zodiac signs beginning with Aries that touches the eastern horizon will be the ascendant (*lagna*).*

5. 5 MEASURING THE TIME IN HOURS IN THE DAY

evaṃ raveḥ saptamarāśibhāgo yatraiva horāvalaye 'sti saiva |
horā dyunāthāc ca tataḥ svaṣaṣṭhaṣaṣṭasya gaṇyāparabhūjavṛttāt ||5||

5. Likewise [when the sun's degree is placed on the altitude circle corresponding to the observed altitude degree], wherever the degree of the seventh sign [from the sun's position, i.e. the opposite point in the ecliptic] touches the hour circle (*horā-valaya*) that is the hour (*horā*) [at the time of observation]. [Thus] the hour should be counted from the western horizon, by moving six signs from the sun's position [marked on the rete] ?

Commentary:

evem iti ko 'rthaḥ | pūrvavad bhāskarāṃśe iṣṭonnatāṃśopari sthāpite sati tasmāc ca saptamarāśyaṃso yasmin horāvalaye 'sti saiva taddine ādyā dinavārādihorā | tato dinavārahorātaḥ ṣaṣṭhasya dvitīyādyā

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* On a given day, suppose that the sun is at Libra 15° and the sun's altitude as measured by the alidade is 36°. Turn the rete so that Libra 15° in the ecliptic touches the eastern horizon if it is in the forenoon or western horizon if it is in the afternoon. Note where the Capricorn index touches the degree scalw. Then turn the rete so that Libra 15° touches the altitude circle for 36°. Note where the Capricorn index touches the degree scale now. Divide the difference in degrees of arc by 6. The quotient in *ghaṭīs* is the time elapsed since sunrise if it is the forenoon or time remaining up to sunset if it is the afternoon.
Again, when the Libra 15° is on the determined circle of altitude, that point on the ecliptic in the rete which touches the eastern horizon is the ascendant.

dvādaśaparyantā horā jñeyā | ādyā dinavārato vāropalakṣitagrahasya
ṣaṣaṣṭhasya dvitīyā | param iyam āmnāyahorāparabhūjavṛttād gaṇyā |

When the sun's (longitude) degree is placed, as before, on the desired altitude degree, the [corresponding degree] of the seventh sign from there falls on whichever hour circle that is the first [hour] on that day of the week (*saiva taddine ādyā dinavārādihorā*) ? From that, i.e. from that hour of the day of the week, of the sixth should be known as the hours starting from the second up to the twelfth ?

Moreover, this conventional hour (*āmnāya-horā*) should be counted from the western horizon circle (*aparabhūjavṛtta*).*

5.6-7 ASCERTAINING THE SUN'S ALTITUDE FROM THE GIVEN TIME

atha dinagataśeṣaghaṭībhyo ravyunnatāṃśānayanam |

ravyaṃśakaṃ prākkṣitije niveśya cihnaṃ mṛgāsye vidadhīta paścāt |
abhīṣṭakāle ghaṭikoparisthaṃ tad eva kṛtvā paricintanīyam ‖6‖
ravyaṃśako yatra hi tuṅgavṛtte tadaṅkasaṃkhyās tapanonnatāṃśāḥ |
madhyāhnato 'stakṣitijāt tathaiva te bodhanīyāḥ sudhiyāvaśiṣṭāḥ ‖7‖

Now ascertaining the degrees of the sun's altitude from the elapsed *ghaṭīs* or those to come in the day.

6. Having placed the [longitude] degree of the sun on the eastern horizon (*prākkṣitija*), make a mark then on [the limb where] the Capricorn index [touches]. Then place the same [Capricorn index] on the given time in *ghaṭīs*.

7. Where the degree of the sun's [longitude] lies on the altitude circle (*tuṅgavṛtta*), its serial number denotes the sun's altitude degrees. From midday onwards, one [places the sun's longitude degree] on the western horizon (*asta-kṣtija*) [makes a mark. Then moves the Capricorn index to the given time]. Learned men should understand that these are the *ghaṭīs* remaining [till sunset].

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* Here Mahendra is obviously explaining the Islamic method of counting unequal hours from the western horizon. He calls the unequal hours *āmnāya-horā,* 'conventional or traditional hours of the Muslims'. But the second half of the text and the commentary on it are not clear. Commentary uses the terms *ādyā* and *dvitīyā;* do they refer to the two sets of 12 unequal hours, one for the day and another for the night? Then what is *dina-vāra-ādihorā* ?

Commentary:

ravyaṃśakaṃ prākṣitije niveśya mṛgāsye cihnaṃ viracya paścād abhīṣṭakle ghaṭikoparisthaṃ tad eva mṛgāsyaṃ kṛtvā gaṇakena vilokanīyam | yasmin tuṅgavṛtte ravyaṃśaḥ sthito 'sti tāvadaṅka-pramāṇāḥ pūrvataḥ sūryonnatāṃśās tāvatīṣu ghaṭīṣu jātā iti śeṣaḥ | tathā madhyāhnato 'stakṣitijāt tathaiva pūrvoktarītyā sudhiyā viduṣā avaśiṣṭāsv iṣṭaghaṭīṣu avaśiṣṭā unnatāṃśā bodhanīyāḥ ||

Having placed the sun's degree on the eastern horizon and having made a mark where the Capricorn index touches, then having moved the Capricorn index to the given time, the astronomer should look. On which ever altitude circle the sun's degree is situated, the degrees of altitude corresponding to that circle; so many altitude degrees of the sun were reached from the east during so many *ghaṭīs*. In the same manner, the scholar should determine in the afternoon the remaining (*avaśiṣṭa*) altitude degrees from the western horizon from the remaining *ghatīs*,.

5.8: MEASURING THE TIME AT NIGHT FROM THE ALTITUDE OF THE STARS

atha rātrau viddhanakṣatronnatāṃśebhyo
rātrigataśeṣaghaṭikānayanam āha |
viddhonnatāṃśopagate ca bhāsye ravyāṃśake 'stendrakujasthite ca |
cihnadvayāntargataśeṣanāḍīpalāni pūrvāpararātribhāge ||8||

Now he teaches how to find the elapsed and remaining *ghaṭīs* at night from the altitude degrees of the star observed (*viddha*) at night.

8. When the star-pointer (*bhāsya*) is placed on [the altitude circle corresponding to] the measured degrees of altitude (*viddhonnatāṃśa*) and then when the sun's degree is placed on the western horizon (*asta-kuja*) or eastern horizon (*indra-kuja*) [as the case may be] in the first half or second half of the night, [one obtains from the interval] between the two marks [of the Capricorn index] the elapsed or remaining *ghaṭīs* and *palas.*

Commentary:

rātrau bhujāgreṇeṣṭanakṣatre viddhe prācyāḥ pratīcyā vā ye unnatāṃśāḥ prāpyante teṣūnnavalayasthiteṣu viddhonnatāṃśeṣu viddhe nakṣatramukhe dhṛte, sūryāṃśe astakujasthe aindrakujasthe vā pūrvāpararātribhāge kramān makara-mukhacihnadvayāntargataṃ śeṣaṃ nāḍīpalādi-sphuṭaṃ syāt ||

At night, when the desired star is sighted, the degrees of its altitude in the east or west are obtained through the tip of the alidade (*bhujāgra*). When the pointer of the star (*nakṣatra-mukha*) that has been observed is placed on those altitude circles corresponding to the measured degrees of altitude, and the sun's degree is placed on the western horizon or eastern horizon respectively in the first or the second half of the night, then the elapsed time or remaining time in *ghaṭī* (*nāḍī*) and *palas* can be read off from the [interval] between the two positions of the Capricorn index.

5.9 Ascertaining the ascendant and the time at night

tatraiva nakṣatramukhe niviṣṭe prāgbhūjagaṃ sāyanam eti lagnam |
sūryāṃśakādhiṣṭhitavṛttasaṃsthā tadātra horāpi niśi sphuṭā syāt ||9||

9. When the star-pointer (*nakṣatra-mukha*) is placed at the same place (i.e. on the altitude circle corresponding to the measured altitude degree), [the point on the ecliptic resting] on the eastern horizon [indicates] the ascendant with precision (*sāyanaṃ lagnaṃ*). Then, at that time, the hour corresponding to the circle on which the sun's degree is situated is clearly the hour of the night.

Commentary:

tatraiva viddhonnatāṃśeṣveva viddhanakṣatramukhe niviṣṭe pūrvarātrau apararātrau prāgbhūjagaṃ sāyanaṃ lagnam eti | tadā tasmin kāle sūryāṃśakādhiṣṭhita-vṛttasaṃsthā horā niśi rātrau sphuṭā syāt | lagnakāle yasmin valaye 'rkaḥ sthito'sti tadvalaye tadgatahorā bhavatīty arthaḥ |

At the same place, i.e., on the sighted altitude degrees when the pointer of the sighted star is placed, in the first half of the night or in the second half [the point of the ecliptic that] touches the eastern horizon is the ascendant with precision. Then, at that time, the hour corresponding to the circle on which the sun's degree is situated is clearly the hour of the night. That means, at the time of the ascendant, in whichever circle the sun is situated in that circle the hour of that circle occurs.*

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* The second half of the verse and the commentary on it are rather obscure; the altitude circle where the sun's longitude is situated will not indicate the hour by itself; from the sun's position on the altitude circle, one should count six signs and find the corresponding hour line in the lower half of the plate.

5. 10: ASCERTAINING THE ALTITUDES OF THE STARS FROM THE GIVEN TIME

atha rātrigateṣṭaghaṭībhyo nakṣatrākrāntonnatāṃśānayanam āha |
sūryāṃśake 'stakṣitijasthite 'ṅkaṃ kṛtvā mṛgāsye gatanāḍikāsu |
niveśite 'tronnatavṛttagāḥ svāḥ prācyapratīcyoḍubhavonnatāṃśāḥ ||10||

Now he teaches how to determine the altitude of the star from the given *ghaṭīs* at night.

10. Having made a mark [on the limb touched by the Capricorn index] when the sun's degree is on the western horizon (*astakṣitija*), place the Capricorn on the elapsed *ghaṭīs*. [Then wherever the star-pointer touches] on the altitude circle there will be the degrees of the star's altitude in the east or west.

Commentary:

sūryāṃśake 'stakṣitijasthite sati mṛgāsye aṅkaṃ kṛtvā paścād gateṣṭanāḍikāsu mṛgāsye niveśite sati unnatāṃśavṛttasthitāḥ svakīyāḥ prācya-pratīcyoḍubhavāḥ pūrvāparakapāla-sthita-nakṣatrākrāntā unnatāṃśā sphuṭā bhavantīti śeṣaḥ ||

When the sun's degree is on the western horizon, make a mark [on the limb] where the Capricorn index [touches]. Then place the Capricorn index on the elapsed *ghaṭīs* (that means, move the Capricorn index on the limb by so many *ghaṭīs*); then the altitude degrees of the star situated on the altitude circle [touched by the star pointer] originating from the star in the east or west are clearly the altitude degrees attained by the star in the eastern or western hemisphere.

5.11 ASCERTAINING THE ASCENDANT FROM THE *GHAṬĪS*

atha dinarātrigataghaṭībhyo lagnānayanam āha |
prāgastabhūjopagate 'rkabhāge 'ṅkite mṛgāsye gatanāḍikāsu |
sthite ca tasmin dyuniśoḥ kramāt syāt prāgbhūjagaḥ sāyanalagnabhāgaḥ ||11||

Now he teaches how to determine the ascendant (*lagna*) from the elapsed *ghaṭīs* in the day or at night.

11. When the sun's degree is placed on the eastern or western horizon and a mark is made at the point touched by the Capricorn index, then the Capricorn index is placed at the elapsed *ghaṭīs*, then the degree of the ascendant with precision will be situated upon the eastern horizon either for the day or for the night.

Commentary:

> *dine sūryāṃśe prākkṣitijopage mṛgāsye cihnite tato gatanāḍikāsu tasmin mṛgāsye sthite sati prākkṣitijasthaḥ sāyano lagnababhgaḥ syāt | evaṃ rātrāv astakṣitijasthe sūryāṃśe mṛgāsyaṃ cihnayitvā tato rātrigata-ghaṭīṣu mṛgāsye āropite prākkṣitijagataḥ sāyano lagnabhāgo bhavati ||*

In the daytime, the sun's longitude is placed on the eastern horizon, and a mark is made [on the limb touched by] the Capricorn index. Then this Capricorn index is moved to the elapsed *ghaṭīs*, then the degree of the ascendant with precision (*sāyana-lagna-bhāga*) will be situated upon the eastern horizon. Likewise, at night, place the sun's degree on the western horizon and mark where the Capricorn index touches the limb, then move the Capricorn index to the elapsed *ghaṭīs*, the degree of the ascendant with precision (*sāyana-lagna-bhāga*) will be on the eastern horizon.

Other Uses of the Astrolabe

The rest of the chapter discusses several other uses to which the astrolabe can be put. These are listed below.

5.12-17: Determination of the twelve zodiac houses.

5.18-19: How to find the degrees of sun's longitude that lie lie in between the sexpartite almucantar circles.

5.20-21: How to find the altitude degrees that lie in between the sexpartite almucantar circles.

5.22-23: Ascertaining the ascendant and the altitude degrees of the stars in the four watches of the night (*yāma*).

5.24: Ascertaining the sun's true position.

5.25: Ascertaining the longitudes of stars and the remaining planets.

5.26: A different method for finding out the true longitudes of the five planets starting with Mars from the star's altitude degrees.

5.27: Ascertaining the daily motion by a planet (*graha-bhukti*).

5.28-31: Ascertaining the half of the maximum ascensional difference (*parama-caradala*) at the given degree [of latitude].

5.32: Ascertaining the lengths of the day and of the night.

5.33: Ascertaining of the degrees of precision (*ayanāṃśa*).

5.34-35: Determination of the conjunction of planets (*grahayut*i).

5.36: Ascertaining the ascendant (*lagna*) of the next year from the ascendant of the current year.

5.37-38: Determination of the accurate ascendant through correction for the longitude difference.

5.39: Determination of the northern/southern declination (*saumya-yāmya-krānti*) of the fixed stars.

5.40-42: From ascendant derived from the terrestrial latitude marked on the astrolabe, ascertaining the ascendant for other latitude.

5.43: Determination of the latitude of a desired locality from the circumpolar stars (*sadoditarkṣa*).

5.44-45:Ascertaining [the longitudes of] the fixed stars as corrected for *dṛkkarma*n.

5.46-51: Ascertaining the *tithi, nakṣatra* and *yoga*.

5.52: Ascertaining, by the Rule of Three, the shadow of the gnomon of 7 digits from the gnomon of 12 digits.

5.53: Ascertaining the shadow of the gnomon of 12 digits from the gnomon of 7 digits .

5.54: Ascertaining the shadow of the 12 digit gnomon and that of the 7 digit gnomon from any given altitude degrees.

5.55-57: Method of finding the heights of mountains, surrounding walls, temples, arches, pillars, trees etc. by sighting them from a distance.

5.58-60: Finding the times of rising in the east of the five [planets] starting with Mars.

5.61-63: Determination of the times of the setting of the planets Mars etc.

5.67: Author's colophon

abhūd bhṛgupure vare gaṇakacakracūḍāmaṇiḥ
kṛtī nṛpatisaṃstuto madanasūrināmā guruḥ |
tadīyapadaśālinā viracite suyantrāgame
mahendraguruṇoditājani[*] *vicāraṇā yantrajā ||67||*

In the eminent city of Bhṛgupura, there lived the leaned preceptor by name Madana Sūri, the crest-jewel of the circle of astronomers, who was praised by the kings. In this excellent treatise on the instrument (i.e. the astrolabe), composed by the preceptor

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[*] Thus Sudhākara Dvivedi's edition; Raikva's reads °*guruṇoddhṛtā*.

Mahendra, a devotee of his (Madanasūri's) feet, [the chapter dealing with] the use of the instrument is born (i.e., completed).

COMMENTATOR'S COLOPHON

śrīperojaśakendra-sarvagaṇakaiḥ praṣṭo mahendraprabhur
jātaḥ sūrivaras tadīyacaraṇāmbhojaikabhṛṅgadyutā |
sūriśrīmalayendunā viracite 'smin yantrarājāgama-
vyākhyāne pravicaraṇādikathanādhyāyo 'gat pañcamaḥ ||

Master Mahendra Sūri, the eminent scholar, is the foremost one among all the astronomers at the court of the glorious Fīrūz, the sovereign of the Muslims. In this commentary on the treatise *Yantrarāja* composed by the illustrious Malayendu Sūri, who is like the bee at the lotus feet of the [said master], the fifth chapter [that dwells on] the uses and so on [of the astrolabe] is concluded.

APX.D2 THE *DHRUVABHRAMĀDHIKĀRA* OF PADMANĀBHA WITH HIS OWN COMMENTARY: SOME EXTRACTS

Padmanābha (*fl.* 1423) and his works have been discussed in the introduction to section L (Dhruvabhrama-yantra) above. His *Dhruvabhamādhikāra* has not been published so far. There exist some seventy manuscript copies.* I have prepared a working edition of the text and of the commentary on the basis of the following eight manuscripts:

(1) Asiatic Society of Bombay, # 245, dated Monday, 26 January 1660

(2) Bhandarkar Oriental Research Institute, Pune, # 329/1882-83 (text only)

(3) British Museum, London, # 14.365l

(4) Rajasthan Oriental Research Institute, Chittorgarh, of 1878

(5) Varanasi Sanskrit University, # 35606, dated Sunday 3 July 1825

(6) Varanasi Sanskrit University, # 35750 (commentary only)

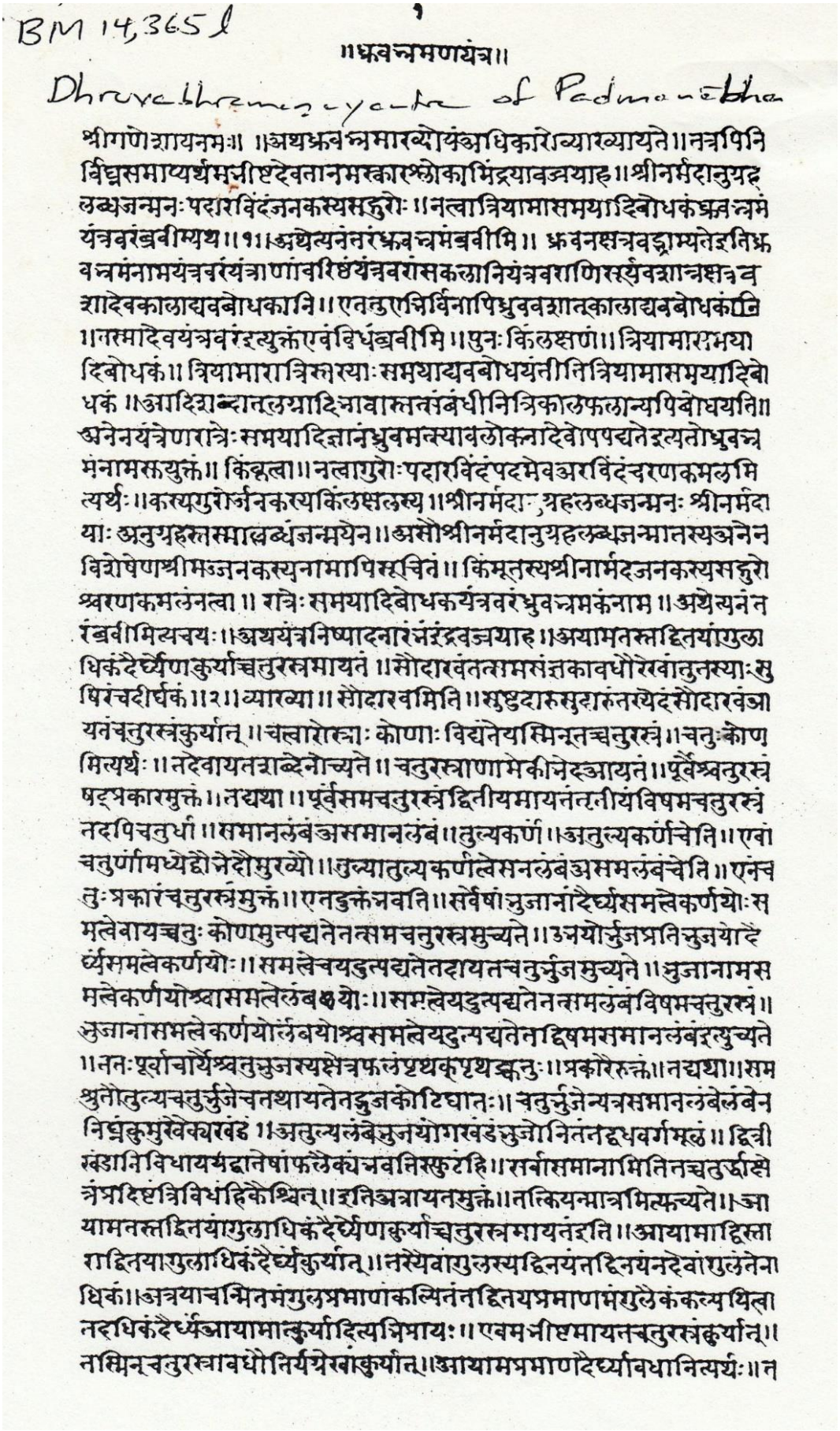
(7) Vishweshwaranand Vedic Research Institute, Hoshiarpur, # 2481, dated Thursday, 6 September 1663 (commentary only)

(8) Vishweshwaranand Vedic Research Institute, Hoshiarpur, # 469.

Some extracts from the text and from the commentary are reproduced in the following pages, together with English translation, but without the critical apparatus.

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* cf. CESS A-4, pp. 170-172; A-5, p. 205.



BM 14,365 l

॥ध्रुवभ्रमणयंत्र॥

Dhruvabhramaṇayantra of Padmanābha

श्रीगणेशायनमः॥ ॥अथध्रुवभ्रमारब्धोयंग्रंथाधिकारोव्याख्यायते॥तत्रपिनि
र्विघ्नसमाप्त्यर्थमभीष्टदेवतानमस्कारश्लोकामिंद्रयावज्रयाह॥श्रीनर्मदानुग्रह
लब्धजन्मनः पदारविंदंजनकस्यसद्गुरोः॥नत्वात्रियामासमयादिबोधकंध्रुवभ्रमं
यंत्रवरंब्रवीम्यथ॥१॥अथेत्यनेनरंध्रुवभ्रमंब्रवीमि॥ ध्रुवनक्षत्रवद्भ्राम्यतेइतिध्रु
वभ्रमंनामयंत्रवरंयंत्राणांवरिष्ठंयंत्रवरंसकलानियंत्रवराणिसर्वेयन्नाभ्रुवभ्र
मादेवकालाद्यवबोधकानि॥एतत्तुएभिर्विनापिध्रुवभ्रमात्कालाद्यवबोधकंनि
॥तस्मादेवयंत्रवरंइत्युक्तंएवंविधंब्रवीमि॥पुनः किंलक्षणं॥त्रियामारात्रमया
दिबोधकं॥त्रियामारात्रिस्तस्याः समयाद्यवबोधयंतीतित्रियामासमयादिबो
धकं॥आदिशब्दात्तत्प्रहरादिग्रहास्तत्संबंधीनित्रिकालफलान्यपिबोधयति॥
अनेनयंत्रेणरात्रेः समयादिज्ञानंध्रुवमन्त्यावलोकनादेवोपपद्यतेइत्यतोध्रुवभ्र
मनामसंयुक्तं॥ किंकृत्वा॥नत्वागुरोः पदारविंदंपदमेवअरविंदंचरणकमलमि
त्यर्थः॥कस्यगुरोर्जनकस्यकिंलक्षणस्य॥श्रीनर्मदा[illegible]ग्रहलब्धजन्मनः श्रीनर्मदा
याः अनुग्रहस्तस्मात्लब्धंजन्मयेन॥असौश्रीनर्मदानुग्रहलब्धजन्मातस्यअनेन
विशेषेणश्रीमज्जनकस्यनामापिस्मरितं॥ किंभूतस्यश्रीनार्मदजनकस्यसद्गुरो
श्चरणकमलंनत्वा॥ रात्रिः समयादिबोधकंयंत्रवरंध्रुवभ्रमंकंनाम॥अथेत्यनेन
रंब्रवीमित्यन्वयः॥अथयंत्रनिष्पादनारंभंद्रवज्रयाह॥अयामतस्तद्दितयांगुला
धिकंदैर्घ्येणकुर्याच्चतुरस्रमायतं॥सोदारवंतत्तामसंज्ञकावधीरेखांतुनस्याःसु
षिरंचदीर्घकं॥२॥व्याख्या॥सोदारवमिति॥सुष्ठुदारुसुदारुतस्यैदंसोदारवंआ
यतंचतुरस्रंकुर्यात्॥चत्वारोस्त्राः कोणाः विद्यंतेयस्मिन्तच्चतुरस्रं॥चतुःकोण
मित्यर्थः॥तदेवायतशब्देनोच्यते॥चतुरस्राणामेकोनिर्दश्यते॥पूर्वंश्चतुरस्रं
षट्प्रकारमुक्तं॥तद्यथा॥पूर्वंसमचतुरस्रंद्वितीयमायतंतृतीयंविषमचतुरस्रं
तदपिचतुर्धा॥समानलंबंऽसमानलंबं॥तुल्यकर्णं॥अतुल्यकर्णंचेति॥एवं
चतुर्णांमध्येद्वौत्रैराशौरुच्यौ॥तुल्यातुल्यकर्णत्वेसमलंबंऽसमलंबंचेति॥एतच्च
तुःप्रकारंचतुरस्रंमुक्तं॥एतदुक्तंभवति॥सर्वेषांभुजानांदैर्घ्यसमत्वेकर्णयोःस
मत्वेवायच्चतुः कोणमुत्पद्यतेतत्समचतुरस्रमुच्यते॥उभयोर्भुजप्रतिभुजयोर्दै
र्घ्यसमत्वेकर्णयोः॥समत्वेचयदुत्पद्यतेतदायतंचतुर्भुजमुच्यते॥भुजानामस
मत्वेकर्णयोश्चासमत्वेलंबकयोः॥समत्वेयदुत्पद्यतेनत्तत्समलंबंविषमचतुरस्रं॥
भुजानांसमत्वेकर्णयोर्लंबयोश्चसमत्वेयदुत्पद्यतेतद्विषमसमानलंबंइत्युच्यते
॥ततःपूर्वाचार्यैश्चतुर्भुजस्यक्षेत्रफलंपृथक्पृथङ्मतं॥प्रकारैरुक्तं॥तद्यथा॥सम
श्रुतेतुल्यचतुर्भुजेचतथायतेतद्भुजकोटिघातः॥चतुर्भुजेन्यत्रसमानलंबेलंबेन
निघ्नंकुमुखैक्यखंडं॥अतुल्यलंबेभुजयोगखंडंभुजोनितंतद्धवर्गमूलं॥द्वित्री
खंडानिविधायतेषांफलैक्यंभवतिस्फुटंहि॥सर्वासमानामितिनच्चतुर्ऽक्षे
त्रंप्रदिष्टंत्रिविधंहिकेश्चित्॥इतिअत्रायतमुक्तं॥तत्क्रियन्मात्रमित्यच्यते॥आ
यामतस्तद्दितयांगुलाधिकंदैर्घ्येणकुर्याच्चतुरस्रमायतंइति॥आयामाद्दिस्ता
राद्दितयांगुलाधिकंदैर्घ्यंकुर्यात्॥तस्यैवांगुलस्यद्दितयंनद्दितयंनदेवांगुलेनाधि
कं॥अत्रयाचन्मितमंगुलप्रमाणंकल्पितंनद्दितयप्रमाणमंगुलेकंकल्पयित्वा
तदधिकंदैर्घ्यंआयामात्कुर्यादित्यभिप्रायः॥एवमभीष्टमायतंचतुरस्रंकुर्यात्॥
तस्मिन्चतुरस्रावधौनिर्यग्रेखांकुर्यात्॥आयामप्रमाणदैर्घ्यावधानित्यर्थः॥त

Figure Apx.D2.1 - British Museum Manuscript

श्रीपद्मनाभ-विरचित-ध्रुवभ्रमाधिकारः स्ववृत्ति-सहितः

1. Preamble

śrīnarmadānugrahalabdhajanmanaḥ
padāravindaṃ janakasya sadguroḥ |
natvā triyāmāsamayādibodhakaṃ
dhruvabhramaṃ yantravaraṃ bravīmy atha || 1 ||

Having bowed to the lotus feet of [my] father, who was [my] best teacher and who was born by the grace of the glorious [River Goddess] Narmadā, I now teach the excellent instrument *Dhruvabhrama,* which shows the time of the night and other [parameters].

2. Construction of the Dhruvabhrama-yantra

āyāmatas taddvitayāṅgulādhikaṃ
dairghyeṇa kuryāc caturasram āyatam |
saudāravaṃ tatsamasaṃjñakāvadhau
rekhāṃ tu tasyāṃ suṣiraṃ ca dīrghakam || 2 ||
aṣṭāṅgulaṃ sūkṣmataraṃ samākhye
vṛttāṣṭakaṃ sārdhayavāntareṇa |
tadbāhukhaṇḍena vidhāya pūrvaṃ
parāṇi caivaṃ hi pṛthak tadantaḥ || 3 ||
randhrasthabāhvardhagavṛttanemyāṃ
cihnaṃ tataś cākṛtināḍikātaḥ |
aṅkyāḥ samāḥ ṣaṣṭir athādito 'dho
vṛttāntarāle prathame ca koṣṭhe || 4 ||
tatas tṛtīye valayāntarāle
vyakṣāḥ kriyādyāḥ svaghaṭībhir aṅkyāḥ |
ṣaṣṭhe svakīyās tadadhaḥ svanāmā-
ny ūrdhve tu dhiṣṇyāni ca sāyanāni || 5 ||

Commentary: *…tatas tasmāt paraṃ tadadhas tṛtīye valayāntarāle tṛtīyakoṣṭhake prathamaghaṭīm ārabhya svasvaghaṭīpramāṇena nirakṣodayena meṣādyā dvādaśarāśayo vyakṣā aṅkyāḥ | tataḥ ṣaṣṭhe koṣṭhe svadeśīyāḥ svasvaghaṭībhir*

aṅkyāḥ | tadadhas tṛtīyaṣaṣṭhakoṣṭhayor adhaś caturthasaptamayo rāśīnāṃ svasvanāmāny aṅkyānīti lekhyāni | tadūrdhve dvitīyapañcamakoṣṭhayor dhiṣṇyāni sāyanānīti | nakṣatradhruvakānām ayanāṃśān dattvā yasmin rāśau yasminn aṃśe yan nakṣatram tadaṃśā aṅkyā iti | sarvāṇy aṅkyāni lekhyāni |

madhyonnatāṃśā nijarāśibhānāṃ
lekhyā upāṅkeṣu nirakṣajānām |
svīyodaye svākṣajadṛṣṭikarma-
kṛtasphuṭāny eva likhed uḍūni || 6 ||

Make an oblong (*āyata caturasra*) board out of hard timber, two finger-breadths (*aṅgula*) longer than the width. Draw a line at the boundary of the square part and upon this make a long slit. It should be eight finger-breadths long and very narrow.

Inside the square [draw] eight [concentric] circles at intervals of one and half barley corns. Having thus drawn the [circle with a radius] equal to half the side [of the square, draw] the remaining circles inside that one.

Make a mark on the circumference of the [first] circle where it touches the middle of the side situated upon the slit. In the first annulus (*koṣṭha*) between the [first and the second] circles, make sixty equal [divisions] and number them from the [above-mentioned] mark, starting with *ghaṭī*[*] twenty-two, and [going up to sixty, and thereafter] from one [to twenty-one].

Then in the third annulus (*valayāntarāla*), mark [the signs of the zodiac] at the equator beginning with Aries (i.e., according to their right ascensions) in *ghaṭīs,* and in the sixth annulus [the signs] in one's locality (*svakīya*) (i.e., according to their oblique ascensions). Below that write their names and above [the polar longitudes of] stars (*dhiṣṇya*) with precession (*sāyana*).

Commentary on 5: Then in the third annulus, starting from the first *ghaṭī,* mark the twelve signs of the zodiac, viz. Aries etc., without latitude, i.e. according to their risings in *ghaṭīs* at the equator (*nirakṣa*). Then in the sixth annulus, mark the same according to their risings in *ghaṭīs* in one's own locality. Below that, i.e. below the third

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[*] *Ghaṭī,* the standard unit of time in traditional India which equals 24 minutes, has three other synonyms in Sanskrit, viz. *ghaṭikā, nāḍikā* and *nāḍī.* While the text uses all the four synonyms, these will be rendered as *ghaṭī* in the translation.

and the sixth annuli, viz. in the fourth and the seventh annuli, write down the names of the zodiac signs. Above that, i.e. in the second and fifth annuli, write down the lunar mansions with the degrees of precession. That is to say, in whichever sign at whatever degree, [the polar longitude of] a lunar mansion is situated, those degrees must be written, after adding the degrees of precession (*ayanāṃśa*) to the polar longitudes (*dhruvaka*) of the stars. Thus all [stars] are to be written down.

Near the marks [of division of the signs], computed according to their right ascensions, write the meridian altitudes (*madhyonnatāṃśa*) of the stars belonging to the respective signs. In [the annuli] of the oblique ascensions, write down the true (*sphuṭa*) [polar longitudes of] the stars after correcting these by the latitudinal *dṛkkarma* (*akṣaja-dṛṣṭikarma*).

3. INDEX

tatkendrakīle viniveśya cakraṃ
cañcutrayāḍhyaṃ śithilaṃ salambam |
prākcañcukāgraṃ nijabhodayāptaṃ
madhyaṃ nirakṣe tv aparaṃ ghaṭīṣu || 9 ||
turyāṃśakeṣv eva niyojiteṣu
lambas tv adhas turyalave yathā syāt |
tathā prakuryāt sudṛḍham ca kīlaṃ
paribhramat tan na pated adhastāt || 10 ||

9. Attach loosely to the pin situated at its centre a circular disc, equipped with three pointers (*cañcu,* literally, beak) and a plumb (*lamba*) in such a manner that the eastern pointer touches the oblique ascensions (*nijabhodaya*), the middle [pointer] the right ascensions (*nirakṣa*), the western [pointer] the *ghaṭīs,*

10. — [the three pointers] being attached in three different quadrants [of the circular disc]— and the plumb rests in the lower-most quadrant. The pin should be fixed tightly [to the instrument] in such a manner that the circular disc does not slip out while rotating.

4. METHOD OF OBSERVATION

dhruvatimimukhapucchādhiṣṭhite tārake dve
yugapad iti bhavetām vedharandhrasya madhye |
mukura iva karābhyām saṃgṛhīte hy amuṣmin
haridiśi bhavatīṣṭaṃ cañcukāgre vilagnam || 11 ||
sacalanam iti nāḍyāṃ vedhacihnaṃ ca paścāt
sacalanalavaṣaḍbhe pūrvacañcvagrage 'rke |
tadaparayutanāḍīcihnato vedhacihnā-
vadhi gataghaṭikāḥ syuś ced ravau cañcuyukte || 12||
tad aparaghaṭicihnaṃ yāvad eṣyā vyadhāṅkād
viyati bhavati madhyaṃ vyakṣabhe yatra cañcuḥ |
viyadudayavilagnābhyāṃ pare veditavyā
abhimataghaṭikā bhāt procyate 'rkāt tathāhnaḥ || 13 ||

11. When this [instrument] is held in both hands like a mirror in such a manner that the two stars situated at the mouth and the tail of the Polar Fish (*dhruva-timi*) are seen simultaneously through the sighting slit, at the tip of the eastern pointer can be seen the ascendant (*vilagna*) for that moment

12. with precession (*sacalana*). Make a mark of observation (*vedha-cihna*) in the west [at the tip of the western pointer] on the *ghaṭī* circle. Move the tip of the eastern pointer to the solar longitude [for that time] with precession, increased by six signs. Then from the corresponding point on the *ghaṭī* circle at the tip of the western pointer up to the [previously laid out] mark of observation (*vedhacihna*) are the elapsed *ghaṭīs* [in the night]. If [the tip of the eastern] pointer is placed on the sun's longitude [with precession],

13. then from the mark of observation (*vyadhāṅka*) up to the mark on the *ghaṭī* circle at the western pointer are [the *ghaṭīs*] to come. Where the [middle] pointer is situated in the sign rising at the equator, it is the upper culmination (*madhya, madhyama-lagna*). Then the other [astrological houses] can be known from the upper culmination (*viyad-vilagna*) and the ascendant (*udaya-vilagna*). Now will be told [the method of finding] the desired *ghaṭīs* [of the night] from [any] fixed star and [the time] of the day from the sun.

5. The Constellation of the Polar Fish (*Dhruva-matsya*): Commentary on Verse 11

pūrvaṃ sṛṣṭyādau śrībrahmaṇākāśa ādhārarahitasya pravahānilākṣiptasya bhacakrasya samīcīnapaścimābhimukhaparibhramaṇāya dakṣiṇottarayoḥ prāntasthite dve tārake dhruvatve niyukte | tayor ubhayor dhruva-saṃjñā kṛtā | yā dakṣiṇā tārā sā tu palāṃśaiḥ kṣitijād adhasthād vartate | yā tūttarā tārā sā palāṃśaiḥ kṣitijād uparito varīvarti | tatparito dvādaśatārakābhir matsyākāramaṇḍalam upalakṣyate | tasya dhruvamatsya-saṃjñā vihitā | tanmukhe pucche sthūle tārake dve dṛśyete | tayor madhye yā mukhasthā sā dhruvatārāyās tribhir aṃśair antaritā | yā pucchasthā sā tu trayodaśabhir aṃśair antaritā vartate | ubhe parasparaṃ ṣodaśabhāgāntarite staḥ |

At the beginning of Creation, the glorious [Creator] Brahmā arranged two stars as the celestial poles at the end of the southern and northern directions so that the stellar sphere (*bhacakra*) can properly revolve in the sky towards the west, without any support but impelled by the *Pravaha* wind. These two stars were designated as the celestial poles (*dhruva*). That which is the southern [Pole] Star is situated below the horizon at the degrees of the local latitude (*palāṃśa*). The northern Pole Star lies above the horizon at the degrees of the local latitude. Around the latter is seen a fish-shaped constellation consisting of twelve stars. This is designated as the Polar Fish (*dhruva-matsya*). Two bright stars are visible at its mouth and tail. Of these, the one at the mouth lies at an interval of three degrees (*bhāga*) from the [actual] Pole Star and the one at the tail lies at thirteen degrees. The two are separated from one another by sixteen degrees.

6. Sine Quadrant on the Back

kadūnadoṣṇā vaṇigūrdhvakoṇato
yantrānyapārśve vṛtituryam ālikhet |
tadrandhrabāhoḥ khaguṇonmitajyakās
tulyāntarālāś ca vilambasūtravat || 14 ||
kendrād adhaḥ koṇapadāc ca nemyāṃ
aṅkyāḥ samāḥ khāṅkalavās tu sāṅkāḥ |
tatturyakendre viniyojya paṭṭīṃ
triṃśatpadāṅkāṃ sahalambasūtrām || 15 ||
randhrordhvabāhūpari kīlayugmaṃ

sarandhrakaṃ prāntagatam vidadhyāt |
iṣṭārkṣamadhyonnatabhāgakeṣu
vinyasya paṭṭīṃ sudṛdhāṃ ca kendrāt || 16 ||

14. On the reverse side of the instrument, from the corner above Libra [which is marked on the front side] draw a quadrant of the circle (*vṛti-turya*) with an arm (radius) slightly less [than the side of the square]. From the side containing the slit, draw thirty sines at equal intervals like dangling strings.

15. Below the centre, starting from the foot of the corner (*koṇa-pāda*), mark ninety equal degrees on the rim and number them. Having attached an index (*paṭṭī*) marked in thirty units together with a plumb line (*lambasūtra*) at the apex of the quadrant (*turya-kendra*),

16. affix two sighting vanes (*kīla*) with holes at the two ends of the edge [of the instrument] on the side of the slit. [While observing a star, move the index] to the degrees of the meridian altitude of that star and hold it there firmly.

7. Observation with the Sine Quadrant

tatpārśvakīlena ca kendrakīla-
pathena dṛṣṭyā khalu vedhayed bham |
kendrāvalambonmitabhāgajīvā-
spṛkpaṭṭikāṅkapramitajyakāṃśāḥ || 17 ||
saduddhṛtās te 'bhimatāś ca nāḍyaḥ
pūrve 'gatāḥ paścimatas ca yātāḥ |
vyakṣasvarāśisthitatatpadāntaś
caraṃ ca tadghnās tithihṛd vināḍyaḥ || 18 ||
tenonayuktā ghaṭikāḥ sphuṭāḥ syur
nyūnādhike vyakṣapade svacihnāt |
bhūjasthacihnordhvaganāḍikāṅkāt[*]
triṃśadyutāc ca kramaśo yutonāḥ || 19 ||
tatsanmukhaprāksthitacañcukāgre
lagnaṃ paratra vyadhacihnam asmāt |

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[*] Should one read *deśastha°* instead of *bhūjastha°* ?

prāgvat prasādhyā ghaṭikā niśāyāṃ
sūryasya tā eva parisphuṭāh syuḥ ‖ 20 ‖

17. Then sight the star along the path of vision between the sighting vane on the side and the sighting vane above the apex. [Note] the number on the index touched by the sine [of the altitude] degrees indicated [by the plumb line] suspended from the apex. The degrees of the sine with the same value as that number,

18. when divided by six, become the desired *ghaṭīs*, those to come (*agata*) if the star is in the east, elapsed (*yāta*) if the star is in the west. The [difference] between the respective positions [of the star on the circles] of the signs in right and oblique [ascensions] is the ascensional difference (*cara*). The *ghaṭīs* are multiplied by that [*cara*] and divided by fifteen. [The result is called the *caraphala.*]

19. The *ghaṭīs,* when diminished or increased by this [*caraphala* according as the star's] position on the [circle of] right ascensions (*vyaksapada*) are less or greater than the mark on the [circle of] oblique [ascensions] (*svacihna*), will be true [*ghaṭīs*]. These are respectively added to or subtracted from the number, augmented by thirty, on the *ghaṭī* [circle] just above the [star's] mark when it is on the horizon (?).

20. At the tip of the eastern pointer, facing this mark, is the ascendant and in the west the mark of sighting (*vedha-cihna*). From this the *ghaṭīs* of the night can be determined as before. In the case of the sun, the same [without the operation detailed above] will be the true [*ghaṭīs*].

8. Meridian Altitudes of the Lunar Mansions at the Latitude of 24°

rasāṣṭau 86 gajāṣṭau 88 navāṣṭau 89 guṇāṣṭau 83
navāśvā 79 gajāśvā 78 śarāṣṭau 85 rasāṣṭau 86 |
navāśvā 79 khanāgā 80 yugāṣṭau 84 yamāṣṭau 82
tribāṇāḥ 53 kubhṛnmārgaṇa 57 nandanāgāḥ 89 ‖ 24 ‖
śaśāṅkeṣavo 51vedavedāḥ 44 kuvedāś 41
catustriṃśad 34 aśvāgnayaḥ 37 śailarāmāḥ 37 |
rasāśvā 76 guṇāśvāh 73 kuśailā 71 rasākṣā 56
yamāṣṭau 82 navāṣṭau 89 dviśailāḥ 72 kramena ‖ 25 ‖
jināṃśāḥ palās tatra madhyonnatāṃśā
upāntyānileśādyayugmasya sārdhāḥ |
vidher bhāt trayādityayāmyānilānāṃ

udaksaṃsthitā dakṣiṇāḥ śeṣabhānām ‖ 26 ‖

24. [The meridian altitudes are] successively [Aśvinī] 86; [Bharaṇī] 88; [Kṛttikā] 89; [Rohiṇī] 83; [Mṛgaśirā] 79; [Ārdrā] 78; [Punarvasu] 85; [Puṣya] 86; [Āśleṣā] 79; [Maghā] 80; [Pūrvaphālguṇī] 84; [Uttaraphālguṇī] 82; [Hasta] 53; [Citrā] 57; [Svāti] 89;

25. [Viśākhā] 51; [Anurādhā] 44; [Jyeṣṭhā] 41; [Mūla] 34; [Pūrvāṣādhā] 37; [Uttarāṣādhā] 37; [Abhijit] 76; [Śravaṇa] 73; [Dhaniṣṭhā] 71; [Śatabhisaj] 56; [Pūrvabhādrapadā] 82; [Uttarabhādrapadā] 89; [Revatī] 72.

26. Here the local latitude is 24 degrees. The [given] meridian altitudes are increased by half a degree in the case of Uttarabhādrapadā (*upāntya*), Svāti (*anila*), Ārdrā (*īśa*), Aśvinī and Bharaṇī (*ādya-yugma*). These are north for Rohiṇī, Mṛgaśirā, Ārdrā (*vidher bhāt traya*), Hasta (*āditya*), Bharaṇī (*yāmyā*) and Svāti (*anila*); and south for the remaining stars.

Table Apx.D2-1 Meridian Altitudes of the Lunar Mansions

	Star Name	Identification	Meridian Altitude
1	*Aśvinī*	β Arietis	86;30° S
2	*Bharaṇī*	41 Arietis	88;30° N
3	*Kṛttikā*	η Tauri	89° S
4	*Rohiṇī*	α Tauri	83° N
5	*Mṛgaśirā*	λ Orionis	79° N
6	*Ārdrā*	α Orionis	78;30° N
7	*Punarvasu*	β Geminorum	85° S
8	*Puṣya*	δ Cancri	86° S
9	*Aśleṣā*	ζ Cancri	79° S
10	*Maghā*	α Leonis	80° S
11	*Pūrvaphālguṇī*	δ Leonis	84° S
12	*Uttaraphālguṇī*	β Leonis	82° S
13	*Hasta*	δ Corvi	53° N
14	*Citrā*	α Virginis	57° S

	Star Name	Identification	Meridian Altitude
15	*Svāti*	α Bootis	89;30° N
16	*Viśākhā*	α Librae	51° S
17	*Anurādhā*	δ Scorpii	44° S
18	*Jyeṣṭhā*	α Scorpii	41° S
19	*Mūla*	λ Scorpii	34° S
20	*Pūrvāṣāḍhā*	δ Sagittarii	37° S
21	*Uttarāṣāḍhā*	σ Sagittarii	37° S
22	*Abhijit*	α Lyrae	76° S
23	*Śravaṇa*	α Aquilae	73° S
24	*Dhaniṣṭhā*	β Delphini	71° S
25	*Śatabhiṣaj*	λ Aquarii	56° S
26	*Pūrvabhādrapadā*	β Pegasi	82° S
27	*Uttarabhādrapadā*	γ Pegasi	89;30° S
28	*Revatī*	ζ Piscium	72° S

9. How to convert the Meridian Altitudes given for the Latitude of 24° into those pertaining to the Observer's Latitude (*svadeśīya*)

akṣabhāgavivareṇa hīnayug
madhyajonnatalavāḥ samānyadik |
te hy udaksvaviṣaye khamadhyajā
yantrataḥ syur iti dakṣiṇe 'nyathā || 27 ||

27. The degrees of the meridian altitude are respectively diminished or augmented by the difference between the desired latitude and 24° according as the two quantities are in the same direction or not. The result will be the meridian altitude in degrees, if one's own latitude is to the north of the instrument's latitude. If it is to the south, the operation will be the reverse.

10. HOW TO MEASURE TIME WITH AN INSTRUMENT CALIBRATED FOR ANOTHER LATITUDE

akṣabhāntaracarārdhajaiḥ palaiḥ
saumyadiksthaviṣaye yutonitāḥ |
golayor abhimatās tu nāḍikāḥ
prasphuṭā yamadiśi syur anyathā || 28 ||

28. In the case of a locality to the north [of the instrument's latitude, the *ghaṭīs* read from the instrument are] increased or diminished by the *palas*[*] of the half *cara* [arising from] the difference between the equinoctial shadows (*akṣabhā*) [at the instrument's latitude and at the given latitude, respectively in the northern and the southern] hemispheres. Then one gets the true *ghaṭīs* that are desired. If [the locality is] to the south [of the instrument's latitude, then the process is] the reverse.

ghatikāparijñānaprakāram kautukāc chārdūlavikrīditābhyām āha |
sārdhākṣā 5|30 ghaṭikā bhavāḥ sacaraṇāh 11|
sāṅghryaṅgaśvina 26|15 khāgnayo 30 vicaraṇā vedāgnayo 33|45 'ṣṭāgnayaḥ38| sārdhāṃśās trikṛtāś ca 43|30 pādarahitās tānāś ca 48|45 vedeṣavaḥ
sārdhāh 54|30 saṣṭir 60 itīndradiksthitatulādyante pratīcyām gatāh || 29 ||
… etā nāḍya indradiksthitatulādyante pratīcyāṃ gatā jñeyāh | yantroparisthita-cakrasya pūrvacañcukāgraṃ [yadā] tulādirāśīnām ante sthitam bhavati tadā pratīcyām sthitam cañcukāgraṃ kramād āsu nāḍīṣu sthitam bhavatīti jñeyaṃ | …
nemyām aṅgulakonnatān samaśiraskān kīlakān sthāpayed |
dīrghādyān pratināḍikāsv ajamukhād dhvānte 'pi tajjñaptaye
bhāsvatsāyanabhāgaṣaḍbhajaghaṭīhīnāḥ svavedhodbhavā
yātā vyatyayato 'gatās tu ghatikā vyabhrāgnayo 'ṅgam vyadhāt || 30 ||
… nemyāṃ yantraparidhau paridhyūrdhvabhāge tiraścīnānān aṅgulakonnatān samaśiraskān kīlakān pratināḍikāsu sthāpayet | kāryāḥ | anya ekonaṣaṣṭikīlakās te samaśiraskāḥ kāryāḥ | kasmād ārabhya kathaṃbhūtān | dīrghādyān iti prathamaghaṭikāsthitakīlakaḥ kiñcid dīrghaḥ

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[*] *Pala* is the one-sixtieth part of a *ghaṭī,* i.e. 24 seconds.

sthāpya ity ucyate | ajamukhān meṣamukhād ity arthaḥ | kasmai | tajjñaptaye prāptaghatīnām jñaptir jñānaṃ dhvānte 'pi kīlakagaṇanayā ghaṭīnāṃ saṃkhyā labhyata ity abhiprāyaḥ | tat katham ity ucyate | bhāsvatsāyanabhāgaṣaḍbhajaghaṭīhīnāḥ svavedhodbhavā nāḍyaḥ kāryās tā yātā nāḍyo bhavanti | ayanabhāgāś ca saḍbhaṃ cāyanabhāgaṣaḍbhe tayoḥ saha sāyanabhāgaṣaḍbham tasmāj jātāś ca | tā ghaṭyaḥ sāyanabhāgaṣaḍbhajaghaṭyaḥ | bhāsvataḥ sūryasya sāyanabhāgaṣaḍbhajaghaṭyaḥ | tābhir hīnā gatā bhavanti vyatyayato 'gatāś ca | viparītaśodhana eṣyāh syuḥ | param tv eṣyās tās trimśadbhir ūnitāh kāryās tā eṣyāh sphuṭāh syḥh | aṅgaṃ lagnaṃ tu vyadhād vedhāj jñeyam | pūrve cañcukāgra iti pūrvavaj jñeyam | etad uktaṃ bhavati | rātrau dhruvam ityādividhinā dhruvaṃ vidhvā paścimacañcukāgraṃ kasyāṃ ghaṭyām lagnaṃ sā ghatī dīrghakīlakād ārabhya katitameti jñātvā tataḥ sāyanasūryaḥ kasmin rāśau kasminn amśe vartate tatsasaḍbhasya kati ghaṭikā prāg uktāḥ santi sārdhākṣā ghaṭikā ityādividhinā yāvatyas tābhir vedhodbhavā nāḍya ūnāḥ satyo rātrer gatā ghaṭikā bhavanti | yadi sāyanaṣadbhasūryaghaṭikā vedhaghaṭikābhir hīnāh kriyante tad ārabhya trimśat paryantam śeṣā rātrer eṣyaghatikā bhavanti | lagnam tu prāgvad iti |

Now he teaches, as a matter of interest (*kautuka*), how to read the *ghaṭīs* [at night, even when it is dark], in two verses in *Śārdūlavikrīḍita* meter.

29. [Libra] 5;30, [Scorpio] 11;15, [Sagittarius] 17, [Capricorn] 22, [Aquarius] 26;15, [Pisces] 30, [Aries] 33;45, [Taurus] 38, [Gemini] 43;30, [Cancer] 48;45, [Leo] 54;30, [Virgo] 60. When the end points of Libra etc. are in the east, these will be the elapsed *ghaṭīs* in the west.*

Commentary. These many *ghaṭīs* are elapsed when the end-points of Libra and other signs are in the east. That is to say, when the tip of the eastern pointer of the index of instrument rests at the end of Libra and other signs [successively], then the western pointer touches these *ghaṭīs* successively.

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* That is to say, when the tip of the eastern pointer of the index rests on Libra, it can be inferred that the time is 5;30 *ghaṭīs* elapsed since sunrise, and so on, for these points are diametrically opposite each other; cf. Figure L003.1.

30. On the rim, starting from the first point of Aries, affix pins at each *ghaṭī.* The first pin should be [somewhat] long[er, the rest one] *aṅgula* long with uniform pinheads. In darkness also, these [will help] in recognition. The *ghaṭīs* obtained by one's own sighting (*svavedhodbhava*), when diminished by the *ghaṭīs* corresponding to the sun's longitude with precession and increased by six signs, will become the past *ghaṭīs.* In the reverse operation, these will be the future *ghaṭīs,* when diminished by thirty. The ascendant (*aṅga*), [however, has to be found] by direct observation (*vyadha*).

Commentary. On the upper part of the rim of the instrument, at right angles to its plane, affix pins with uniform heads at each *ghaṭī.* The first one should be a bit longer. The remaining fifty-nine should have uniform heads. The pins should start from the first point of Aries. By counting the pins, the number of *ghaṭīs* can be known in darkness.* The *ghaṭīs* obtained by direct observation should be diminished by the *ghaṭīs* corresponding to the sun's longitude with precession and increased by six signs. The result will be the past *ghaṭīs.* In the reverse operation, these will be future *ghaṭīs.* But these future *ghaṭīs* should be diminished by thirty. Then they will become true future *ghaṭīs.* The ascendant, however, has to be known from direct observation as before, according to the rule *pūrvacañcukāgre* etc.

Here, this must be added. Having sighted the Pole Star at night according to the rule *dhruva* etc. (vs 11ff), note which *ghaṭī* is touched by the tip of the western pointer by counting the pins from the longest pin. Find out in which sign and at what degree the sun's longitude with precession and increased by six signs lies. Find out the corresponding *ghaṭīs* by the rule *sārdhākṣā ghaṭikāḥ* etc. (vs 29) and subtract them from the *ghatīs* obtained by observation. The result will be the *ghatīs* elapsed in the night [since sunset]. If the *ghaṭīs* corresponding to the sun's longitude with precession and increased by six signs are diminished by the *ghaṭīs* of observation, then the resulting *ghaṭīs* up to thirty are the future *ghaṭīs* of the night [up to the next sunrise]. The ascendant is determined as before.

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* No extant specimen is equipped with such pins. However, in L003 and L004, both made by Morarji in 1815, there are raised dots around the *ghaṭī* circle, about two for each *ghaṭī.*

11. IMPORTANCE OF THE DHRUVABHRAMA-YANTRA

nakṣatrāt samayajñānaṃ tamisrāyāḥ puroditam |
dhruvāt kenāpi na proktaṃ tad etat kautukāt kṛtam ‖ 31 ‖

[Others] have taught previously how to measure time from the stars, but none [has taught how to find time] from the Pole Star. Therefore, out of intellectual curiosity, this has been done [by us].

12. EXCURSUS ON THE CLASSIFICATION OF THE QUADRILATERALS

The auto-commentary on verse 2 contains a long excursus on the types of quadrilaterals which deserves to be cited in full.

catvāro 'srāh konā vidyante yasmims tac caturasram catuskonam ity arthah | … pūrvaiś caturasram satprakāram uktam | tad yathā | prathamam samacaturasram dvitīyam āyatam trtīyam visamacaturasram | tad api caturdhā | samānalambam asamāmānalambam tulyakarnam atulyakarnam ceti | esām caturnām madhye mukhyau dvau bhedau | tulyātulyakarnatve samalambam asamalambam ceti dvau bhedau | evam catusprakāram caturasram uktam | etad uktam bhavati| sarvesām bhujānām dairghyasamatve karnayoh samatve ca yac catuskonam utpadyate tat samacaturasram ucyate | ubhayor bhujapratibhujayor dairghyasamatve karnayoh samatve ca yad utpadyate tad āyatacaturasram | bhujānām asamatve karnayoś cāsamatve lambayoh samatve yad utpadyate tat samānalambavisamacaturasram | bhujānām asamatve karnayor lambayor asamatve yad utpadyate tad visamacaturasram ity ucyate | tatah pūrvācāryaiś caturbhujasya ksetraphalam prthak prthak catusprakāram uktam | tad yathā |

samaśrutau tulyacaturbhuje ca
tathāyate tadbhujakotighātah |
caturbhuje 'nyatra samānalambe
lambena nighnam kumukhaikyakhandam ‖
atulyalambe bhujayogakhandam
bhujonitam tadvadhavargamūlam |
dvitrāni khandāni vidhāya yad vā
tesām phalaikyam bhavati sphutam hi ‖

sarvāsamānām iti tac caturdhā
ksetram pradistam trividham hi kaiścit ||

That which has four corners (*asra*) is called a quadrilateral. Six varieties of quadrilaterals were mentioned by the ancients. The first is the square (*sama-caturasra*), the second the oblong (*āyata*) and the third the uneven quadrilateral (*viṣama-caturasra*). The last one is again fourfold: having equal altitudes (*samāna-lamba*) and having uneven altitudes (*asamāna-lamba*); with equal diagonals (*tulya-karṇa*) and with unequal diagonals (*atulya-karṇa*). Of these four, there are two main varieties: those with equal altitudes and those without, the diagonals being equal or unequal. Thus the quadrilateral is said to have four varieties. In this context, the following needs to be stated (*etad uktaṃ bhavati*). The quadrilateral, produced when the length of all [four] sides is equal and that of the [two] diagonals is equal, is called the square (*sama-caturasra*). That which is produced when the lengths of the two pairs of opposite sides are equal and when the two diagonals are also equal is called the oblong rectangle (*āyata-caturasra*). When the sides are unequal and the diagonals are also unequal but the altitudes are equal, the figure is called trapezium (*samānalamba-viṣama-caturasra*). When the sides are unequal, and the diagonals and the altitudes are also unequal, the figure thus produced is called an uneven quadrilateral (*viṣama-caturasra*). Therefore, the area (*kṣetraphala*) of the quadrilateral (*caturbhuja*) was taught in four different ways by the previous teachers thus:

> 'In the case of an oblong in which the diagonals are equal and the four sides are equal, [the area is] is the product of the base (*bhuja*) and the perpendicular (*koṭi*). In other quadrilaterals, where the altitudes (*lamba*) are equal, [the area is] the product of the altitude and half the sum of the base and the face (*ku-mukhaikya-khaṇḍa*).
>
> 'When the altitudes are [also] unequal, [the area is] the square-root of the product of half the sum of [all fours] sides diminished [severally] by [each] side. Alternatively, make two or three [triangular] segments; the sum of their areas will clearly become [the area]
>
> 'of [quadrilaterals in which] all [the elements] are unequal (*sarva-asama*). Thus the area is stated to be fourfold, or threefold according to some [authorities].'

APX.E REPLICAS AND OTHER IMITATIONS OF SAWAI JAI SINGH'S MASONRY INSTRUMENTS

In the nineteenth and twentieth centuries many small-scale replicas were prepared of the masonry instruments in Sawai Jai Singh's observatories at Delhi and Jaipur. In the Jaipur Observatory can be seen several of these, made of plaster of Paris, marble or brass.



Figure Apx.E.1 – Brass replica of the smaller Samrāṭ-yantra, Jaipur Observatory
(photo by Dr Jean-Michel Delire)

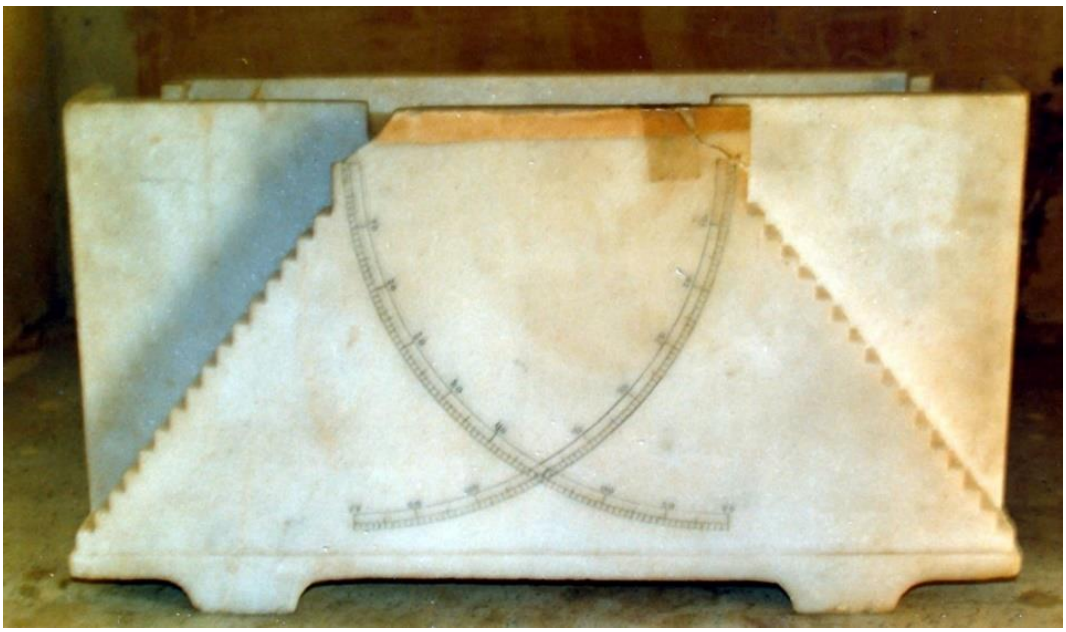


Figure Apx.E.2 – Marble replica of the Bhitti-yantra, Jaipur Observatory
(photo by S. R. Sarma)

The Science Museum in London owns several finely made small replicas. Elsewhere there are also larger replicas and even complete observatories filled with instruments similar to those of Sawai Jai Singh; some of these will be described in the following pages.

1. KALYAN DUTT SHARMA'S STONE OBSERVATORIES

Kalyan Dutt Sharma was in-charge of Jai Singh's Jaipur Observatory for several years. Like the royal predecessor, he also set up observatories at five different places in India, not for actual astronomical observations, but more for didactic purposes, at Varanasi, New Delhi, Haridwar, Ayodhya and Jaipur. He filled these observatories with smaller versions of Jai Singh's masonry instruments, sometimes with minor modifications.

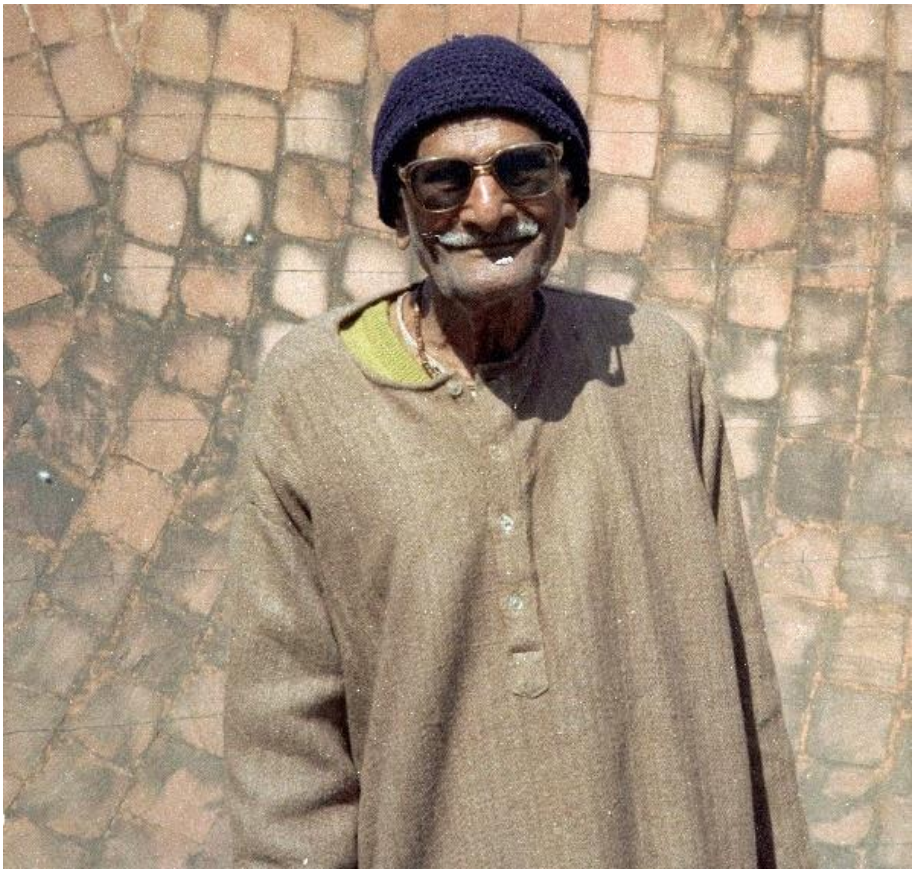
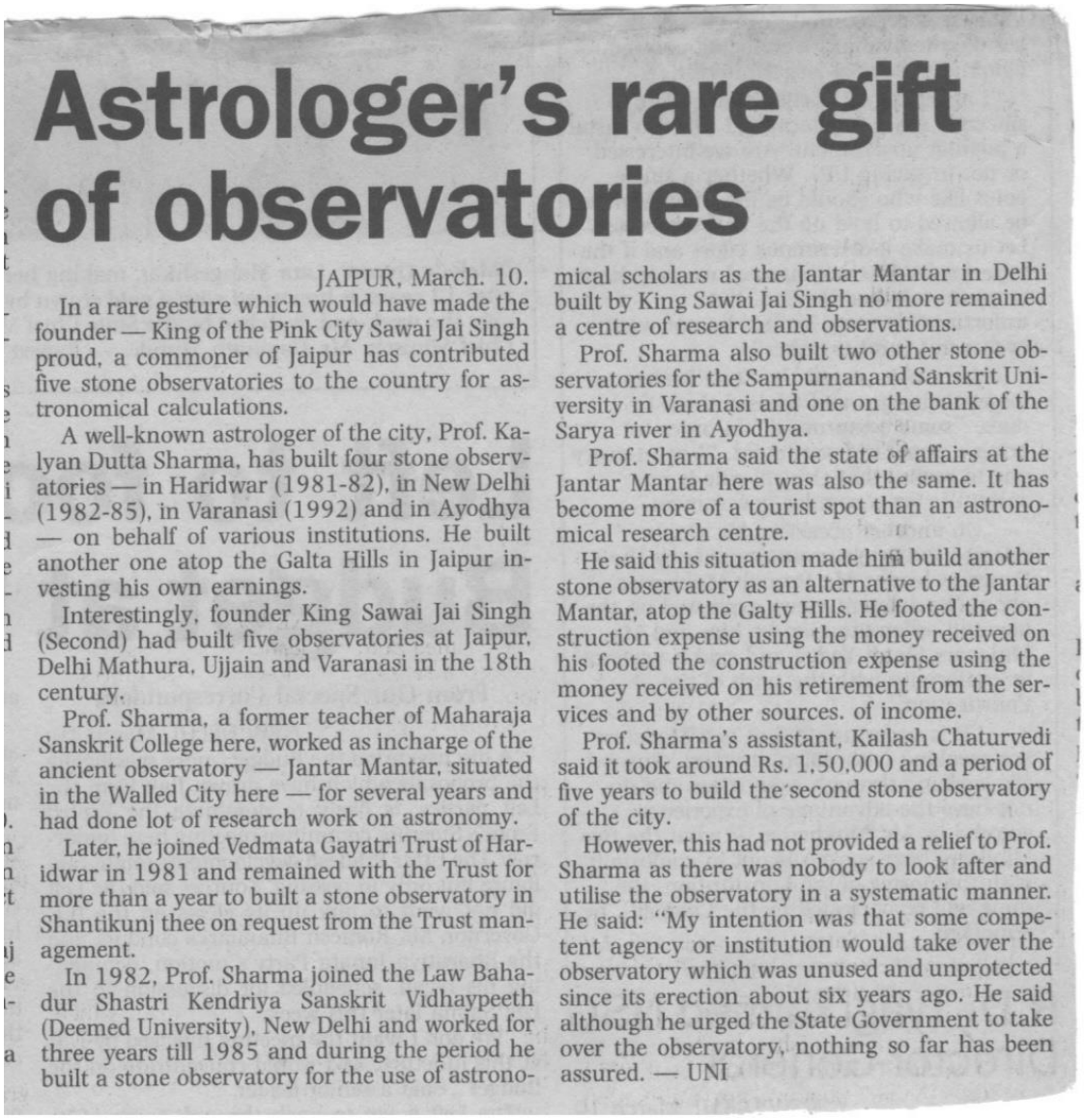


Figure Apx.E.3 – Kalyan Dutt Sharma (photo by S. R. Sarma)

I had the pleasure of meeting him briefly at the Sampurnanand Sanskrit University at Varanasi and he showed me the observatory he had set in the campus there, which was very appropriately named 'Mahāmahopādhyāya Śrī-Sudhākara Dvivedī Vedhaśālā'.*

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* Sudhākara Dvivedī was Professor of Jyotiṣa at the Benares College or the Queen's College, the names under which Sampurnanand Sanskrit University was known in colonial times; he made pioneering contributions to the study and interpretation of Sanskrit texts on astronomy and mathematics; cf. Upadhyaya 1994, pp. 300-317; see also R. C. Gupta, 'Sudhākara Dvivedī (1855-1910): Historian of Indian Astronomy and Mathematics,' *Gaṇita Bhāratī,* 12.3-4 (1990) 83-96.



Astrologer's rare gift of observatories

JAIPUR, March. 10.

In a rare gesture which would have made the founder — King of the Pink City Sawai Jai Singh proud, a commoner of Jaipur has contributed five stone observatories to the country for astronomical calculations.

A well-known astrologer of the city, Prof. Kalyan Dutta Sharma, has built four stone observatories — in Haridwar (1981-82), in New Delhi (1982-85), in Varanasi (1992) and in Ayodhya — on behalf of various institutions. He built another one atop the Galta Hills in Jaipur investing his own earnings.

Interestingly, founder King Sawai Jai Singh (Second) had built five observatories at Jaipur, Delhi Mathura, Ujjain and Varanasi in the 18th century.

Prof. Sharma, a former teacher of Maharaja Sanskrit College here, worked as incharge of the ancient observatory — Jantar Mantar, situated in the Walled City here — for several years and had done lot of research work on astronomy.

Later, he joined Vedmata Gayatri Trust of Haridwar in 1981 and remained with the Trust for more than a year to built a stone observatory in Shantikunj thee on request from the Trust management.

In 1982, Prof. Sharma joined the Law Bahadur Shastri Kendriya Sanskrit Vidhaypeeth (Deemed University), New Delhi and worked for three years till 1985 and during the period he built a stone observatory for the use of astronomical scholars as the Jantar Mantar in Delhi built by King Sawai Jai Singh no more remained a centre of research and observations.

Prof. Sharma also built two other stone observatories for the Sampurnanand Sanskrit University in Varanasi and one on the bank of the Sarya river in Ayodhya.

Prof. Sharma said the state of affairs at the Jantar Mantar here was also the same. It has become more of a tourist spot than an astronomical research centre.

He said this situation made him build another stone observatory as an alternative to the Jantar Mantar, atop the Galty Hills. He footed the construction expense using the money received on his footed the construction expense using the money received on his retirement from the services and by other sources. of income.

Prof. Sharma's assistant, Kailash Chaturvedi said it took around Rs. 1,50,000 and a period of five years to build the second stone observatory of the city.

However, this had not provided a relief to Prof. Sharma as there was nobody to look after and utilise the observatory in a systematic manner. He said: "My intention was that some competent agency or institution would take over the observatory which was unused and unprotected since its erection about six years ago. He said although he urged the State Government to take over the observatory, nothing so far has been assured. — UNI

Figure Apx.E.4 – News report in The Hindu, 11 March 1997, New Delhi edition

I had the occasion to visit Shri Lal Bahadur Shastri Rashtriya Sanskrit Vidyapeeth as a member of a committee and we were taken on a brief tour of the grounds were Kalyan Dutt Sharma erected the same set of instruments as in Varanasi. The instruments, made of masonry with marble dials, are the following:

1. *Samrāṭ-Palabhā-yantra.* It is the same as the *Samrāṭ-yantra,* but here the term *palabhā* is added to emphasize the fact that the base of the triangular gnomon is proportionate to the *palabhā* (equinoctial shadow) of the terrestrial latitude of the place.

2. *Yāmyottarīya-cāpa-yantra.* It is the same as the mural quadrant or *Bhitti-yantra* at the Jaipur Observatory, which consists of a wall erected on the north-south line with a single quadrant on one side and a double quadrant on the other; accordingly the replica in

Varanasi is named *Yāmyottara-Turīya-yantra* (quadrant on the south-north line) and that at New Delhi *Yāmyottarīya-cāpa-yantra* (double quadrant on the south-north line).

3. *Nāḍīvalaya-yantra*. It is a simplified version of the instrument bearing the same name in the Jaipur Observatory. On an inclined plane parallel to the plane of the equator, a semi-circular dial is engraved, which is divided in 12 equal segments, each segment is further subdivided in 15 parts, so that each small part corresponds to a degree of arc, or 4 minutes or 10 *palas* in time.

4. *Śaṅku-yantra.* Straight staff set up vertically on an even ground, inside a graduated circle.

5. *Dhī & Miśra-yantra.* It is a hemispherical bowl somewhat like the *Jayaprakāśa-yantra*, but given different names: *Miśra* (mixed) because it can perform the functions of several instruments, *Dhī* (intellect) because the observer's intellect plays an important role in its use and so on.

6. *Cakra-yantra,* the metal ring of the same name in the Jaipur Observatory.

7. *Karkarāśī-valaya-yantra* and 8. *Makararāśī-valaya-yantra* are made in the same manner as the two carrying the same names among the twelve *Rāśīvalaya-yantras* in Jaipur Observatory. In New Delhi a third *Tulārāśi-valaya-yantra* was added to these.

9. *Yāmyottarīya-dharātalīya-turīya-yantra,* some kind of quadrant in the south-north direction.

10. *Krānti-vṛtta-yantra* (ecliptic instrument) and 11. *Ṣaṣṭāṃśa-yantra* (sextant): I did not have the time to see these two at Varanasi and New Delhi; from the very brief descriptions, both appear to be some kind of aperture gnomons, like the *Vṛtta-ṣāṣṭāṃśa-yantra* of the Jaipur Observatory.

For the two institutions, Kalyan Dutta Sharma prepared separate guidebooks in Hindi where the use of the instruments is explained lucidly with detailed examples and tables.*

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* Kalyāṇadatta Śarmā, *Ma.Ma. Śrīsudhākara Dvivedi Vedhaśālā Paricaya,* Sampurnanand Sanskrit University, Varanasi, 1992; idem, *Vedhaśāla Paricaya Pustikā,* Shri Lal Bahadur Shastri Rashtriya Sanskrit Vidyapeeth, New Delhi, 1994.



Figure Apx.E.5 – Samrāṭ-yantra at Varanasi; on the right can be seen the mural quadrant and behind it the original Neo-Gothic building of the university (photo by S. R. Sarma)

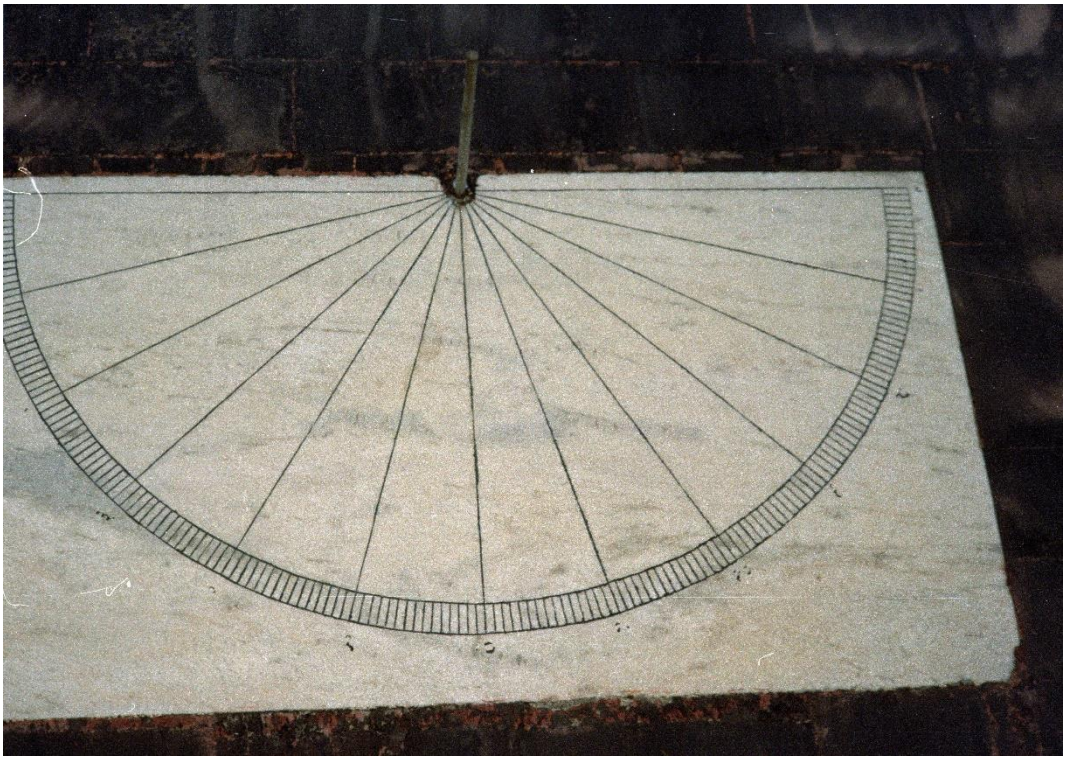


Figure Apx.E.6 – Nāḍivalaya-yantra at Varanasi (photo by S. R. Sarma)



Figure Apx.E.7 – The mural quadrant at Varanasi, front and rear views (photos by S. R. Sarma)

While these two observatories set up in institutions imparting Sanskrit learning in the traditional manner are useful for students studying Sanskrit astronomy (*jyotiṣa*), it is not clear what purpose the remaining were intended to serve. I have not seen the two observatories at Hardwar and Ayodhya, nor could I find any reports or descriptions of the instruments set up there.

The fifth one was set on the Galta Hills at Jaipur, to the east of Jai Singh's observatory. I walked there on a hot summer day in 2003 and had some difficulty in locating the observatory built in a desolate place. The barbed wire enclosing the instruments was trampled down and cows and pigs were resting amid the marble instruments.

There were five instruments, erected one behind the other on the north-south line. Each instrument carried a small plaque on which the name and the function of that instrument were written in Hindi. The five instruments are *Samrāt-yantra*, *Makararāśī-valaya-yantra, Karkarāśī-valaya-yantra, Bhitti-yantra* and *Ṣaṣṭyaṃśa-yantra.*

The last name literally means 'Sixty-degree-instrument'. It is built like a room, closed on three sides, but open in the north. On the top, where there should be an aperture to let in a ray of sunlight, cow dung cakes were arranged to dry. Inside the room, a sextant is built in masonry in the north-south direction, the arc is divided in single degrees, and labelled with the names of the zodiac signs in Hindi, starting with *Karka* at the bottom and ending with *Makara* at the top, in the following manner:

0° *Karka, sab se baḍā din* (Cancer, the longest day of all)

Siṃha / Mithuna (Leo, Gemini)

15° *Vṛṣa / va Kanyā* (Taurus and Virgo)

27° *Tulā / Meṣa krāṃti 0 din rāt barābar* (Libra, Aries, declination zero, day and night equal) *Mīna / Vṛścika* (Pisces, Scorpio)

47° *sā[yana] Kuṃbha / Dhana* (tropical Aquarius, Sagittarius)

60° *Sā[yana] Makara, sab se choṭā din* (tropical Capricorn, the shortest day of all)

It was highly distressing that the instruments here were in such a sad state of neglect;* it is not known what their situation is now.

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* It is perhaps good that I cannot locate my photos of these instruments any more!

2. GUNMA OBSERVATORY, JAPAN



Figure Apx.E.8 – Gunma Observatory, General View (photo courtesy Gunma Observatory)

When the population in the province of Gunma, in central Japan, crossed two million, it was decided to commemorate the event by erecting a lasting monument. Since the first Japanese lady astronaut Chiaki Mukai who made a space flight in 1994 was born in this province, it was further decided to built an astronomical observatory in her honour and also to add replicas of some ancient observatories next to the modern one on the top of a 850 metres high mountain. The noted architect Arata Isozaki was commissioned to design the entire complex.

In the photo above, the observatory is in the foreground; on the right can be seen the replicas of the smaller *Samrāṭ-yantra* and of the twelve *Rāsīvalaya-yantras* at the Jaipur Observatory and behind them the replica of Stonehenge. The replica of the smaller *Samrāṭ-yantra* is about half the size of the original and the *Rāśivalaya-yantras* are of about the same size or slightly larger than the originals. The location is splendid and the replicas are made with the greatest care and accuracy. Opened to the public in 2001, it has now become an important centre of tourism. I visited this place in May 2002.



Figure Apx.E.9 – Replicas of Jaipur instruments, with the replica of Stonehenge in the background (photo courtesy Gunma Observatory)



Figure Apx.E.10 – Replica of the smaller Samrāṭ-yantra (photo courtesy Gunma Observatory)

3. COTTESLOE SUNDIAL, NEAR PERTH, AUSTRALIA*

For commemorating the two hundred years of European settlement in 1988, the Australian Government offered financial support for a suitable bicentennial monument. Cottesloe, a waterfront suburb 11 km west of Perth, capital of the State of Western Australia, took up the offer and erected a high sundial in mid 1990s on the cliff above Mudurup Rocks. The sundial, visible to motorists travelling along Marine Parade, is a blend of the old and the modern; the original design is based on the *Samrāṭ-yantra* of Jaipur, but it also incorporates computer-generated equation curves.



Figure Apx.E.11 – Cottesloe Sundial (photo courtesy Professor John Perdrix)

In the place of the single triangular gnomon of the original *Samrāt-yantra*, two gnomons are set up here, which are separated by a walkway. They are constructed of limestone blocks, each capped by a precast concrete section in order to give a sharper shadow line. The height of the gnomon is 7 metres and the hypotenuse is inclined from

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* I am grateful to Professor John Perdrix, Managing Editor of the *Journal of Astronomical History and Heritage* for the photos; the description is based on a note kindly sent by him on 22 June 2000.

the base at an angle of 31;56°, which is the geographical latitude of the place and thus parallel to the earth's axis.

The quadrants are made of 316 marine grade stainless steel with a thickness of 5.3 mm and a width of 1.2 metres. In order to convert apparent solar time indicated by the gnomon's shadow to mean solar time, equation of time curves are engraved on the surfaces of the quadrants. The curves were engraved with a computer-controller laser, the program for which was written by the astrophysicist Tony Hooley.

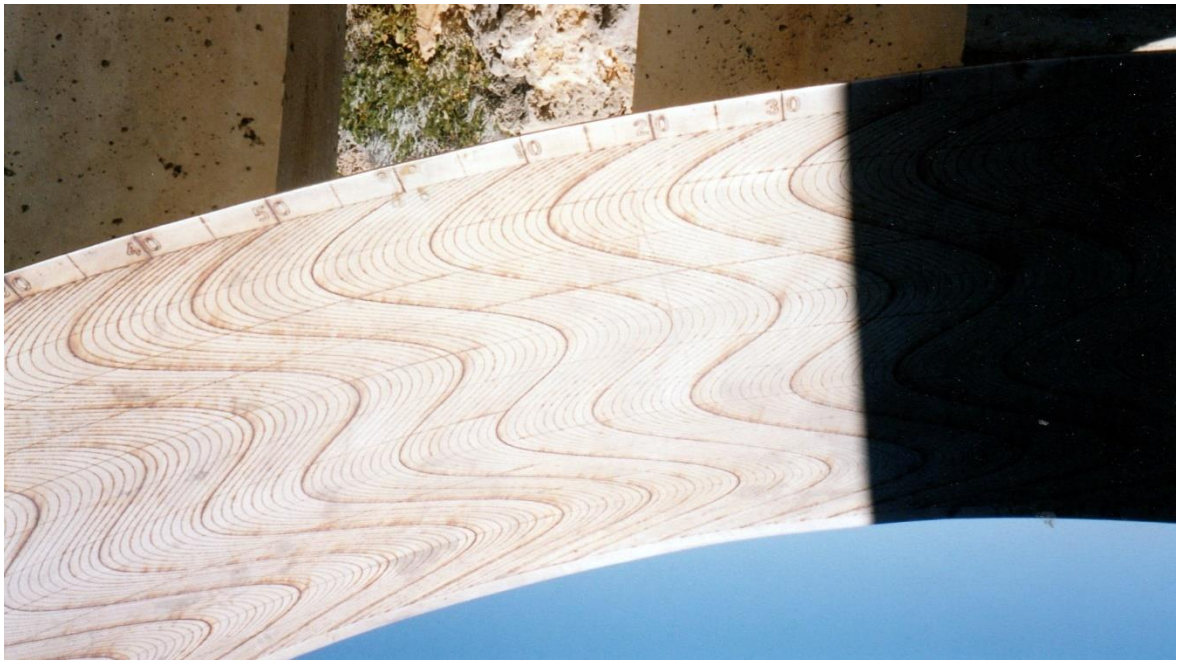


Figure Apx.E.12 – Dial on the quadrant engraved with equation of time curves,
on the right is the shadow of the gnomon (photo courtesy Professor John Perdrix)

4. MIŚRA-YANTRA IMITATIONS IN AMUSEMENT PARKS IN FRANCE



Figure Apx.E.13 – Miśra-yantra in the Delhi Observatory (photo by S. R. Sarma)

The question when and by whom the *Miśra-yantra* of the Delhi observatory was erected will remain an unsolved enigma, but pictures of this instrument with its elegant curves inspired some structures in the amusement parks in and around Paris in early nineteenth century, not for astronomical observation, but for the diversion of the visitors as the forerunners of roller-coasters.

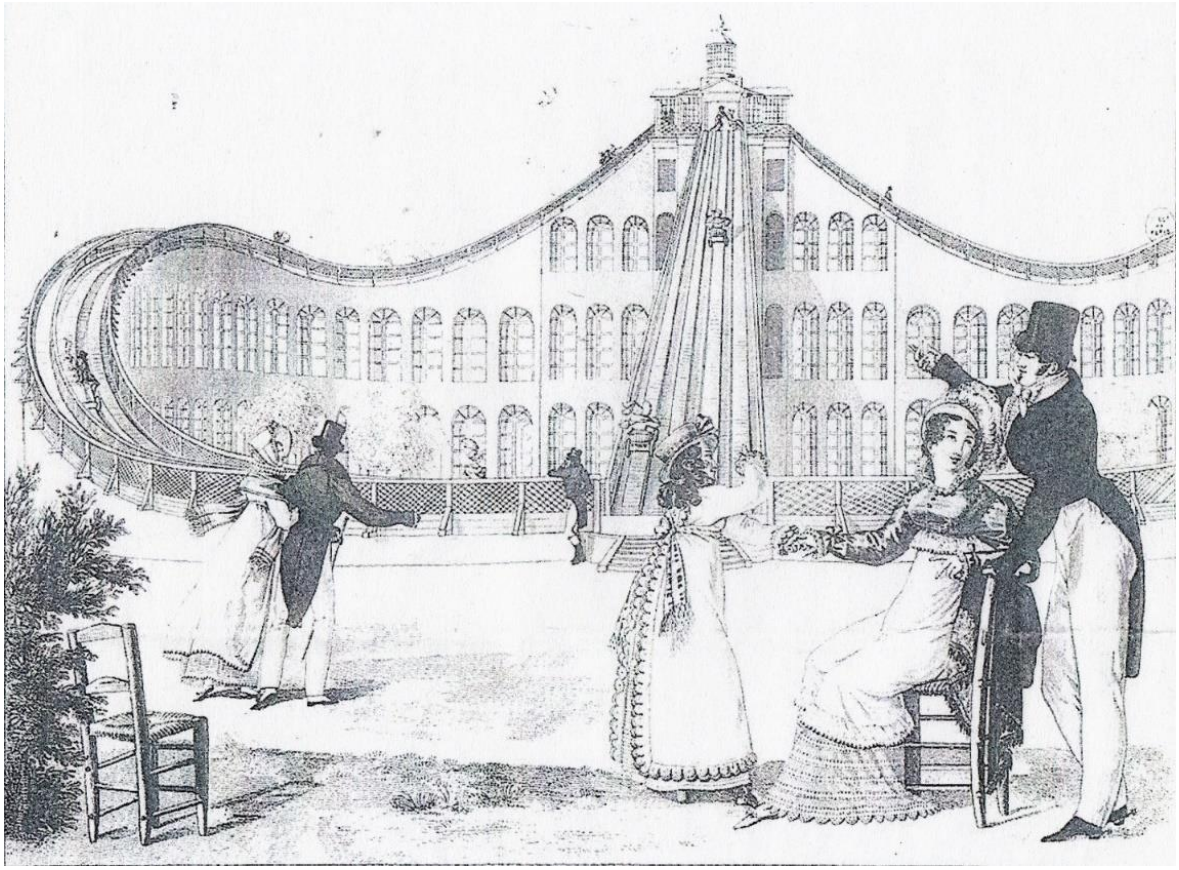


Figure Apx.E.14 – Prominade aérienne, Neuilly (image courtesy Anthony J. Turner)

In the structure called 'prominade aérienne' (aerial promenade) at Neuilly, a suburb of Paris, there was a pavilion at the top of the central aisle. The visitor reached the pavilion by a staircase at the back and sat in a little wheeled carriage which was then pushed down one of the curved wings. In descent the carriage would gain such a speed that it would go up the central aisle up to the pavilion, from where the visitor could go down for one more round.*

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* Penelope Chetwode, 'Delhi Observatory: the Paradise of an early Cubist,' *The Architectural Review,* 1935, pp. 57-60, esp. 59.

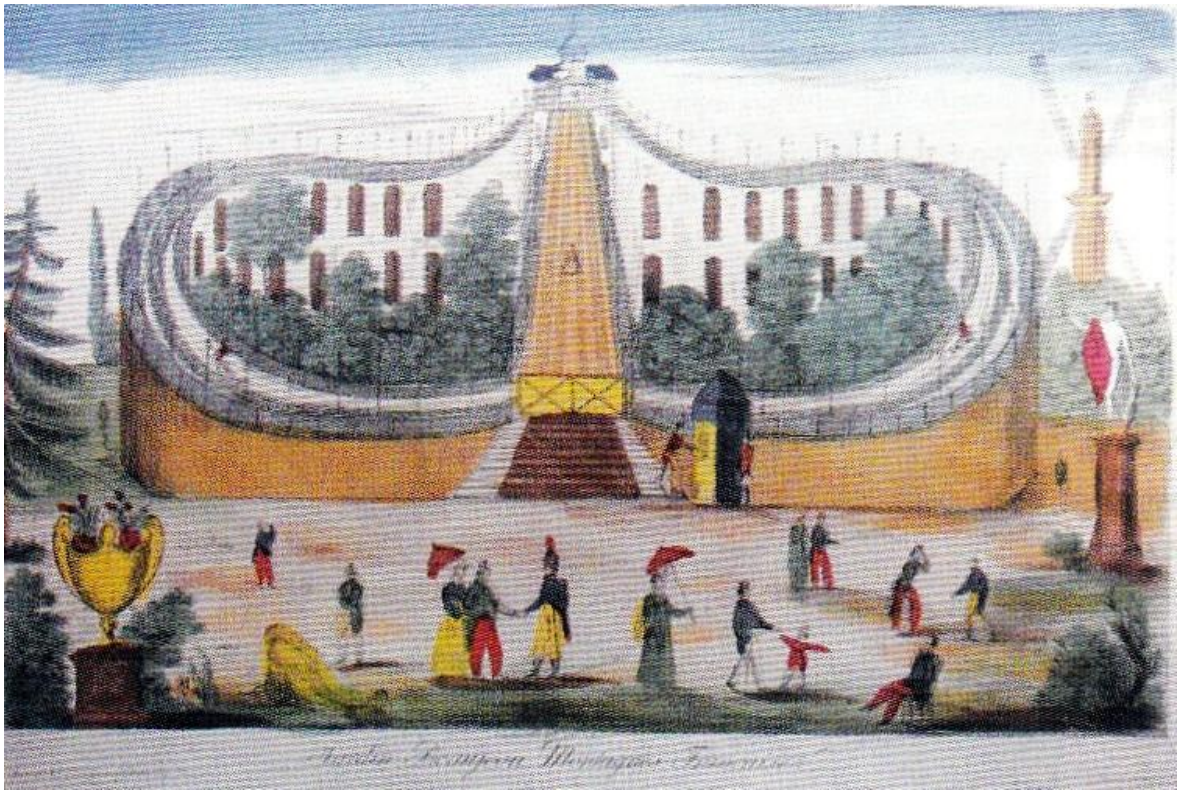


Figure Apx.E.15 –'Les Montagnes françaises' (image courtesy Anthony J. Turner)

Another structure was set up in 1817 in an amusement park by name 'Folies Beaujon' (Beaujon's Follies) in the vicinity of the present Champs Élysées and this one carried the name 'Les Montagnes françaises' (the French Mountains). Here the visitor was driven up one or the other side wings in a horse drawn carriage. At the top, the carriage was detached from the horses and made to slide down the central aisle at a bewildering speed. None of these structures are extant anymore, except for the pictorial records.

5. MAHARISHI VEDIC OBSERVATORY

From amusement, we now go to spiritualty. In 1997 Maharishi Vedic University appropriated Sawai Jai Singh's astronomical instruments and marketed a product: 'The Maharishi Vedic Observatory: An Ancient Vedic Technology to Expand Awareness, Train the Vision and Mind to focus on the Mathematical Precision and Order that Regulate the Universe without Problems'.*

In this product, stylized replicas of Jai Singh's astronomical instruments from the Jaipur and Delhi observatories are arranged in a circle; starting at the top and proceeding clockwise, these are *Samrāṭ-yantra, Nāḍīvalaya-yantra,* the pair of *Rāma-yantras,* the pairs of *Kapāla-yantras* and of *Cakra-yantras, Miśra-yantra, Digaṃśa-yantra,* the pair of *Jayaprakāśa-yantras* and *Dakṣiṇodak-bhitti-yantra.* The large circle surrounded by eight small circles in the centre is said to represent the *Rk-veda.* The website describes the structures and their astronomical functions reasonably correctly, but in each case the emphasis is not on astronomical observation, but on viewing the instrument itself in order to awaken one's consciousness.

In the interpretation of this organization, the instruments designed by Sawai Jai Singh in the first quarter of the eighteenth century have become part of 'ancient Vedic technology'. Sawai Jai Singh's name is mentioned nowhere, nor the names of the Jaipur Observatory and of the Delhi Observatory from where the instruments are copied.

Lest one should question the ahistorical approach in the misattribution of instruments created for the first time in the eighteenth century to the Vedas and the total suppression of the name of Sawai Jai Singh, one is told: 'When viewing the Maharishi Vedic Observatory what is important is the actual perception, nor the intellectualization.'

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* http://vedicobservatory.svr.com/YRkVedaDisplay.html
[also https://goo.gl/dRSvcu, last accessed in January 2018]

